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

Redcar and Cleveland Borough Council

March 2017

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Abbreviations and Acronyms

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

Water Levels Used in Interpretation of Changes

Water Level Parameter	Water Level (m AOD) Hartlepool Headland to Saltburn Scar	Skinningrove	Hummersea Scar to Sandsend Ness	Sandsend Ness to Saltwick Nab
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**
HAT	3.10	3.05	3.05	3.10
MHWS	2.60	2.45	2.45	2.50
MLWS	-2.20	-2.35	-2.35	-2.30

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

Glossary of Terms

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

Preamble

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

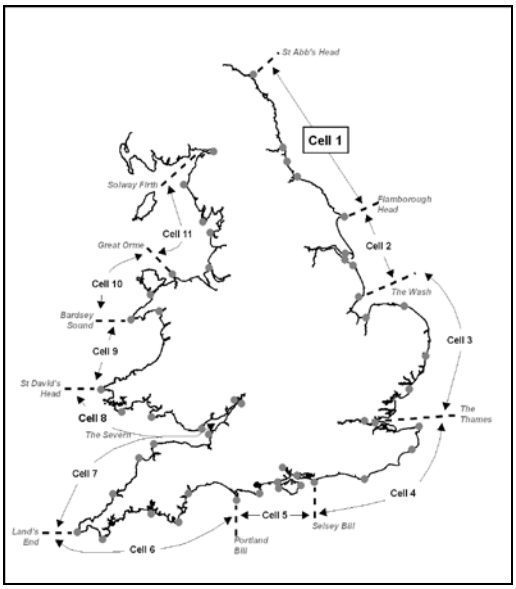


Figure 1 Sediment Cells in England and Wales

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

Northumberland County Council
Northumberland Coast AONB
North Tyneside Council
South Tyneside Council
Sunderland City Council
Durham County Council
Redcar & Cleveland Borough Council
Hartlepool Borough Council
Scarborough Borough Council
A great place to live, work & play
East Riding of Yorkshire Council
Environment Agency
Natural England
The National Trust

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

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

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

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

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

Table 1 Analytical, Update and Overview Reports Produced to Date

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	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-Oct 11	Oct 12	Mar-May 12	Feb 13	
5	2012/13	Sep 12	Mar 13	Feb- Mar 13	May 13	
6	2013/14	Oct-Nov 13	Feb 14	Mar-Apr 14	Jul 14	
7	2014/15	Sep-Oct 14	Feb 15	Mar-Apr	July 15	
8	2015/16	Sep-Oct 15	Feb 16	Mar 16	Jul 16	
9	2016/17	Sep-Nov 16	Feb 17 (*)			

* The present report is **Analytical Report 9** and provides an analysis of the 2016 Full Measures survey for Redcar and Cleveland 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 sections listed in Table 2.

Table 2 Sub-divisions of the Cell 1 Coastline

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

Redcar & Cleveland Borough Council's frontage extends from the South Gare breakwater at the mouth of the River Tees to Cowbar Nab, Staithes. For the purposes of this report, report and for consistency with previous reporting, it has been sub-divided into six areas, namely:

- Coatham Sands
- Redcar Sands
- Marske Sands
- Saltburn Sands
- Cattersty Sands (Skinningrove)
- Staithes

The Staithes frontage straddles the boundary of jurisdiction of Redcar & Cleveland Council and Scarborough Borough Council and therefore reporting has been duplicated in both reports.

1.2 Methodology

Along Redcar & Cleveland Borough Council's frontage, the following surveying is undertaken:

- Full Measures survey annually (since 2008) each autumn/early winter comprising:
    - Beach profile surveys along nine transect lines
    - Topographic survey along Coatham Sands
    - Topographic survey along Redcar Sands
    - Topographic survey along Marske Sands
    - Topographic survey along Saltburn Sands
    - Topographic survey along Cattersty Sands
- Partial Measures survey annually each spring (since 2009) comprising:
    - Beach profile surveys along nine transect lines
    - Topographic survey along Redcar Sands
    - Topographic survey along Saltburn Sands
    - Topographic survey along Cattersty Sands
- Cliff top survey annually at:
    - Staithes

The Full Measures survey was undertaken along this frontage in September, October and November 2016. The weather and sea state varied considerably, for further details please refer to the Survey Report from Academy Geomatics.

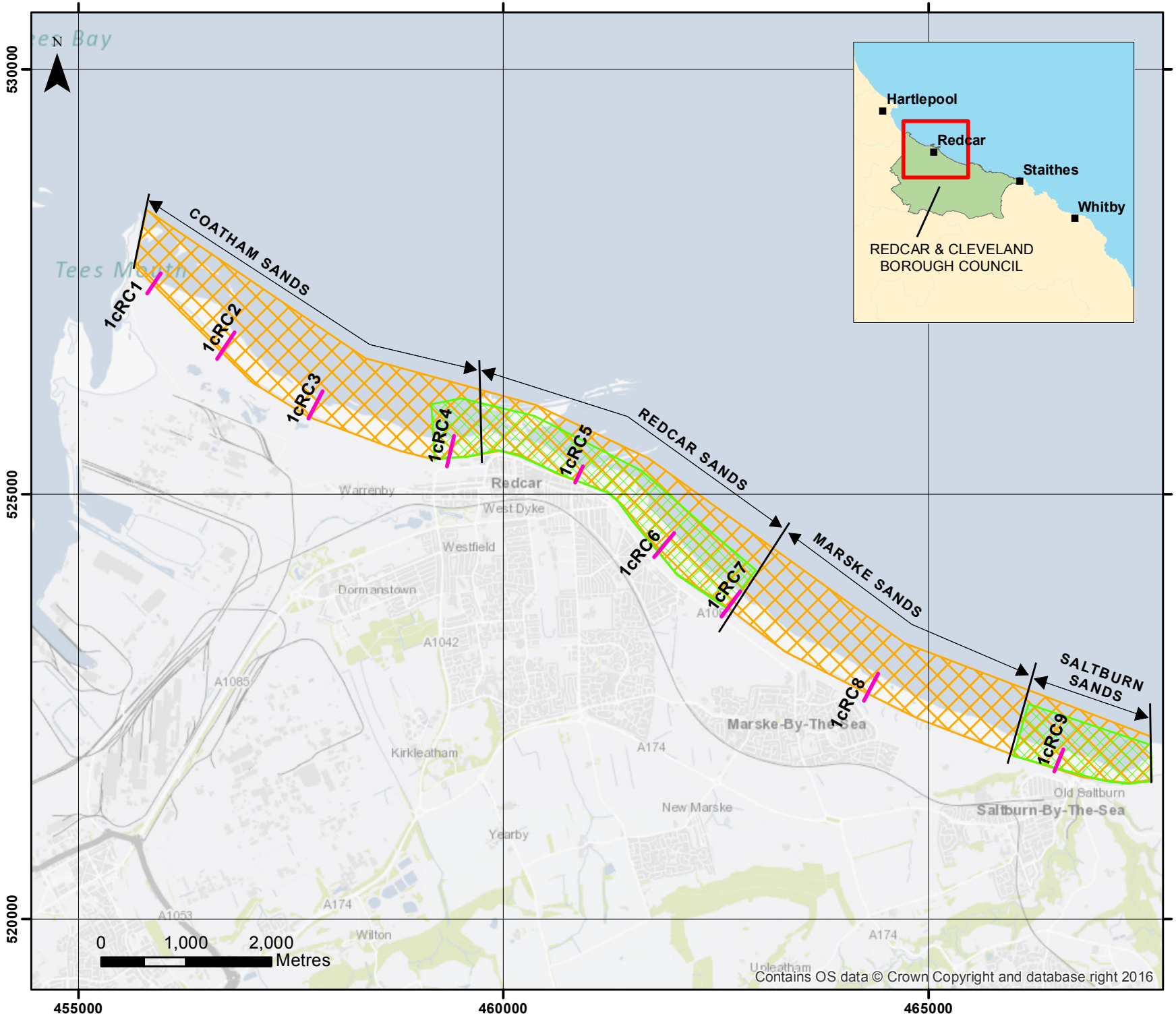
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data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

Redcar & Cleveland Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:60,000

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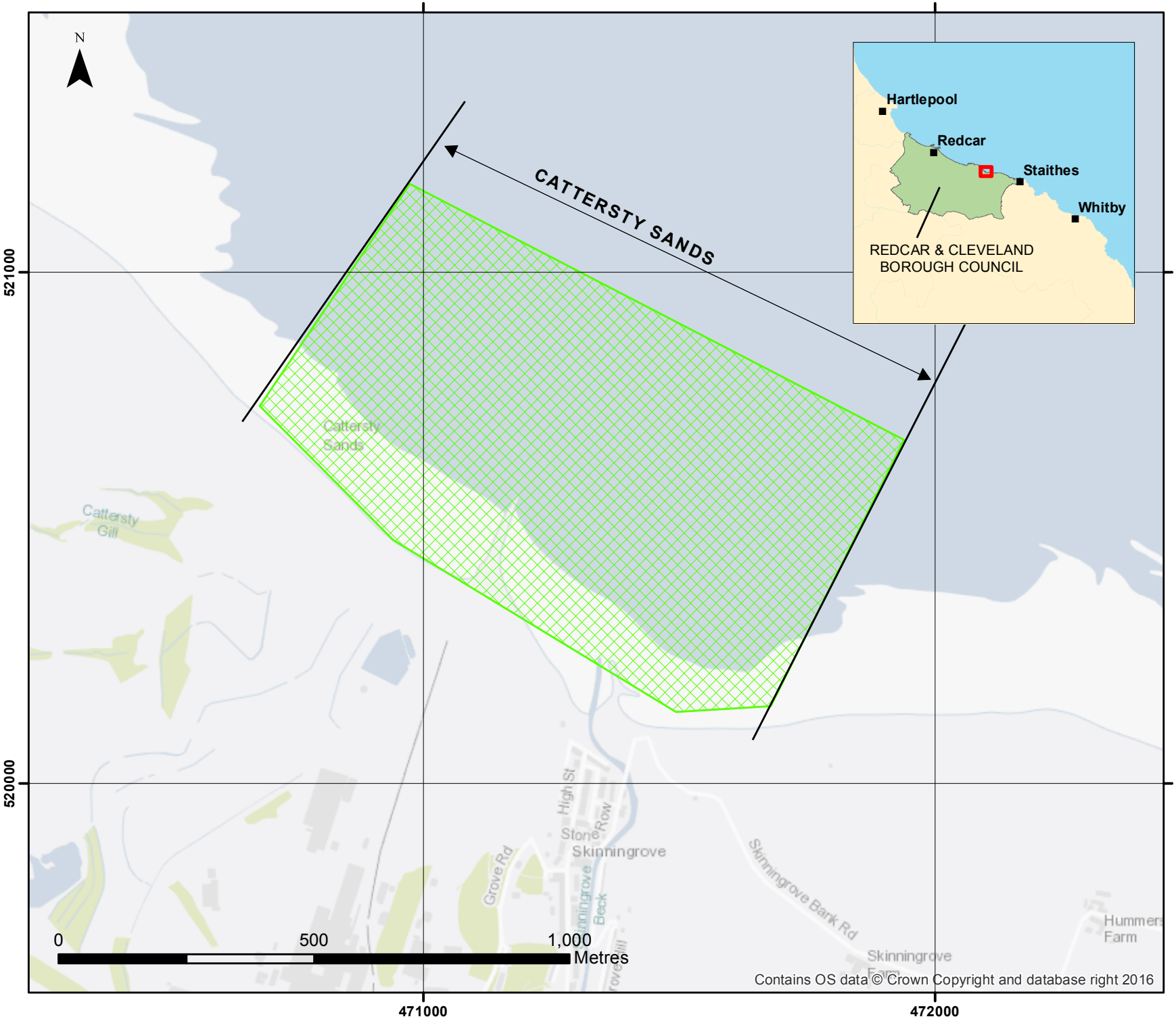

Key

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Topographic Profiles

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Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 2

Redcar & Cleveland Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:10,000

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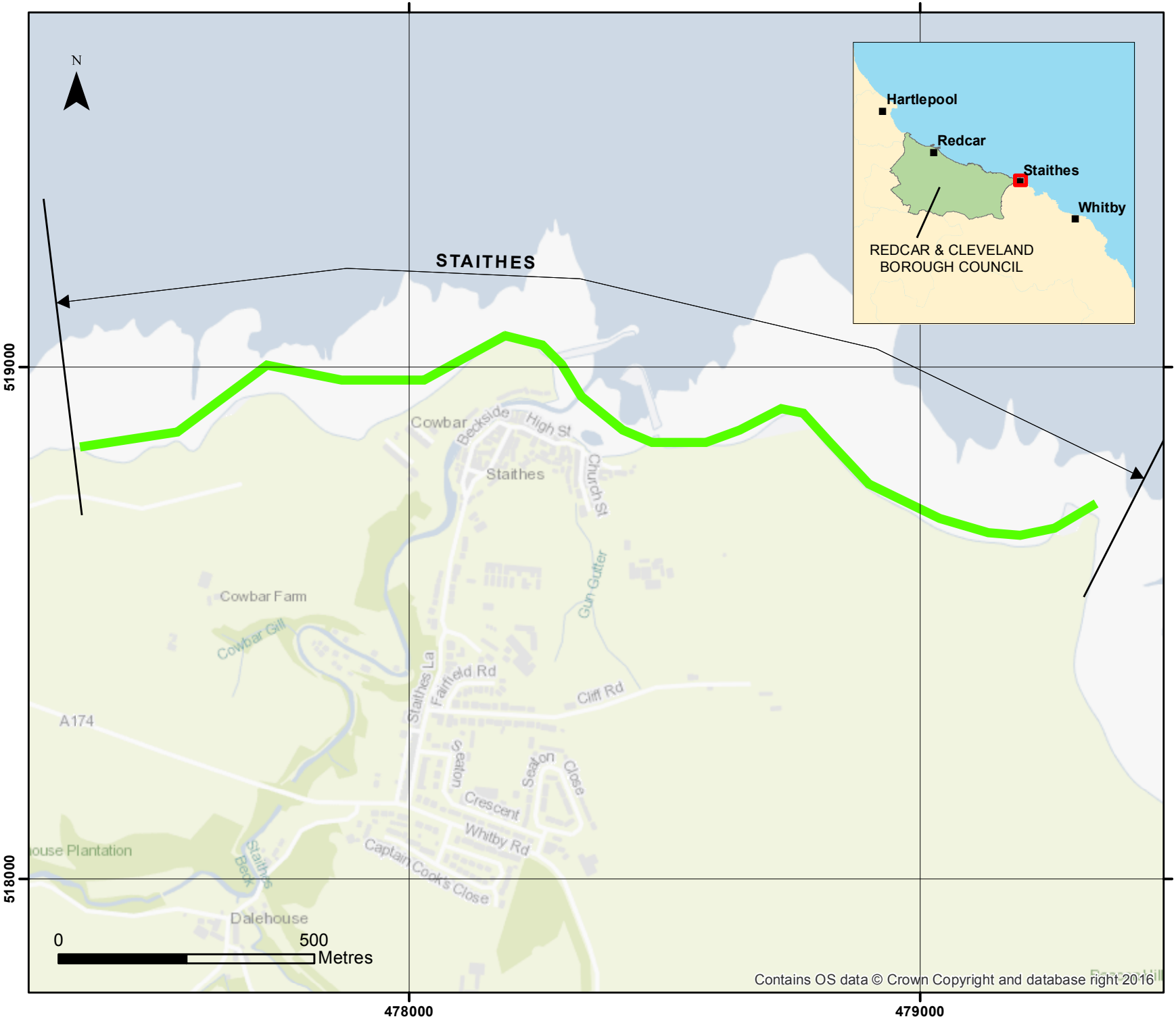

Key

SURVEY LOCATIONS

Frequency

@ 50

@ 100

@ 300

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 3

Redcar & Cleveland Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:10,000

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2. Analysis of Survey Data

2.1 Coatham Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
3rd-7th October 2016	**Beach Profiles:** Coatham Sands is covered by four beach profile lines during the Full Measures survey (RC1 to RC4; Appendix A). Profile **1cRC1** is located approximately 300m south of the South Gare breakwater, in the lee of the German Charlies slag banks. The upper profile is dominated by dune ridges, which have remained stable since the 2009 surveys. The foredune has increased by 0.3m in height and extended forwards by c.3m. The berm present at the toe of the foredune in the April 2016 has extended seawards by 35m, raising beach levels by up to 1.2m. Seaward of the berm, from chainage 170m, there has been loss of beach material of up to 0.8m. The gradient of the beach remains similar to the April 2016 survey. Overall, the beach level remains high compared to previous profiles. At Profile **1cRC2,** the beach and dunes continue to be high compared to the profiles recorded since 2008. The dune profile has changed little since October 2015 and April 2015. Over the summer of 2016, the foredune at 80m chainage has continued to accrete by 0.4m compared with April 2016. The foredune has moved out over the beach by c.3m with the beginnings of a new dune developing at chainage 87m. Between chainage 90m and 105m the beach has accreted by up to 0.3m. The rest of the profile has seen limited change. The beach levels are high compared to the range from the previous surveys. Profile **1cRC3** shows a reasonably stable dune area as far as 60m chainage, with a small amount of growth of up to 0.2m compared to April 2016. Most of the beach has seen accretion of up to 0.4m, with the exception of chainage 230m to 270m. The mid beach berm between chainage 140m and 210m has grown by up to 0.4m and moved seawards by c. 10m. The lower beach berm has moved seawards by c.30m and reduced in height by 0.3m. The depression between the berms has lowered by 0.4m. Overall, the beach level is high compared with the previous surveys, except for the depression between the berms. Profile **1cRC4** is the beginning of the defended section at Redcar. There has been very little (less than ±0.2m) change since April 2016, with the largest difference being the creation of an upper beach berm	All of the profiles have seen accretion over the summer of 2016, with the full measures 2016 surveys being high compared with the range recorded from previous surveys. The difference plots show a patchy distribution of variable change, with accretion dominating over erosion across the full survey extent. The southern extent of the survey is dominated by erosion of less than 1m, while part of the centre of the frontage have more than 1m accretion. **Longer term trends**: The magnitude of change in 2015 is more modest than that seen in the past. The upper beach in the southern part of the frontage has shown consistent erosion.

Survey Date	Description of Changes Since Last Survey	Interpretation
	between 50m and 90m chainage. Overall, the beach levels are medium compared to the range recorded from previous surveys.	
	Topographic Survey: Coatham Sands is covered by an annual topographic survey extending from the South Gare Breakwater, although the survey is contiguous with the 6-monthly Redcar Sands survey. Data have been used to create a DGM (Appendix B – Map 1) using GIS. This shows that the beach contours recorded in Autumn 2016 were relatively shore parallel along the frontage, with a gently shelving beach slope. The beach is narrower and steeper to the north west of the subtle promontory around 1km SE of the breakwater and of shallower gradient further south-east. The GIS has also been used to calculate the differences between the current topographic (Autumn 2016) survey and the earlier topographic survey (Autumn 2015), as shown in Appendix B – Map 5, to identify areas of erosion and accretion. The topographic difference plot shows accretion is dominant over erosion, but there are large areas of negligible change. The beach to the east has seen little change with some patchy areas of accretion. The beach around the small promontory and to the west shows the most change, being dominated by accretion. In the centre of the bay there is a small section of alternating bands of accretion and erosion parallel to the shore.	

2.2 Redcar Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
3rd – 7th October 2016	**Beach Profiles:** Redcar Sands is covered by three beach profile lines during the Full Measures survey (RC5 to RC7; Appendix A), with RC7 being approximately on the boundary with the Marske Sands area. At profile **1cRC5,** the beach has dropped by 0.3m at the toe of the sea defence. There has been accretion of up to 0.2m between chainage 30m and 60m, and erosion of up to 0.5m between 60m and 130m where the rock platform becomes exposed. The effect of this is to steepen the profile compared to the April 2016 survey. Seaward of chainage 185m the beach has dropped by up to 0.6m. Overall, the beach is at a medium level compared to the range recorded by the previous surveys. At profile **1cRC6** there continues to be very little change since October 2014. The main change has been erosion of around 0.2m between chainage 190m and 255m compared to the April 2016 survey. As a result, the October 2016 profile remains one of the highest recorded beach profiles. Profile **1cRC7** has experienced very little change on the dune frontage and the upper beach since April 2016. Between 60m and 250m chainage there has been little change of up to ±0.3m, smoothing out the two berms and infilling the depression between to create a smoother profile. On the lower beach, seaward of 250m the toe of the beach has fallen away sharply by up to 1m. Overall, the beach is at a high-medium level compared to the range recorded by the previous surveys.	All three of the profiles show beach levels in autumn 2016 at high-medium levels compared to the range recorded from previous surveys. However all the profiles show erosion in the lower foreshore, particularly 1cRC5 and 1cRC7. The topographic change plot reflects this pattern with erosion on the lower beach and accretion in the middle and upper beaches. **Longer term trends**: The beach levels are high compared to previous years, suggesting recovery since the storms and surge of winter 2013/14. The most substantial accretion in front of the new defences may relate to the defence improvements introducing a less reflective seawall.
	Topographic Survey: Redcar Sands is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 2) using GIS. The plot shows shore-parallel contours for most of the frontage with the exception of the beach in front of Redcar, where there is a bay between the Redcar Rocks and West Scar. The most landward part of this embayment is close to Redcar Esplanade, where the beach is steeper than on any of the surrounding coast. The coastal defence scheme here was constructed between the October 2012 and March 2013 surveys. The GIS has also been used to calculate the differences between the current topographic survey	

Survey Date	Description of Changes Since Last Survey	Interpretation
	(Autumn 2016) and the previous full measures survey (Autumn 201%) and the most recent (Spring 2016) topographic survey, as shown in Appendix B – Maps 6 and 9, to identify areas of erosion and accretion. To the east of Redcar Rocks the changes are limited to less than ±1m; accretion generally dominates with a couple of patches of erosion on the lower foreshore. Between Coatham Rocks and Redcar Rocks there was accretion on the upper beach and erosion on the lower beach between the April 2016 and October 2016 surveys, however when compared to the October 2015 survey there has been erosion in the upper and lower beach with accretion in the middle section of the beach. To the west of Coatham Rocks there has been little change, with erosion being more typical since the April 2016 survey but accretion more typical compared to October 2015 survey.	

2.3 Marske Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
3rd – 7th October 2016	**Beach Profiles:** Marske Sands is covered by two beach profile lines during the Full Measures survey (RC7 to RC8; Appendix A), with RC7 being approximately on the boundary with the Redcar Sands area. Profile **1cRC7** is located along The Stray and has been discussed in Section 3.2. Profile **1cRC8** experienced significant erosion at the cliff toe between October 2013 and April 2014, but there has been very little further change above HAT since April 2014. There has been accretion of up to 0.5m along the entire beach profile from the toe off the dunes (60m chainage) to chainage 300m on the lower foreshore, with a berm forming at chainage 150m. Below 300m chainage the beach has lowered slightly by 0.2m. Overall, the beach is at high level compared to the range recorded from previous surveys.	The impact of the December 2013 storm surge is still evident at the cliff toe in the profiles above HAT because the dune face is steep, however sand has now started to accrete at the toe. The general pattern is of stability. The difference plot for Autumn 2014 to Autumn 2015 shows accretion on the upper beach and a mixture of erosion and accretion in the mid-lower beach. **Longer term trends:** Current beach profiles are among the highest recorded, but the toe of the beach shows erosion. The change is due to the movement of bars on the beach, which is also shown on the topographic difference plots.
	Topographic Survey: Marske Sands is covered by an annual topographic survey. This survey is contiguous with the Redcar Sands and Saltburn Sands topographic surveys that are both surveyed six-monthly. 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 Autumn 2015 and Autumn 2016 topographic survey, as shown in Appendix B – Map 7. The topographic contours are generally shore parallel except where the outfalls of small, culverted streams issue in front of the Marske itself. Since the previous topographic survey in Autumn 2015, the erosion and accretion has been patchy, though generally it has occurred in discontinuous elongate strips along the frontage. This is similar to previous years. Overall, there are more areas of accretion than erosion. The greatest degree of change is in the west of the frontage. .	

2.4 Saltburn Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
3rd – 7th October 2016	**Beach Profiles:** Saltburn Sands is covered by one beach profile during the Full Measures survey (RC9; Appendix A). Profile **1cRC9** was stable where there are sea defences between 0m and 30m chainage over the summer of 2015. There has been accretion across the rest of the profile of up to 0.3m, with the formation of a small berm at chainage 130m. Overall, the beach has recovered from the low level recorded in the April 2016 survey to be at a medium level compared to the range recorded from previous surveys.	The beach showed an overall increase in level at profile 1cRC9. The difference plot for 2016 shows modest change across much of the beach. There is limited erosion across much of the upper beach. **Longer term trends**: the October 2015 beach level was one of the lowest recorded profile since 2008, suggesting progressive erosion, however this survey shows some recovery of beach levels.
	Topographic Survey: Saltburn Sands is covered by a six-monthly topographic survey, although the survey is contiguous with the Marske Sands topographic survey that is surveyed annually. Data have been used to create a DGM (Appendix B – Map 3) using a GIS software package. This shows that the beach contours are shore parallel and gently shelving for the majority of the frontage. The contours are slightly indented opposite Skelton Beck, where the stream has eroded the foreshore. The GIS has also been used to calculate the differences over the six month period between Spring 2016 and Autumn 2016 topographic survey, as shown in Appendix B – Map 10, and the change since the last full measures survey in autumn 2015, to identify areas of net erosion and accretion. The pattern of change is similar for both the plots showing changes since autumn 2015 and spring 2016. Overall, there are more areas of accretion than erosion but the changes are generally of a small magnitude. The most significant erosion is the area where a stream discharges across the beach. There is also a narrow band of erosion at the uppermost beach along much of the survey length compared with the April 2016 survey.	

2.5 Cattersty Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
16th November 2016	**Topographic Survey:** Cattersty Sands is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 4) using a GIS package. The beach is steeper to the west of the breakwater than the east, but in both areas the gradient is relatively smooth. East of the breakwater, the beach is punctuated by Kilton Beck and the harbour so the gradient is shallower. Immediately east of the fishtail groyne, the stream has cut a channel, which is most deeply incised at its landward extent. The GIS has also been used to calculate the differences between Spring 2016 and Autumn 2016 topographic surveys and is presented as DGM (as shown in Appendix B – Map 8), to identify areas of net erosion and accretion. The difference plot shows a patchy distribution of accretion and erosion. To the west of the breakwater, accretion dominates in the upper and lower beach with erosion occurring in the middle beach. To the east of the breakwater, there is a similar pattern except at the end of the fishtail groyne where there is erosion down the beach to the edge of the survey limit.	The topographic change data shows Cattersty Sands is very dynamic, influenced by both coastal and fluvial processes and the breakwater. Short term change, over the preceding six-monthly shows similar beach behaviour either side of the breakwater with shore parallel strips of erosion and accretion indicating bar migration. The exception is in the vicinity of the fish tailed groyne, works carried out in 2015 may have impacted on the beach behaviour. **Longer term trends**: On the south east side of the breakwater the long term pattern of erosion in the channel and accretion in the mid beach continued although there was a patch of erosion on the lower beach which was not a continuation of the long term trend for the beach. The winter erosion dominates the overall behaviour of the beach but the calmer weather in the summer months should lead to some accretion. If the erosion of the upper beach continues, it is likely to drive cliff failures, which would add material to the upper beach for redistribution.

2.6 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
23rd September 2016	**Cliff-top Survey:** 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. Between April 2016 and September 2016, nine of the 20 posts showed change within a range of ±0.1m, which is not considered significant given the error of the technique. Posts 3, 6, 7, and 13 showed the largest erosion with 0.1 to 0.3m cliff recession recorded. Calculation of longer-term erosion rates based on the recorded change between 2008 and 2015 indicates that eighteen on the frontage recorded a change rate within a range of ±0.1m/yr., which is considered to be within the error of the measurement. Post 13 (near the eastern breakwater) shows consistent erosion through the surveys at 0.3m/yr. Posts 9 to 12 were inaccessible due to a landslip on the headland; the area was fenced off by the National Trust. Appendix C provides results from the September 2016 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.	Four stations showed erosion of between 0.1 and 0.3m over the summer of 2016. A further four stations were inaccessible due to a landslip on the headland suggesting there may have been significant recession in this area. **Longer term trends**: Table C1 shows that survey location 13 has shown the greatest total erosion with a loss of 2.3m (±0.3m) between the November 2008 baseline and September 2015, resulting in a long term average recession rate of 0.3m/yr. This area is above the eastern breakwater and is known to have experienced rock falls previously.

3. Problems Encountered and Uncertainty in Analysis

Individual Surveys

At Redcar the beach was being groomed in the vicinity of profile 1cRC4 at the time of survey.

Cliff Top Surveys

The cliff top surveys at Staithes are assumed to have a limit of accuracy of ± 0.1m due to the techniques used. One of the previous survey station has been buried under a newly installed man made embankment. New survey station 4 was installed and a new fence has been replaced adjacent to it. Posts 9 to 12 were inaccessible due to a landslip on the headland; the area was fenced off by the National Trust.

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

5. Conclusions and Areas of Concern

- At Coatham Sands, there has been accretion across all profiles with beach levels being high compared to the range recorded from previous surveys.
- At Redcar Sands there has been loss of material from the toe of the beach but the profiles overall remain high compared to the range recorded from previous surveys.
- At Marske Sands, the 2016 beach profiles show the beach is generally accreting. The short term topographic change plot reflects this with evidence of the migration of beach berms.
- The beach at Saltburn Sands has shown some recovery in levels between April and October 2016.
- The Cattersty Sands the difference model shows that the changes in the summer of 2016 were similar either side of the breakwater with accretion dominating in the upper and lower beach and erosion occurring in the middle beach.
- The measurements of the Cowbar and Staithes cliff top shows stability over the summer of 2016, with the exception of the area on the headland where a landslip has been fenced off preventing collection of survey data. The rest of the cliff has modest recession rates which will become more accurate as more data is collected.

Appendices

Appendix A

Beach Profiles

Beach Profile

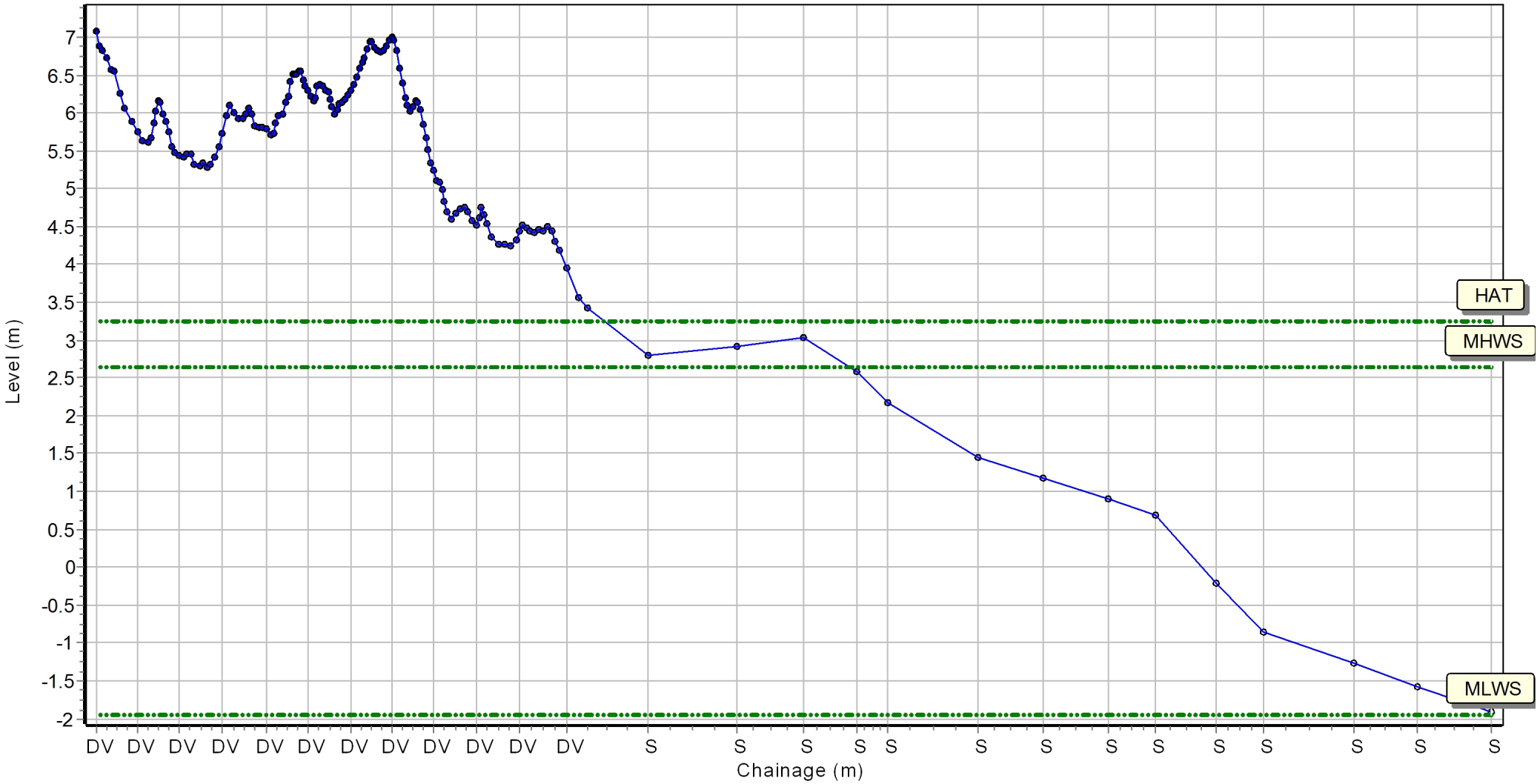
Location: **1cRC1**

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 455811.436 **Northing:** 527373.402 **Profile Bearing:** 34 ° from North



Beach Profile

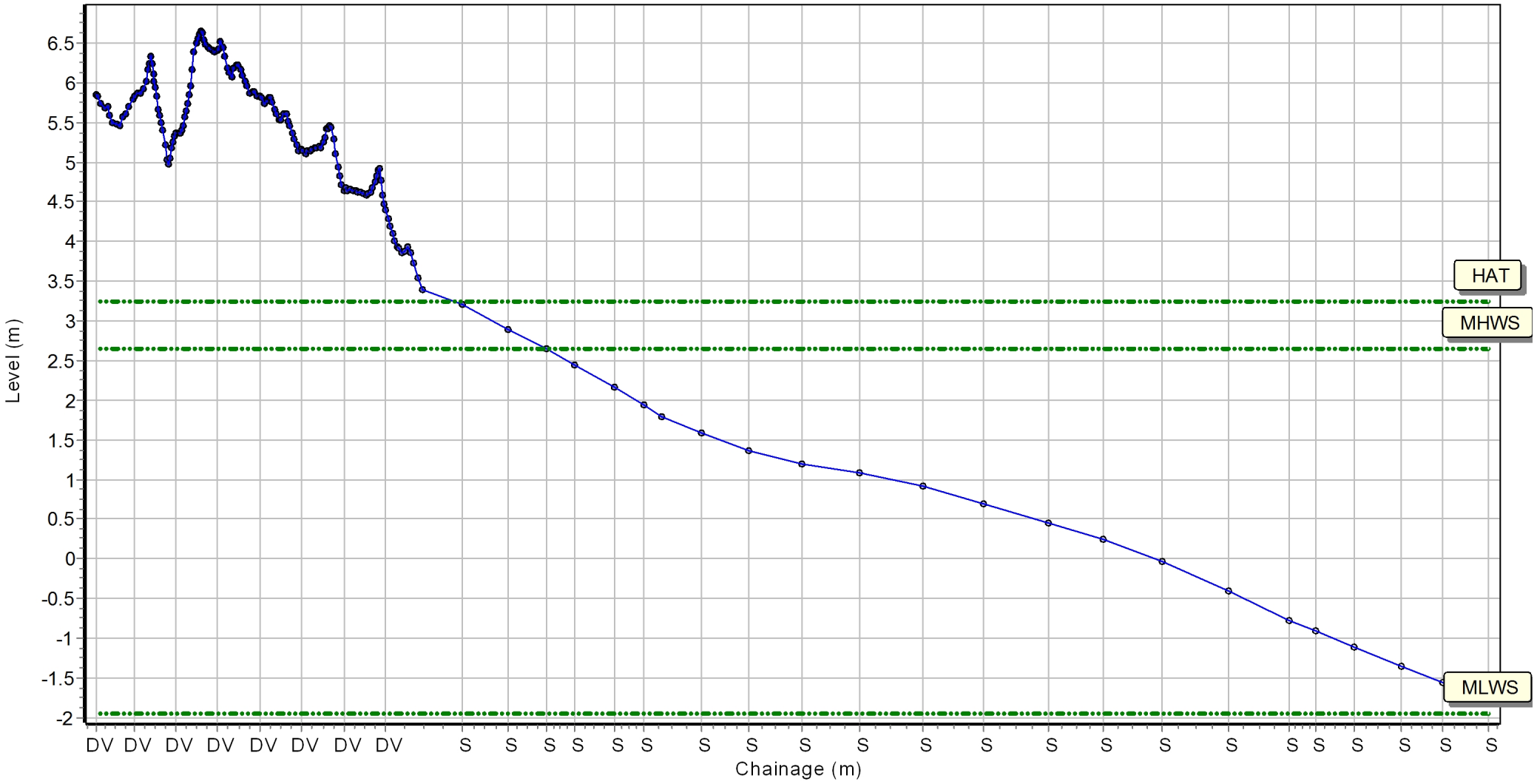
Location: 1cRC2

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 456633.253 **Northing:** 526599.577 **Profile Bearing:** 34 ° from North



Chainage (m)	Level (m)	FC
388.572	-1.793	S

Beach Profile

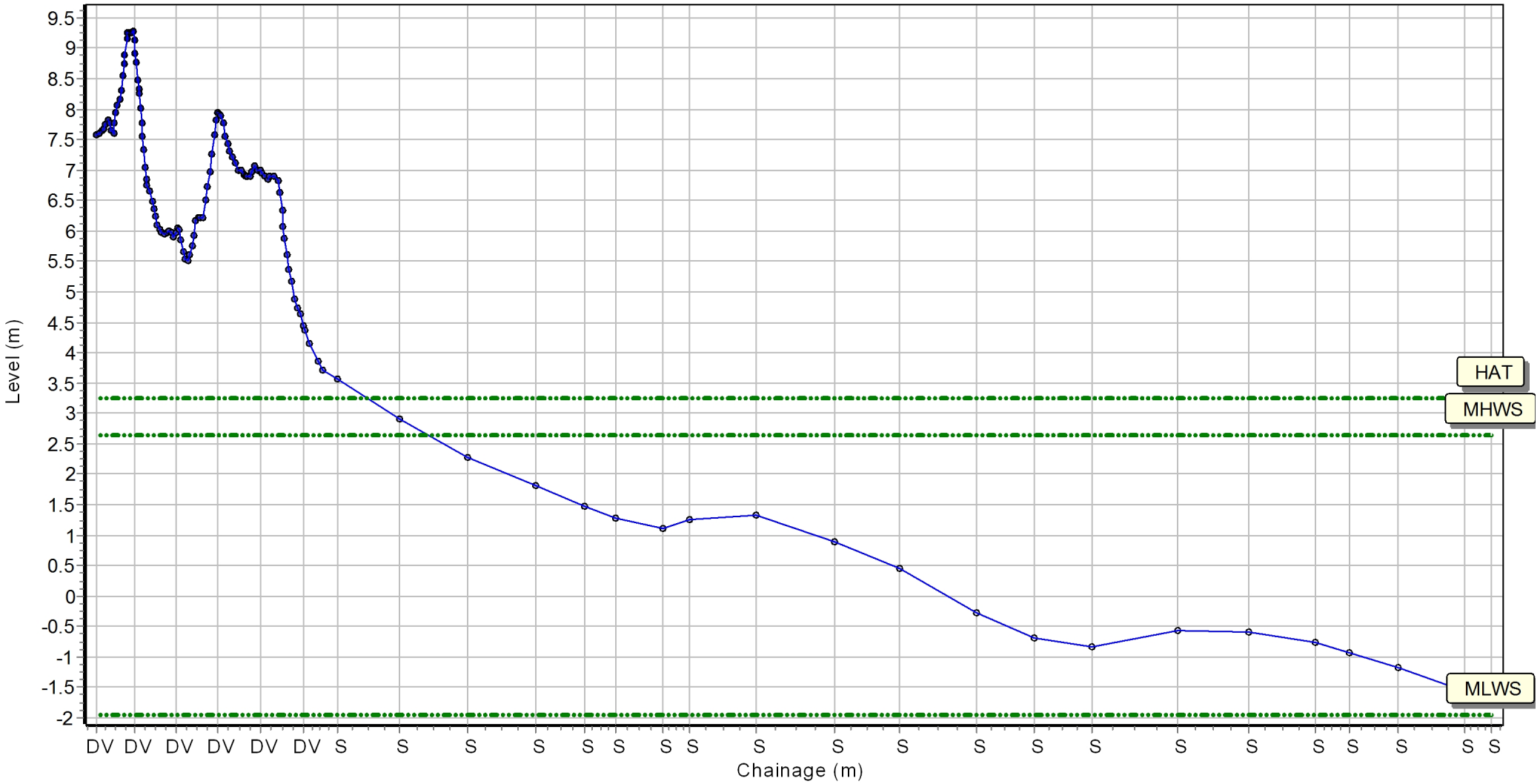
Location: **1cRC3**

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 457706.365 **Northing:** 525898.597 **Profile Bearing:** 28 ° from North



Beach Profile

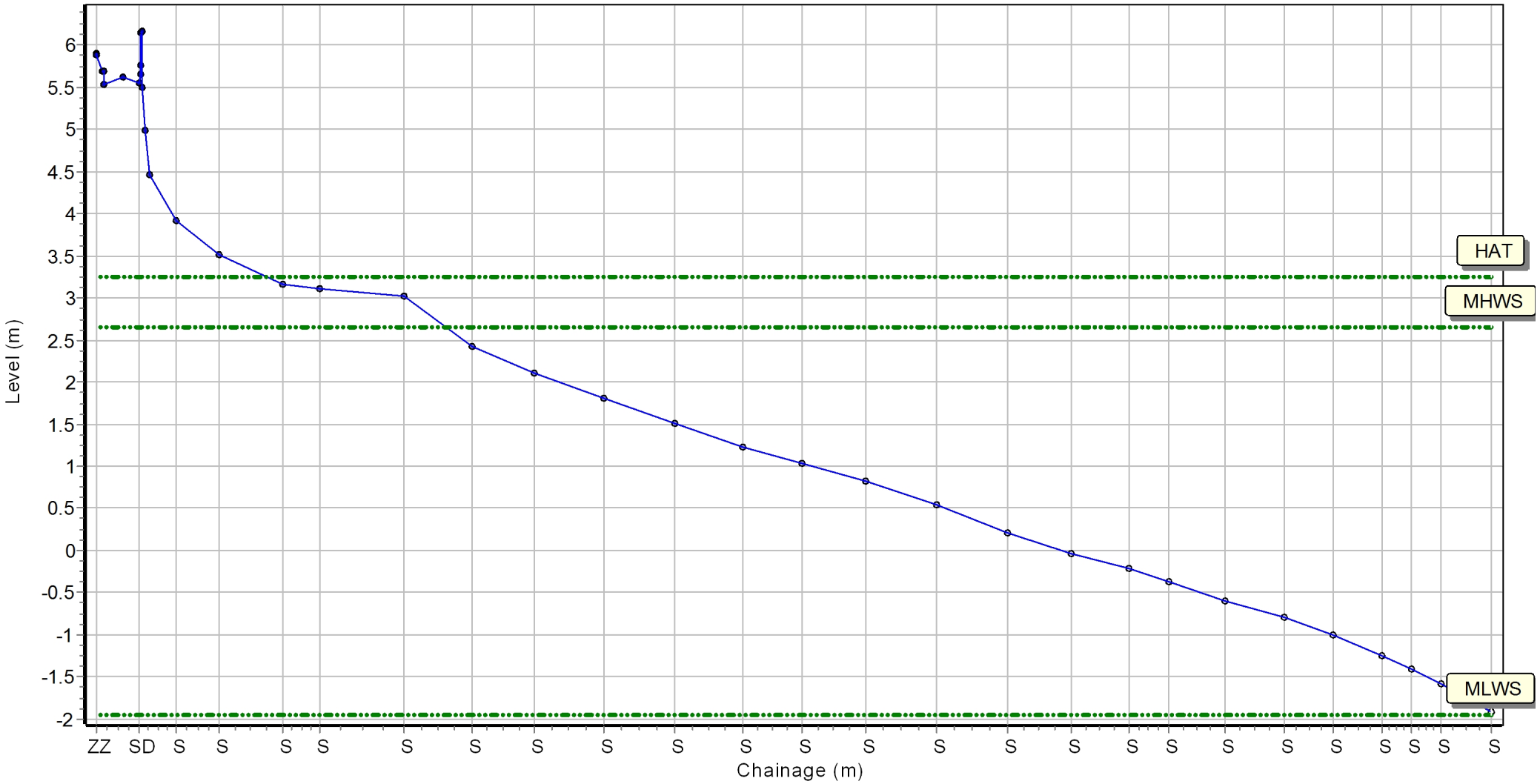
Location: **1cRC4**

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 459337.597 **Northing:** 525336.99 **Profile Bearing:** 13 ° from North



Beach Profile

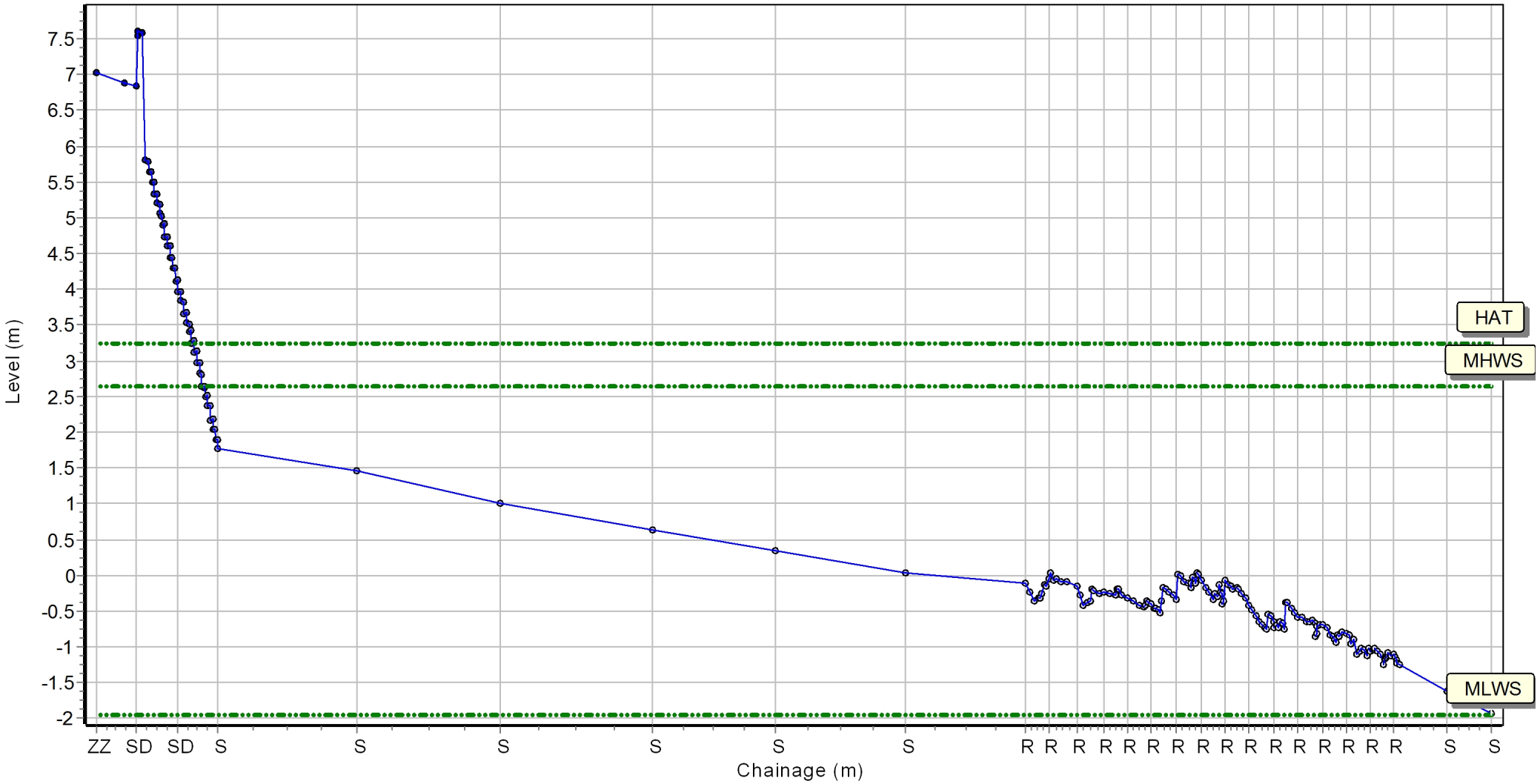
Location: **1cRC5**

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 460845.21 **Northing:** 525146.997 **Profile Bearing:** 26 ° from North



Beach Profile

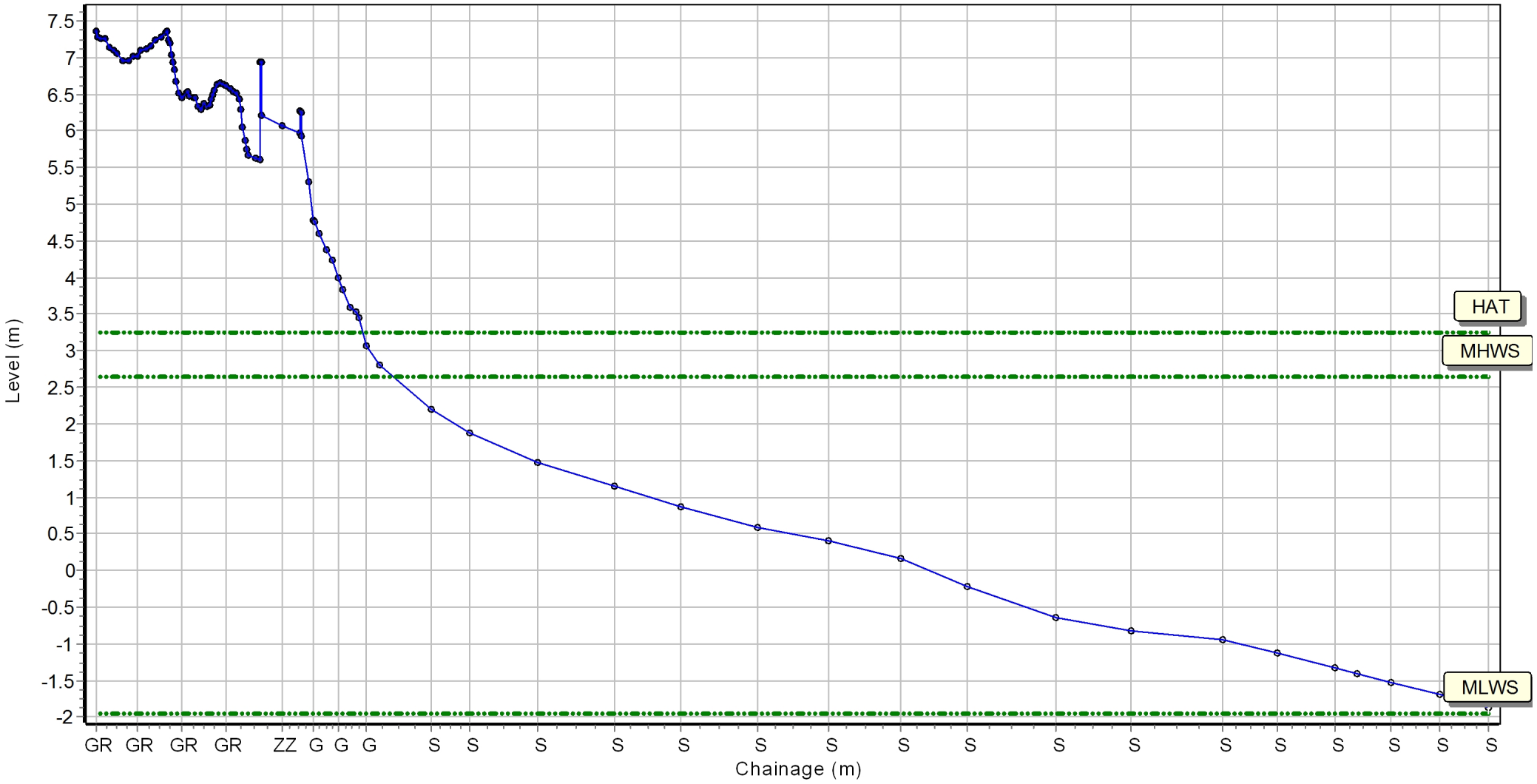
Location: **1cRC6**

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 461776.835 **Northing:** 524269.592 **Profile Bearing:** 39 ° from North



Beach Profile

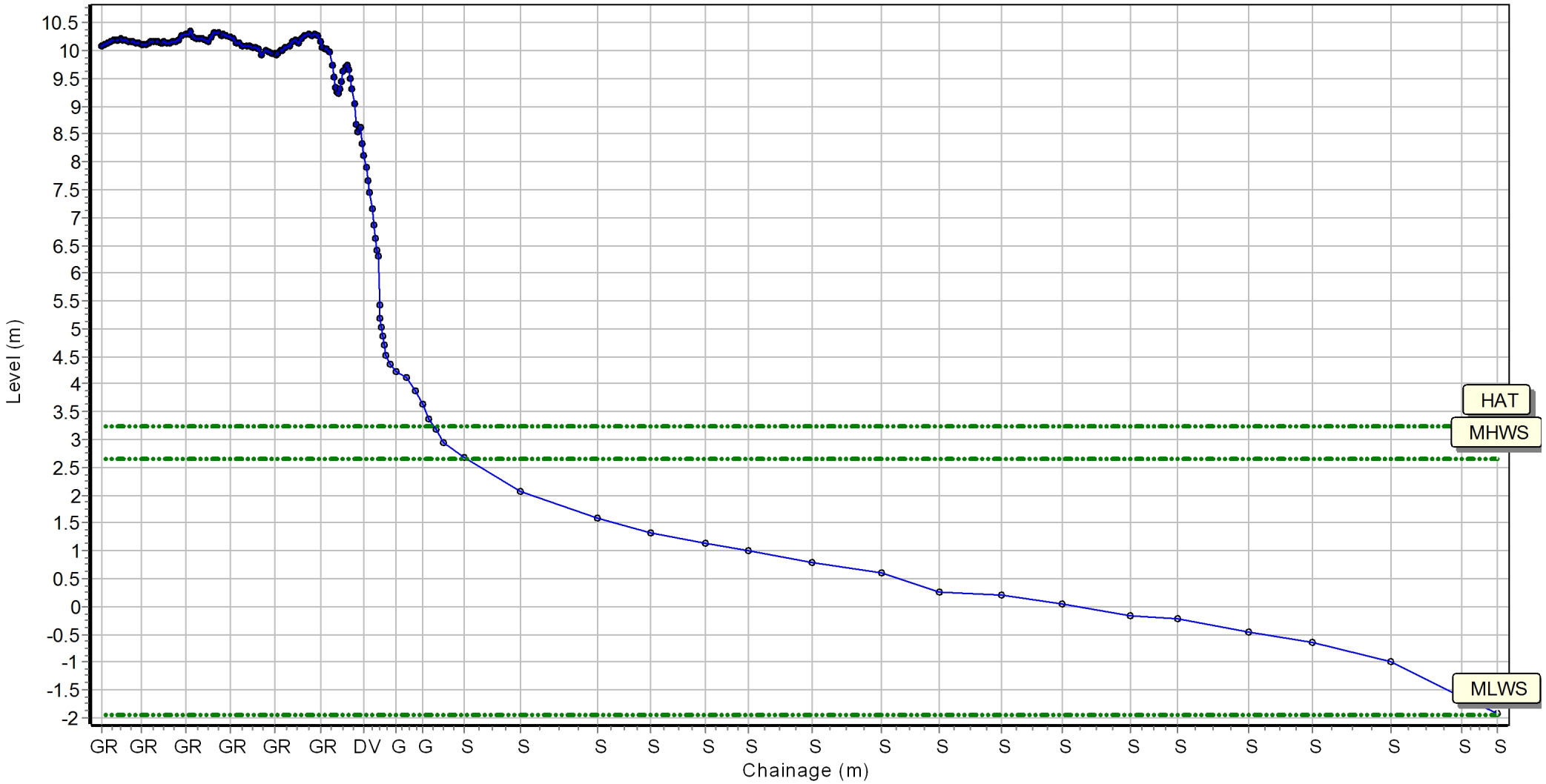
Location: **1cRC7**

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 462568.453 **Northing:** 523568.436 **Profile Bearing:** 37 ° from North



Beach Profile

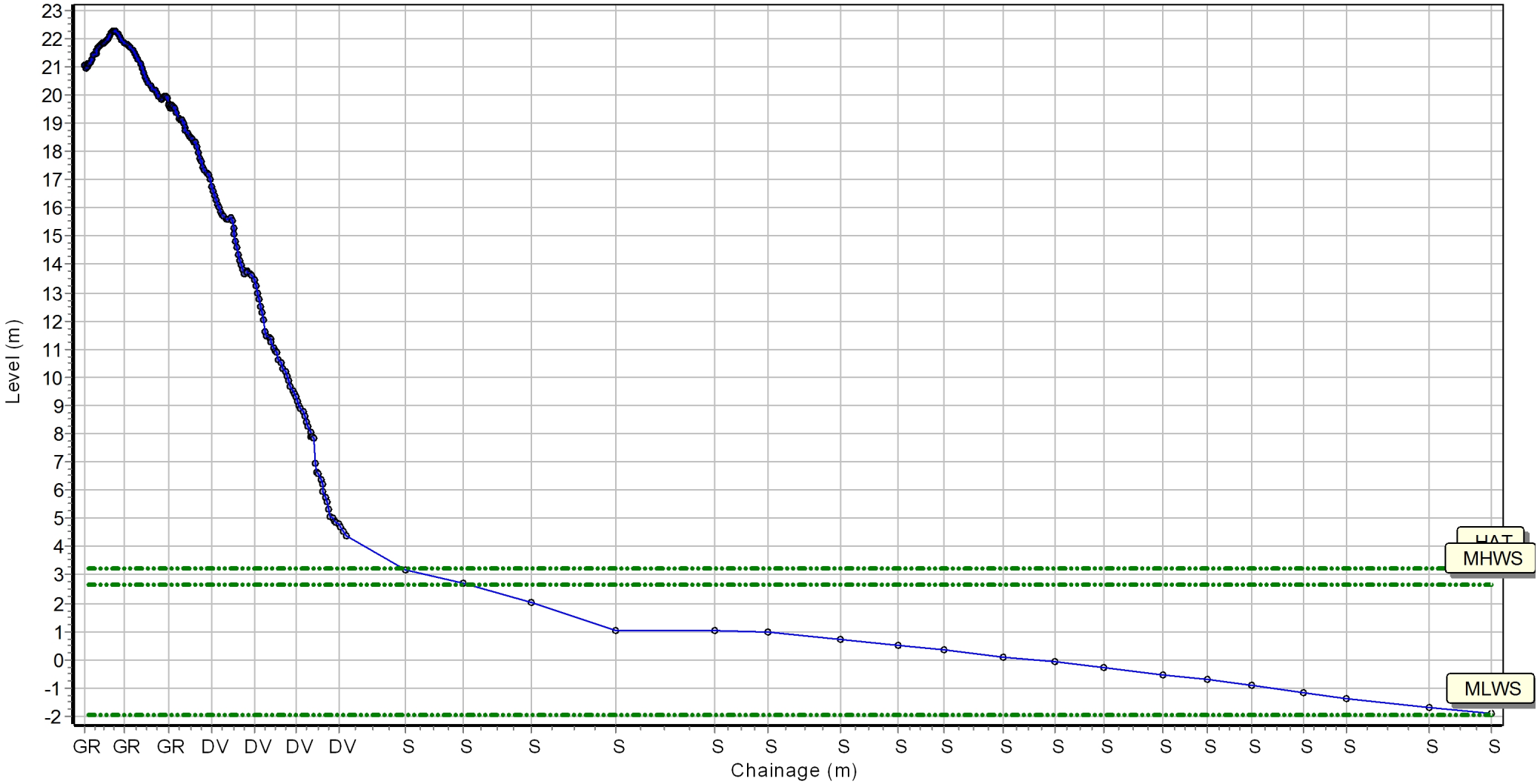
Location: **1cRC8**

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 464245.579 **Northing:** 522578.097 **Profile Bearing:** 28 ° from North



Beach Profile

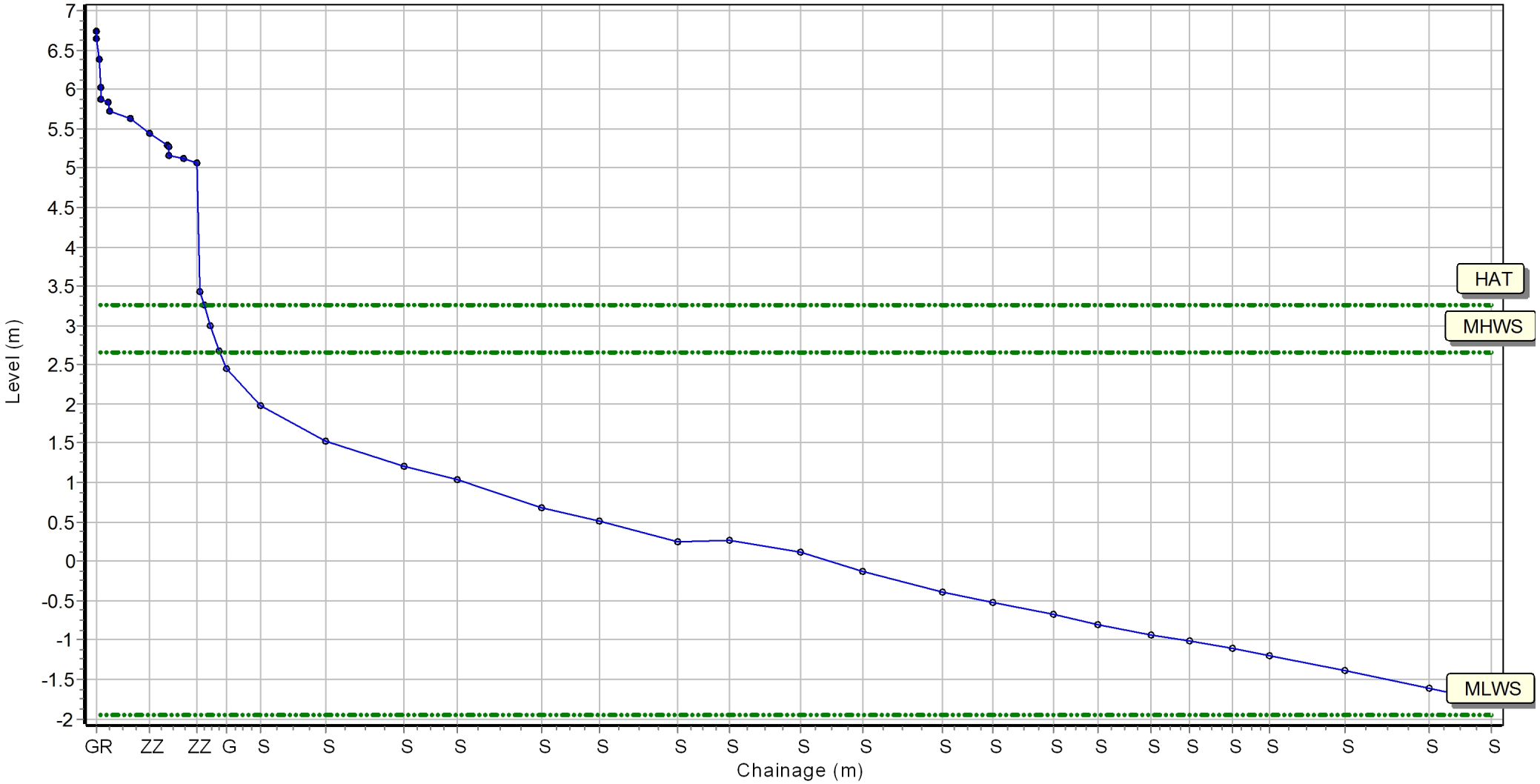
Location: **1cRC9**

Date: 07/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2016 Full Measures Topo Survey

Easting: 466477.532 **Northing:** 521748.87 **Profile Bearing:** 22 ° from North

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30/10/2015
07/04/2016
07/10/2016
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MHWS
MLWS
SANDS
Level (m)
Chainage (m)
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6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
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0
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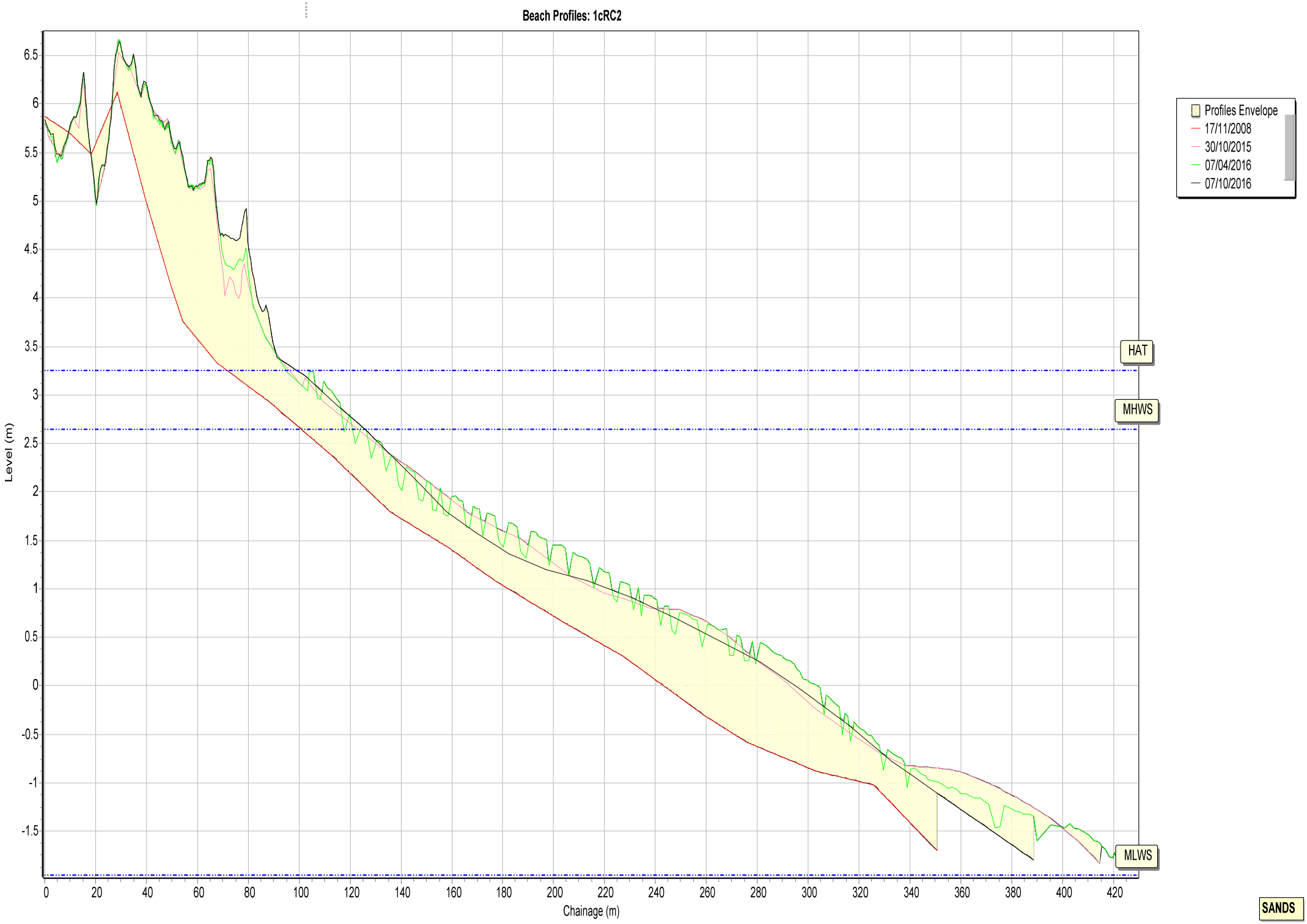
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30/10/2015
07/04/2016
07/10/2016
HAT
MHWS
MLWS
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Level (m)
Chainage (m)
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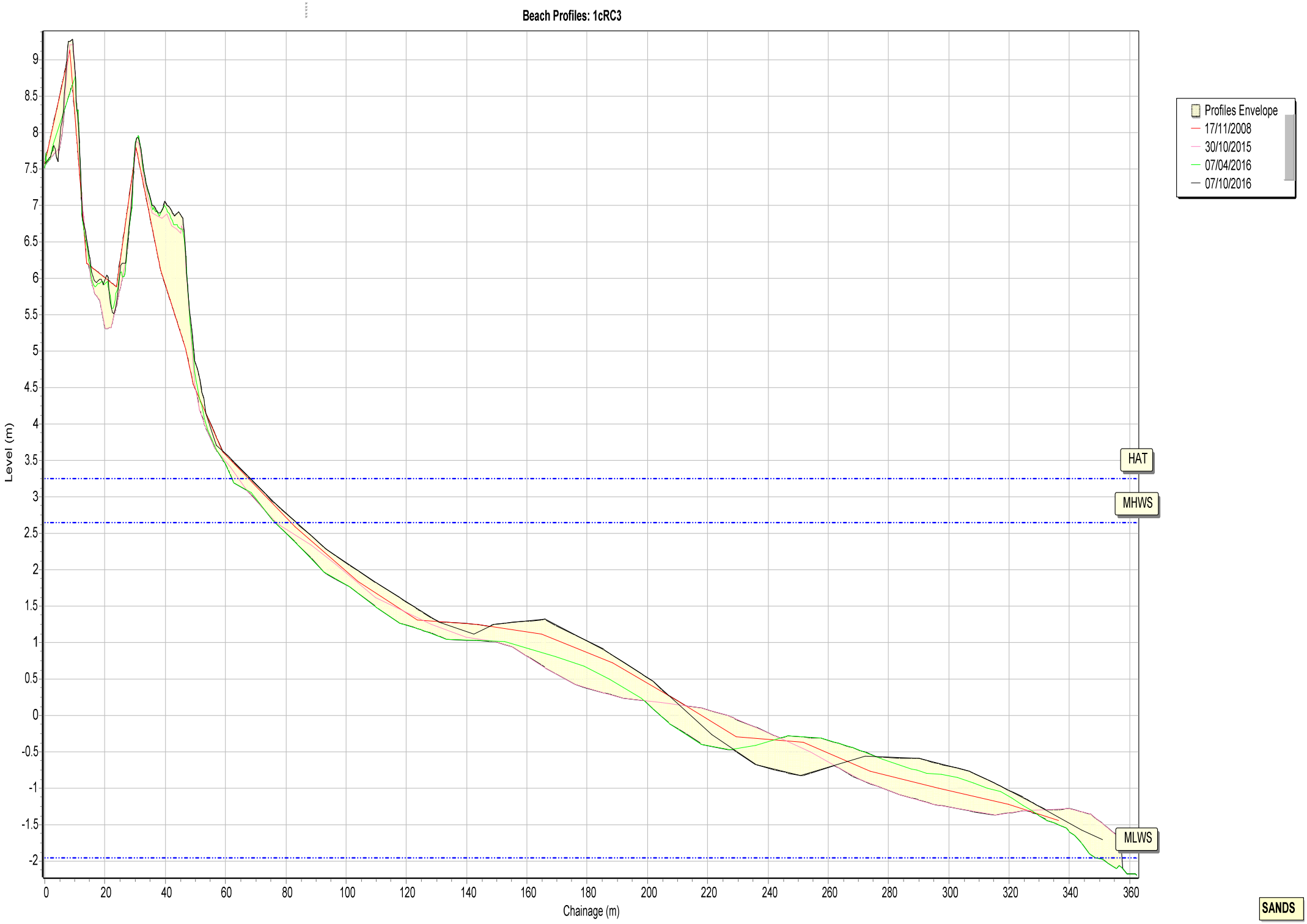
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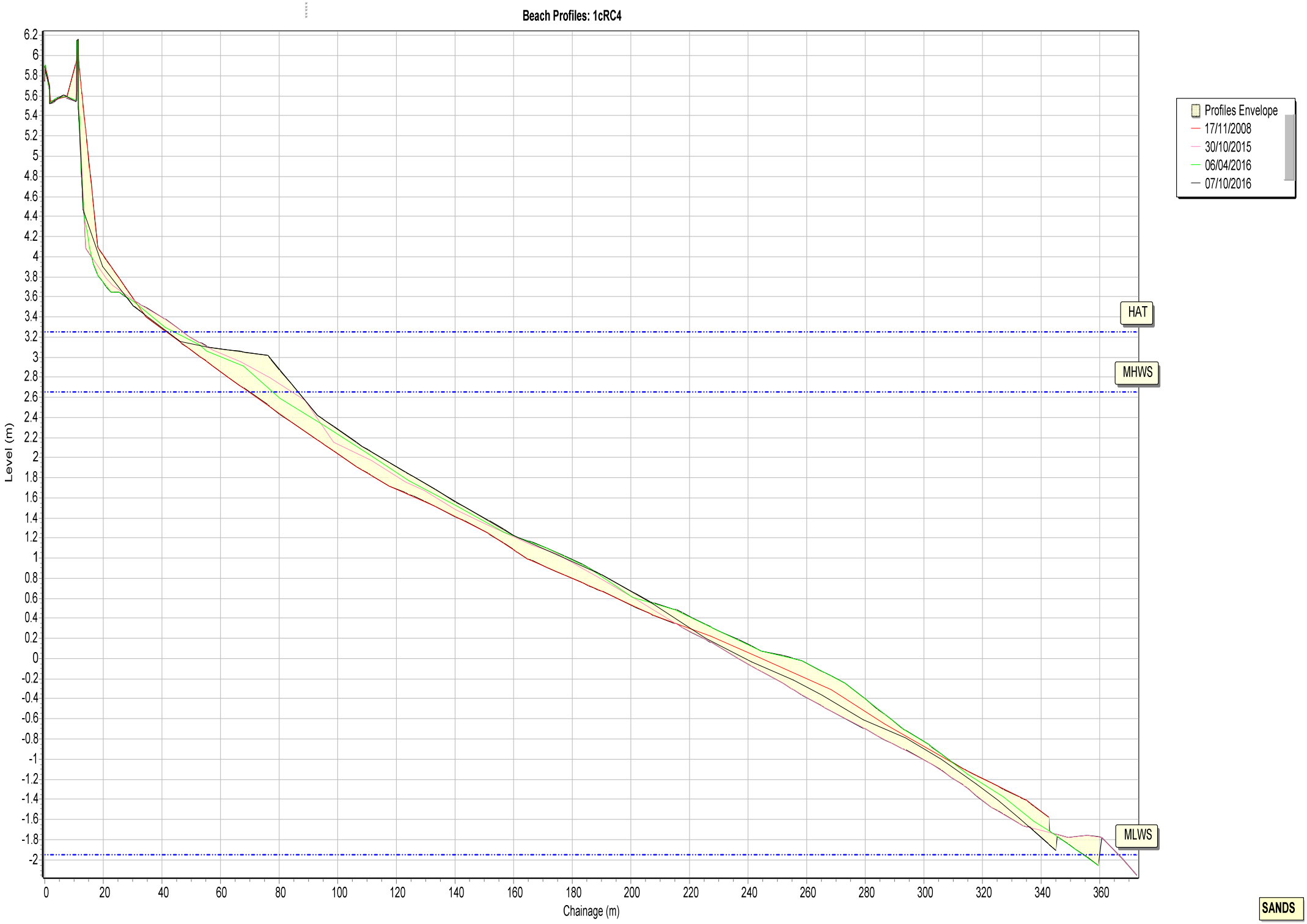
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Chainage (m)
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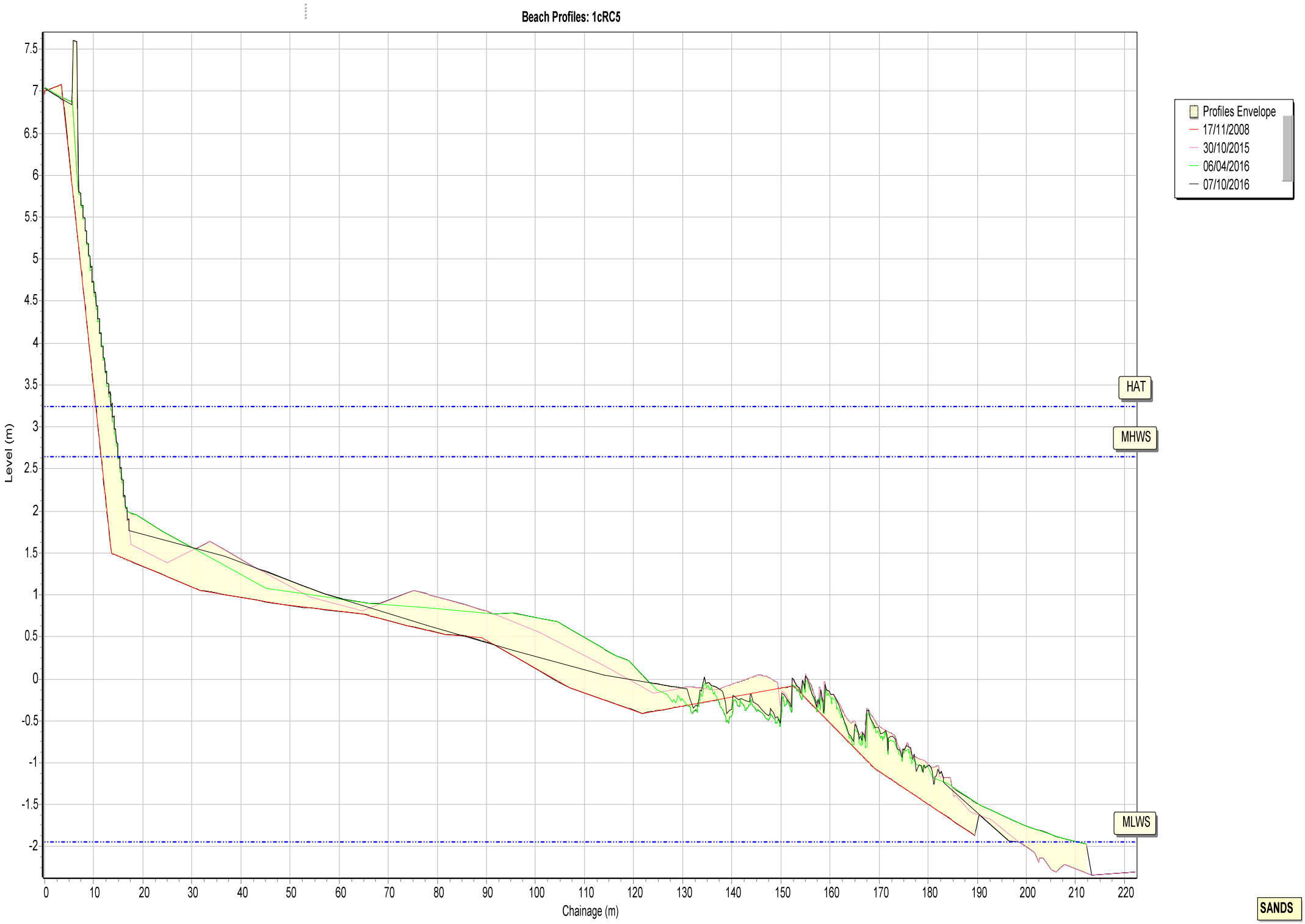
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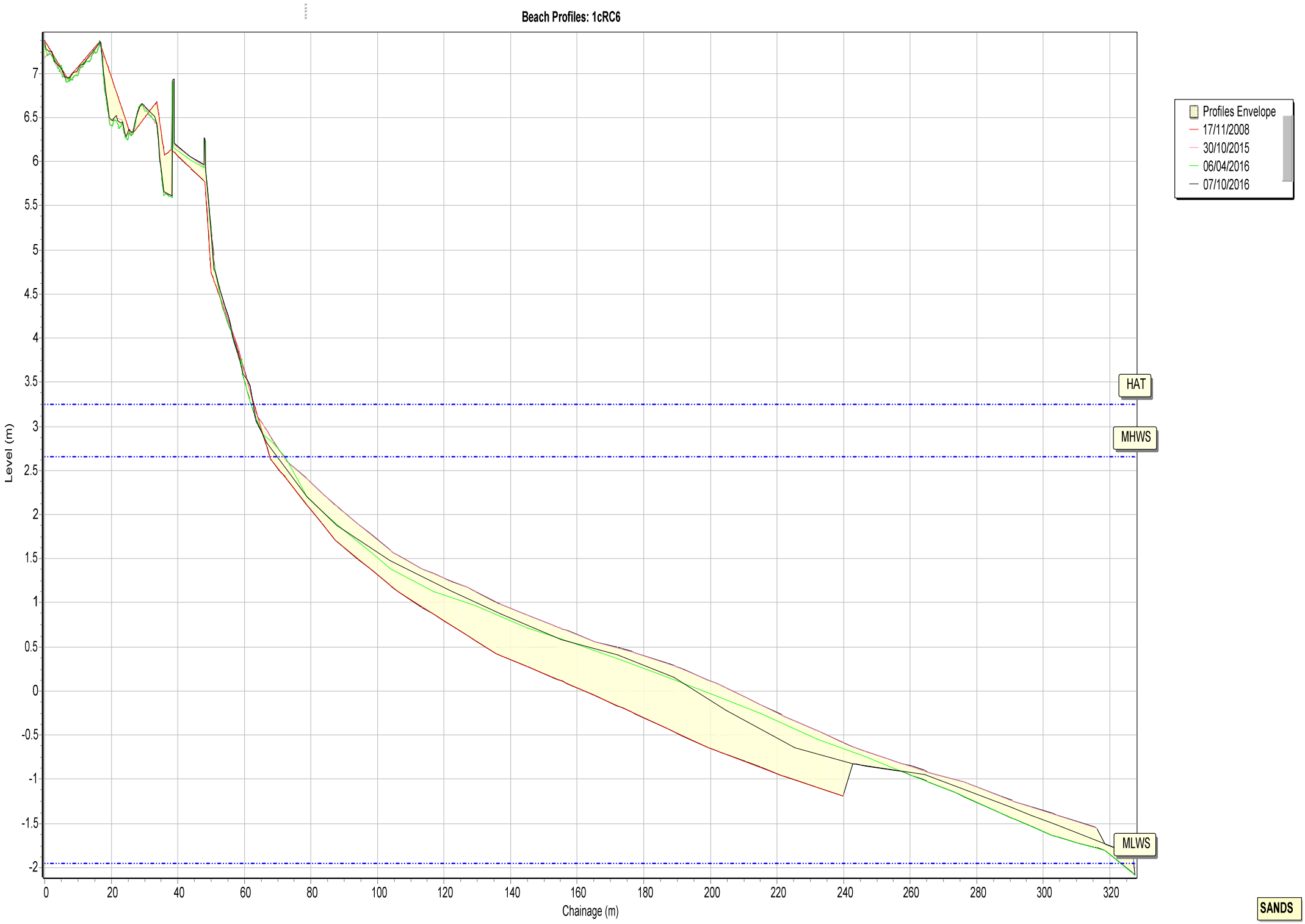
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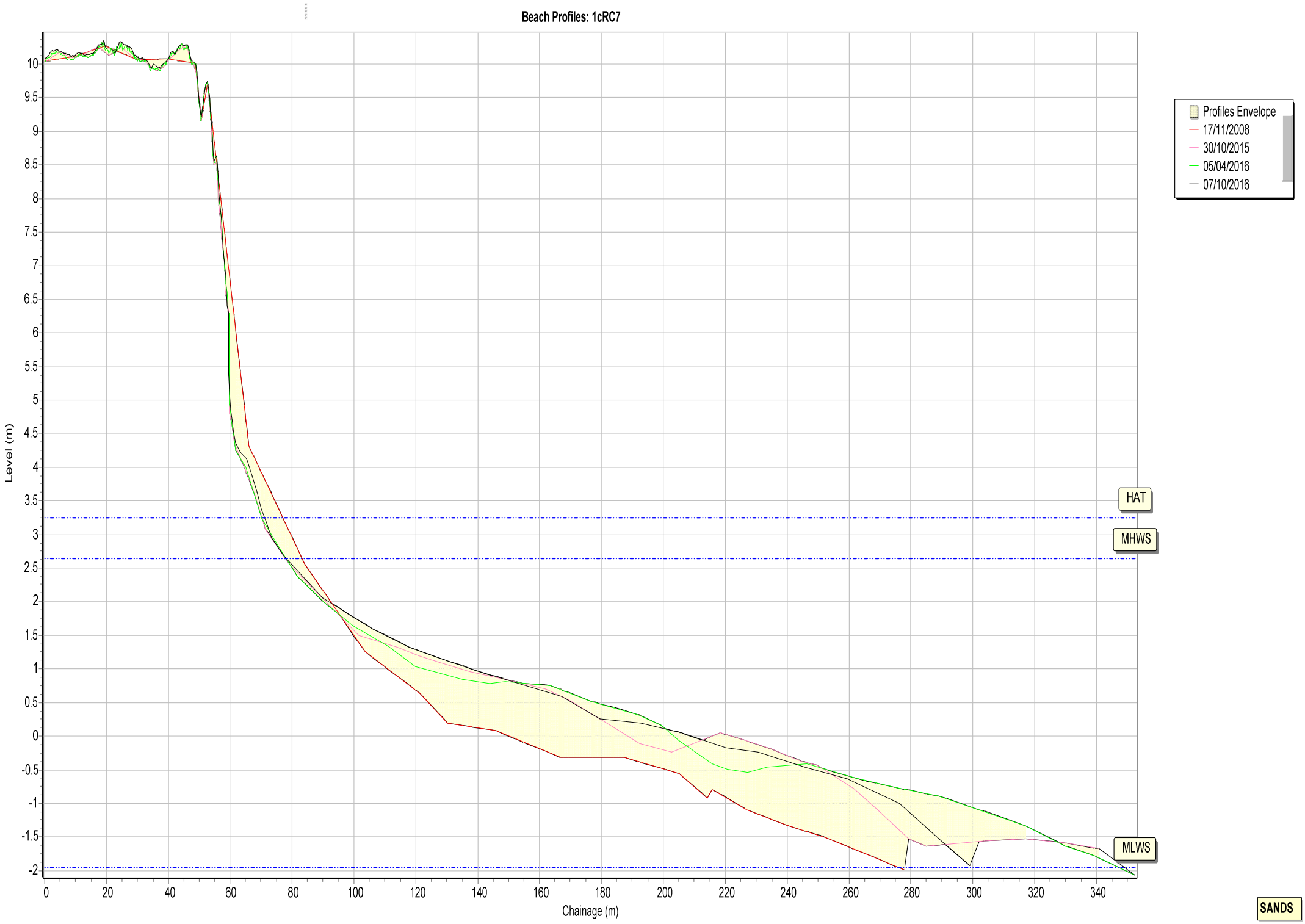
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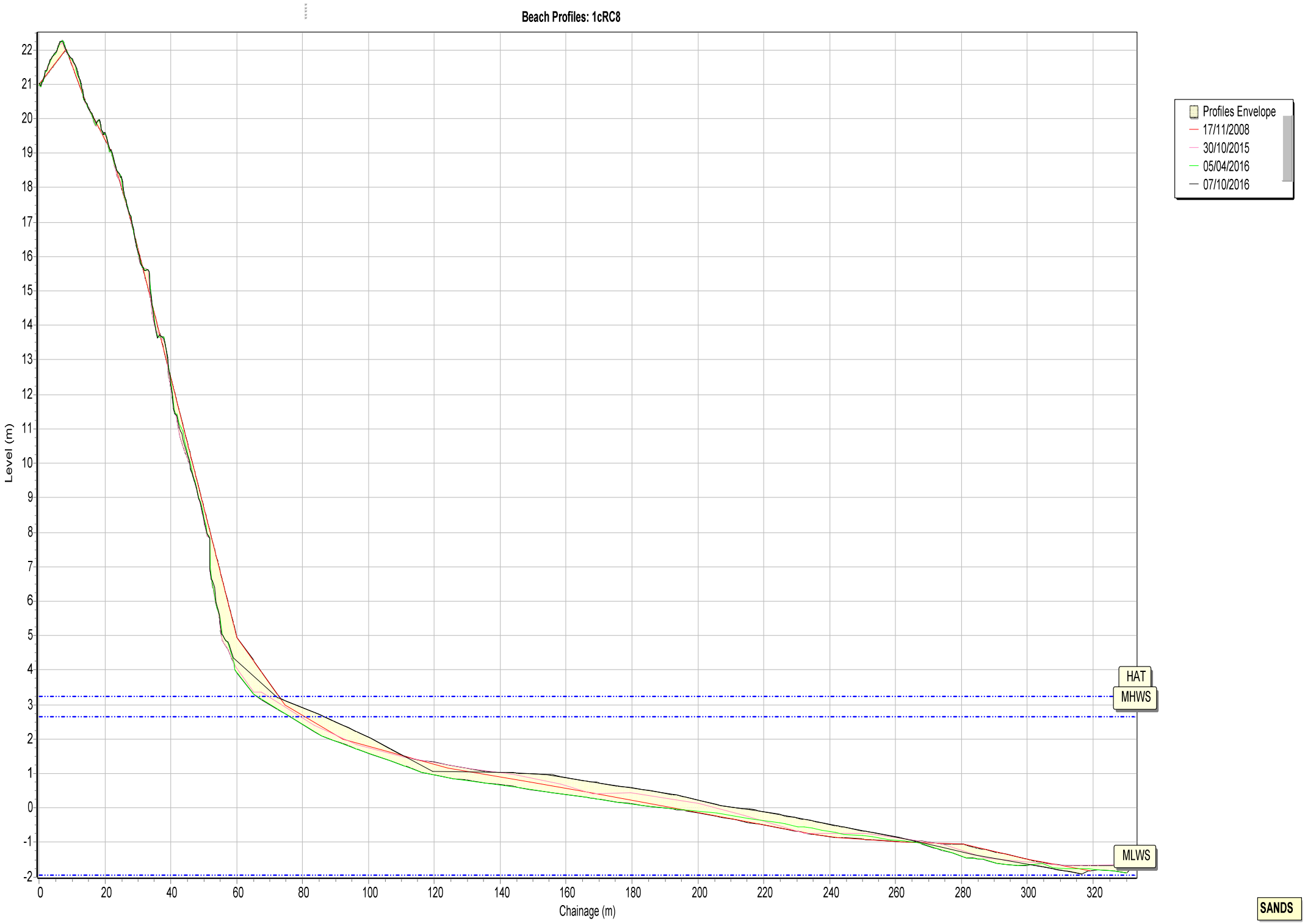
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Chainage (m)
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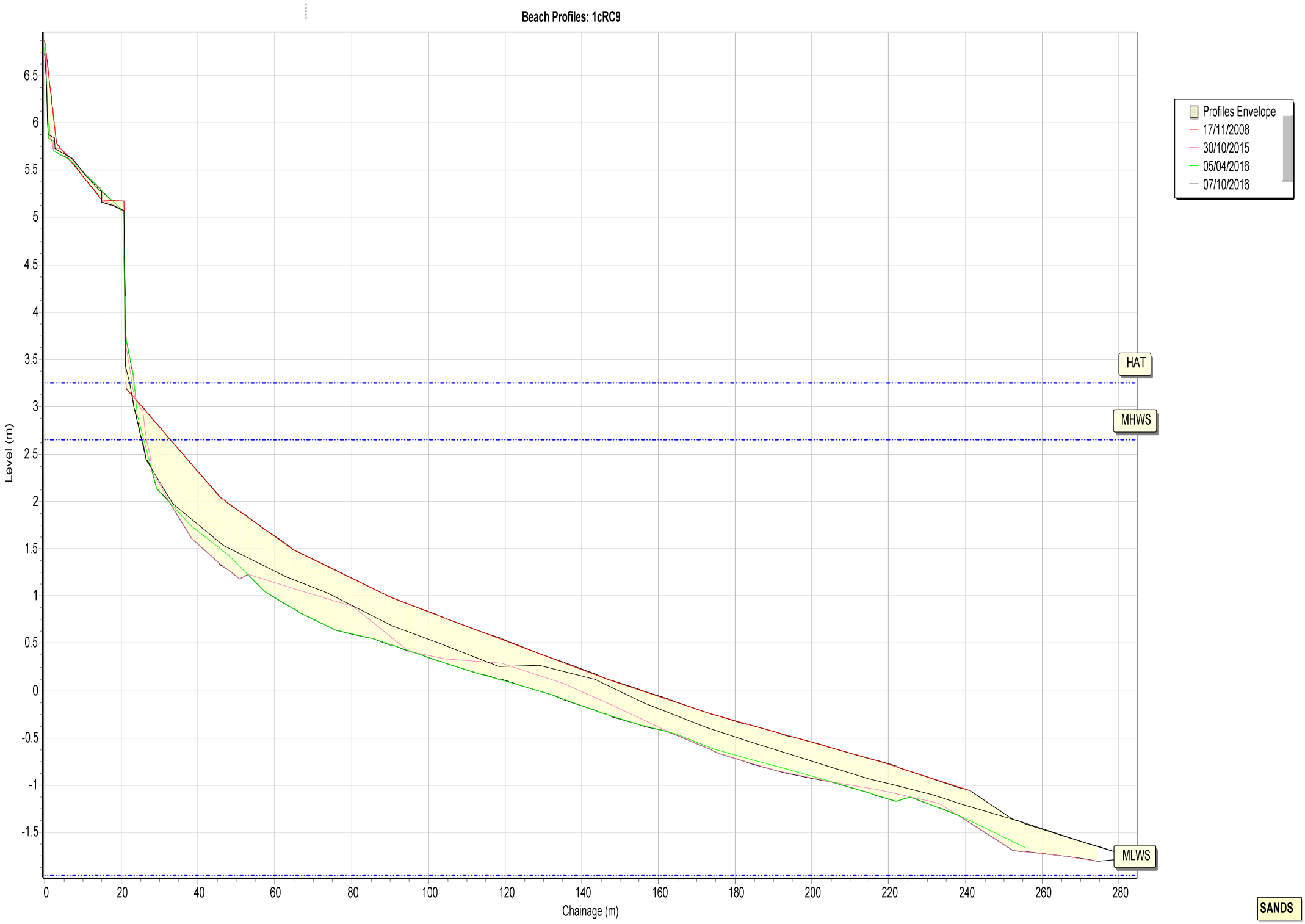
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Chainage (m)
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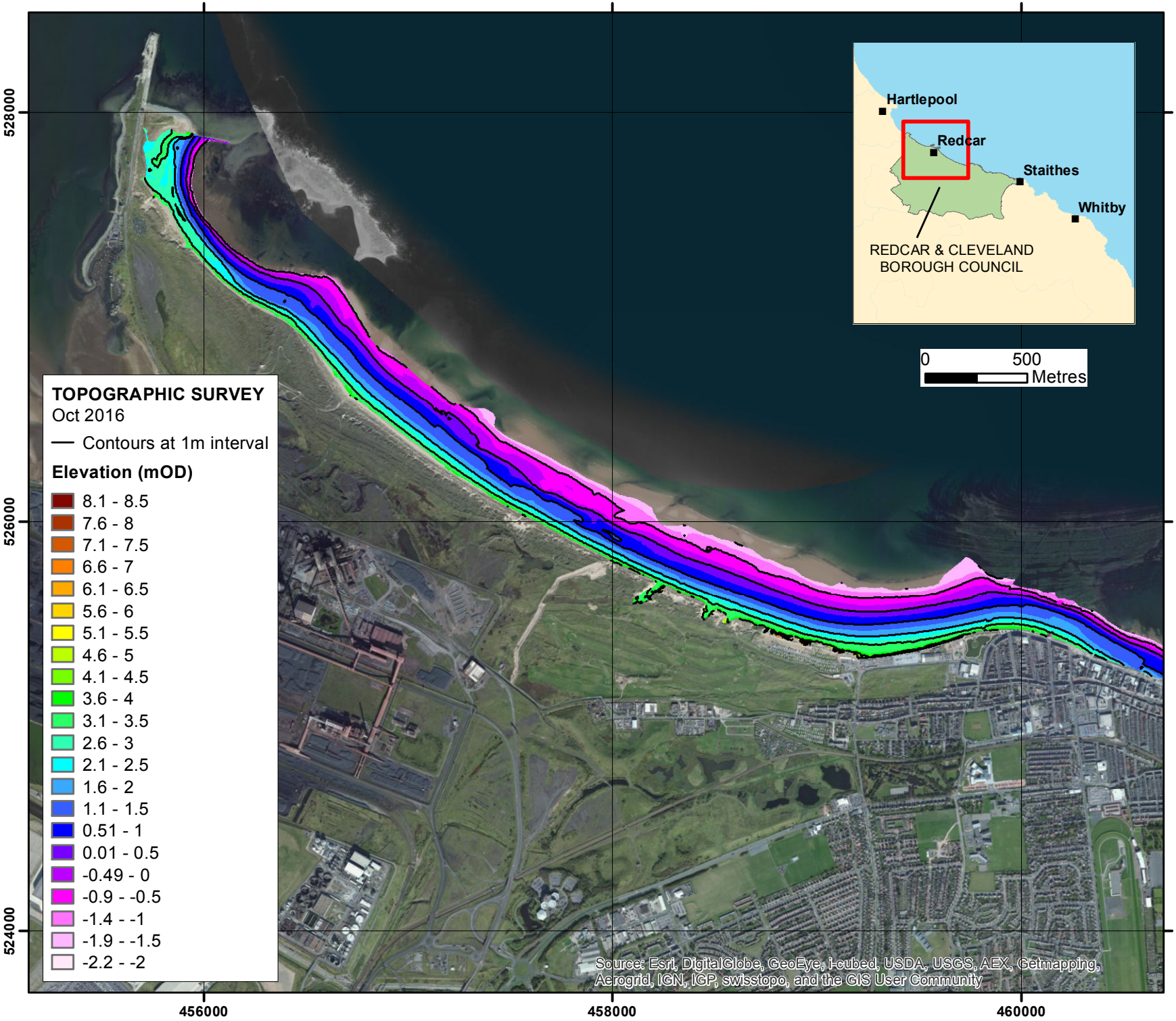
280

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

Code	Description
S	Sand
M	Mud
G	Gravel
GS	Gravel & Sand
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Saltmarsh
W	Water Body
GM	Gravel & Mud
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
ZZ	Unknown

Appendix B

Topographic Survey



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1

COATHAM SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

WATER
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www.royalhaskoningdhv.com

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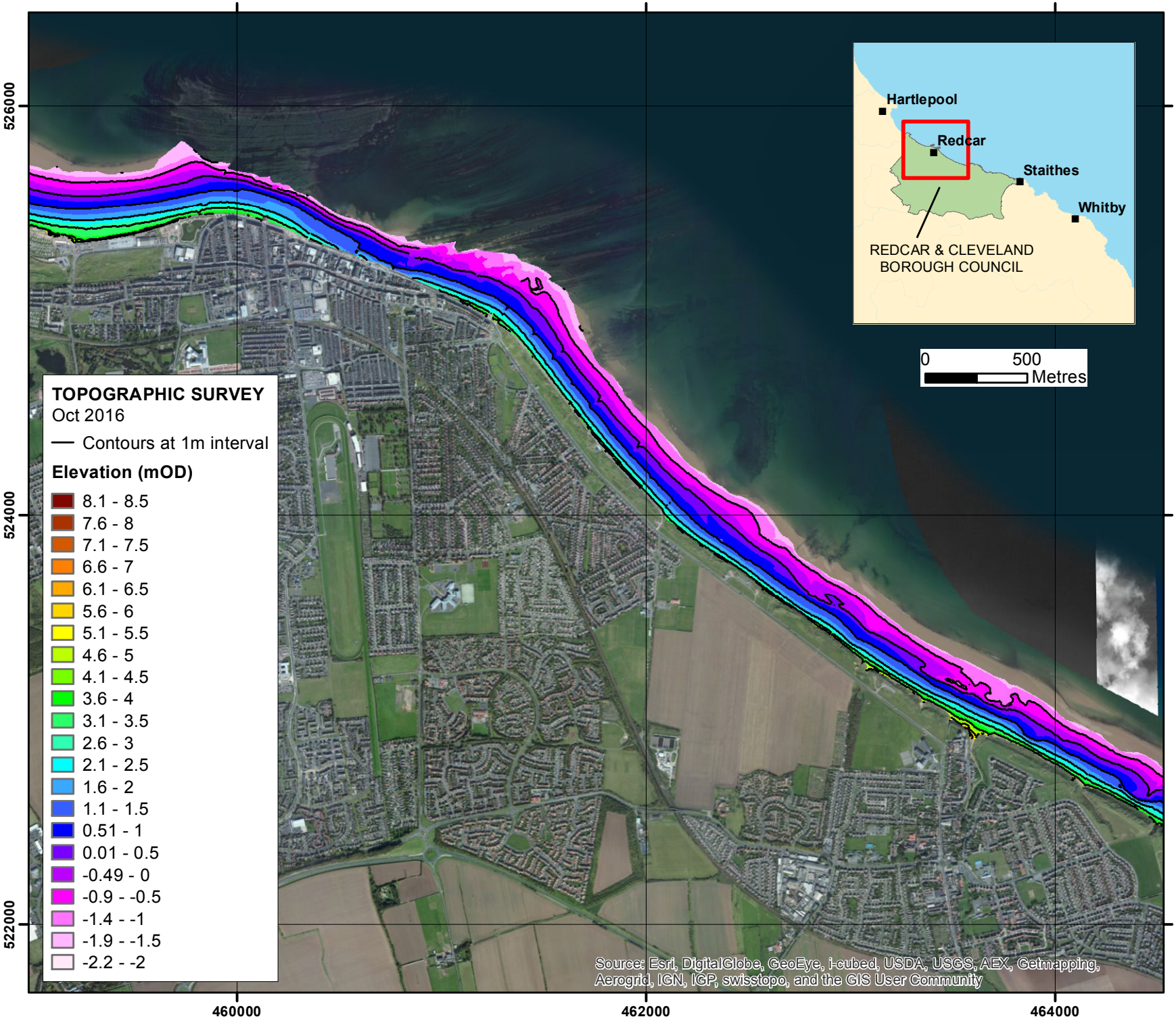

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2

REDCAR/MARSKE SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

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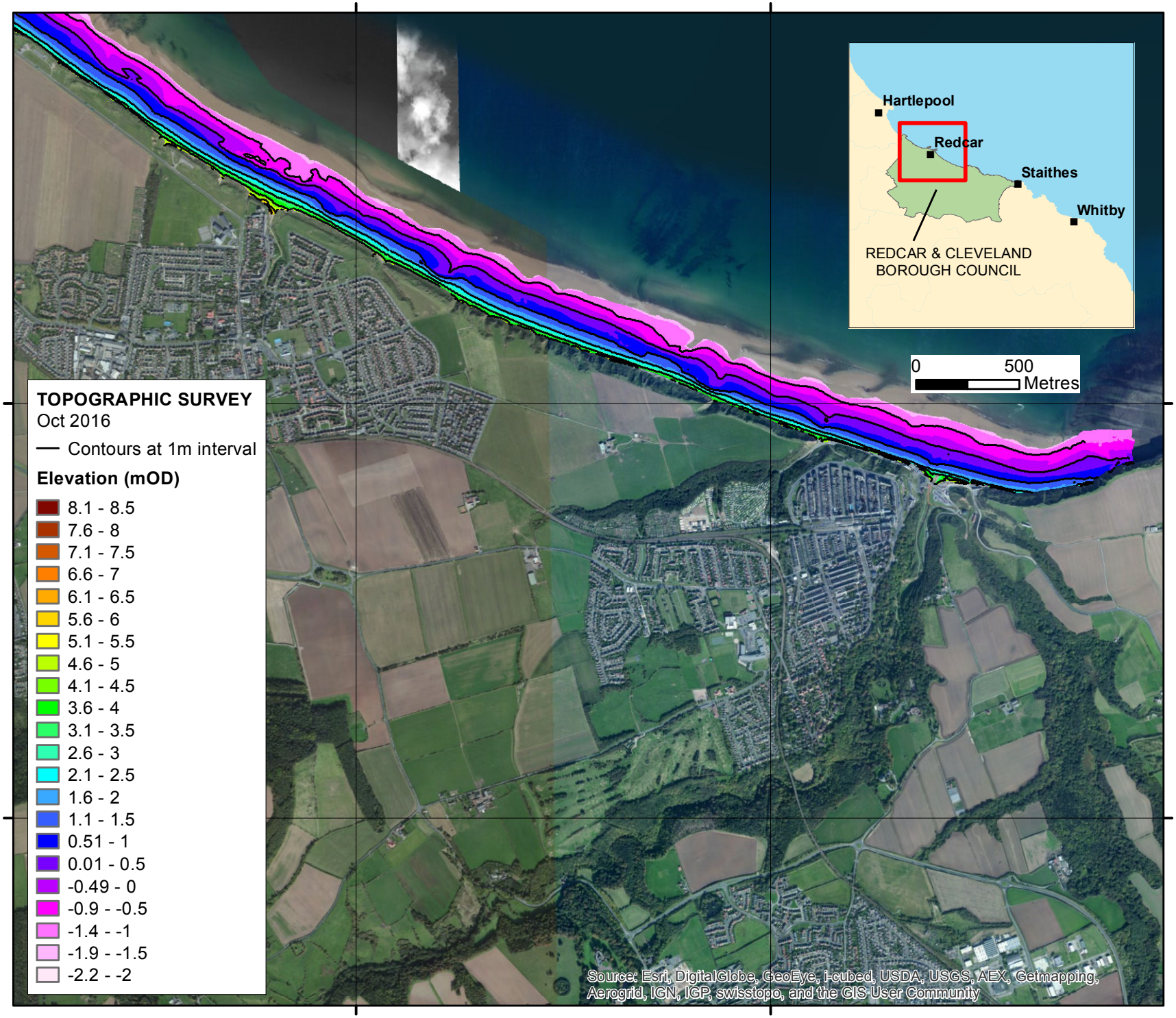

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3

MARSKE/ SALTBURN SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

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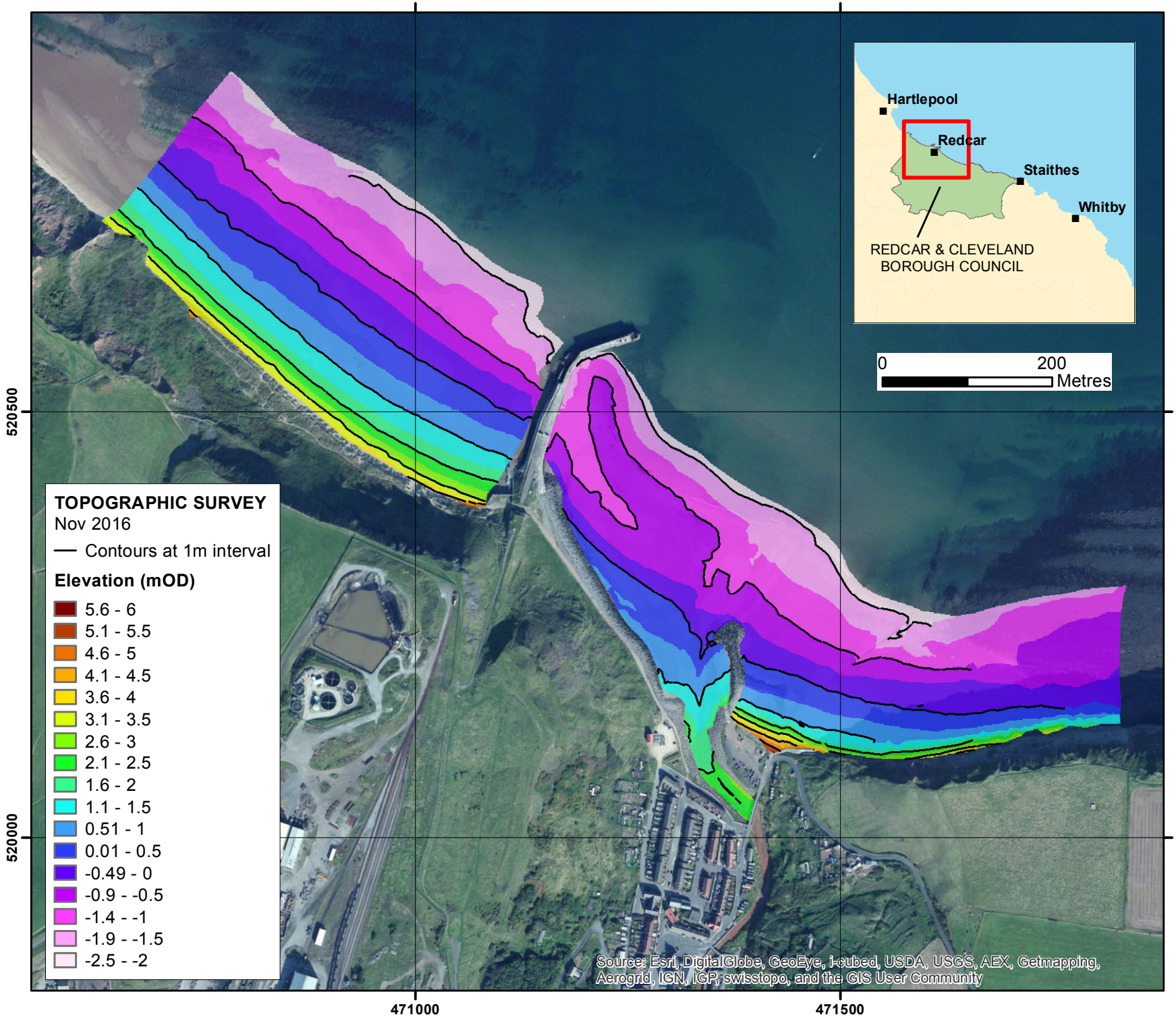

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4

CATTERSTY SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:6,000

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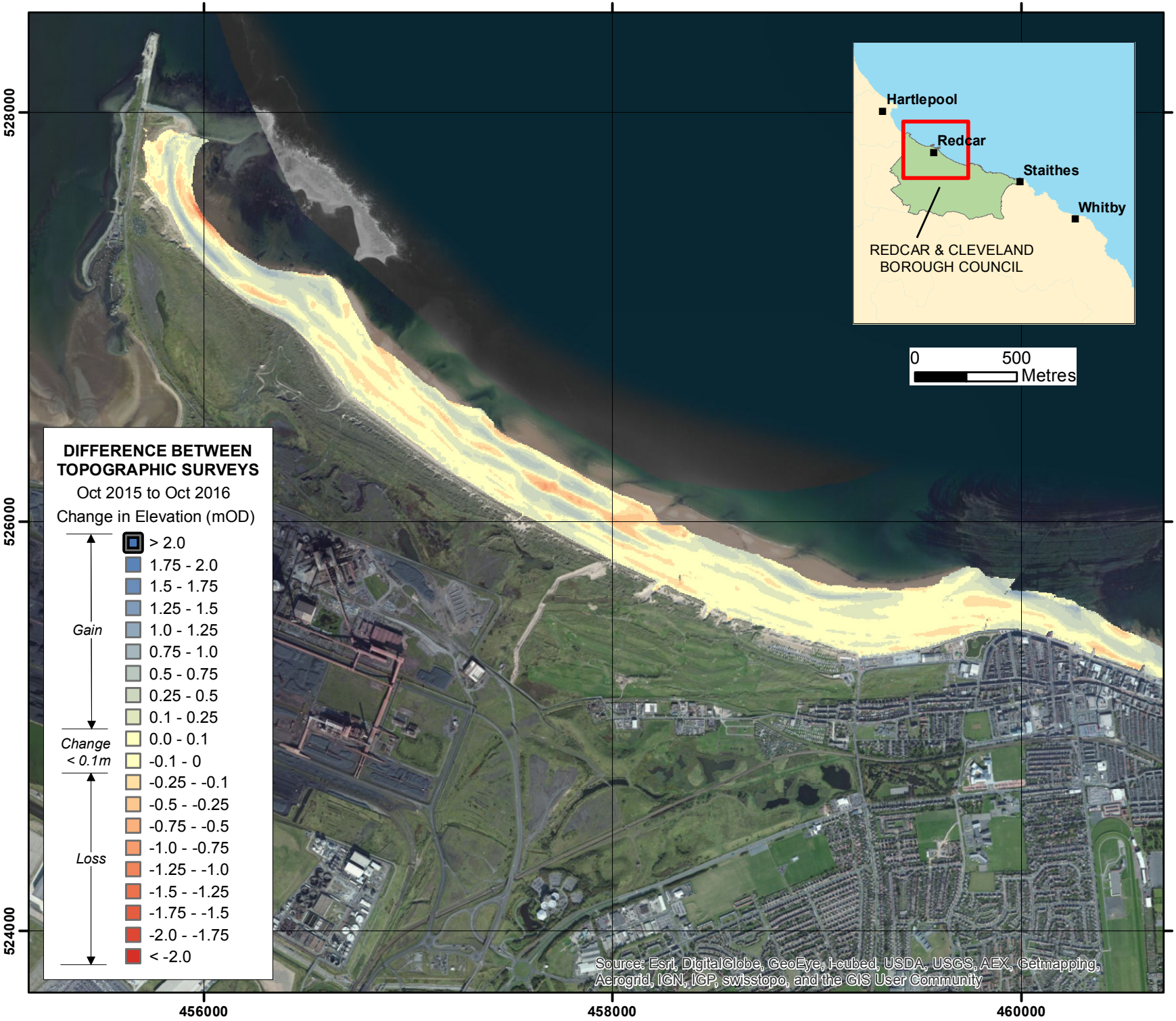

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 5

COATHAM SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

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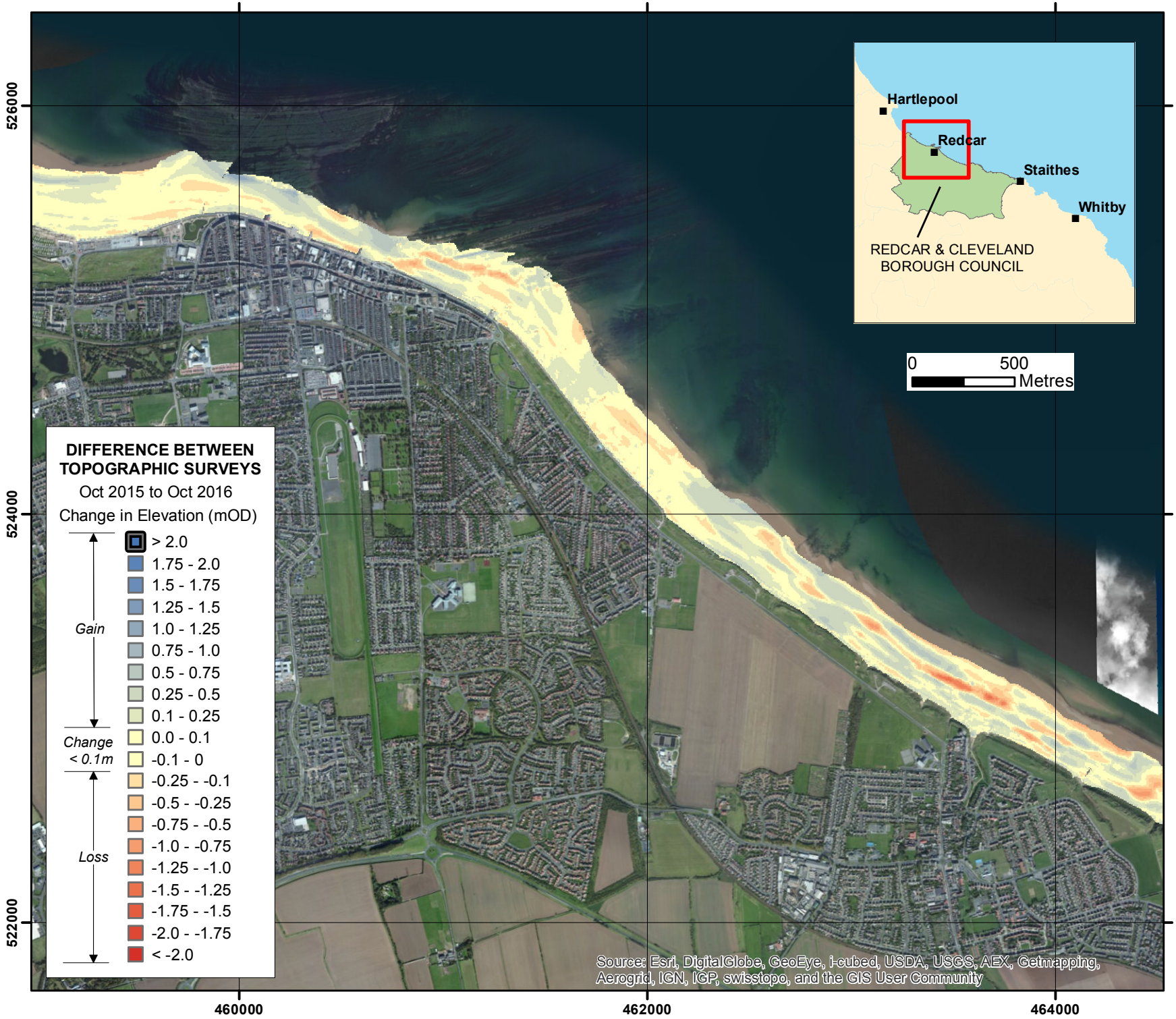

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 6

REDCAR/MARSKE SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

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Marlborough Crescent
Newcastle upon Tyne
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Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

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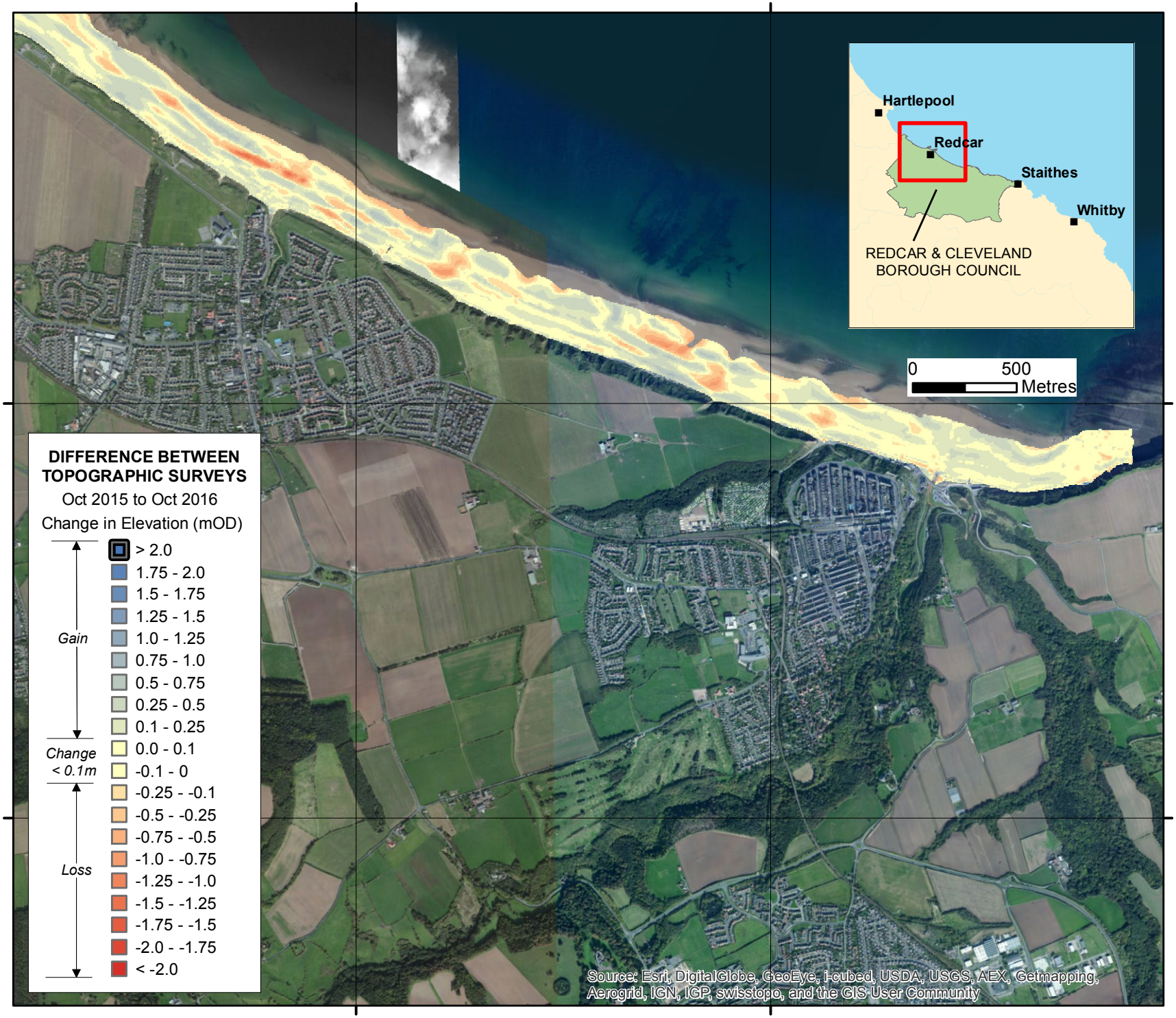

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 7

MARSKE/ SALTBURN SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

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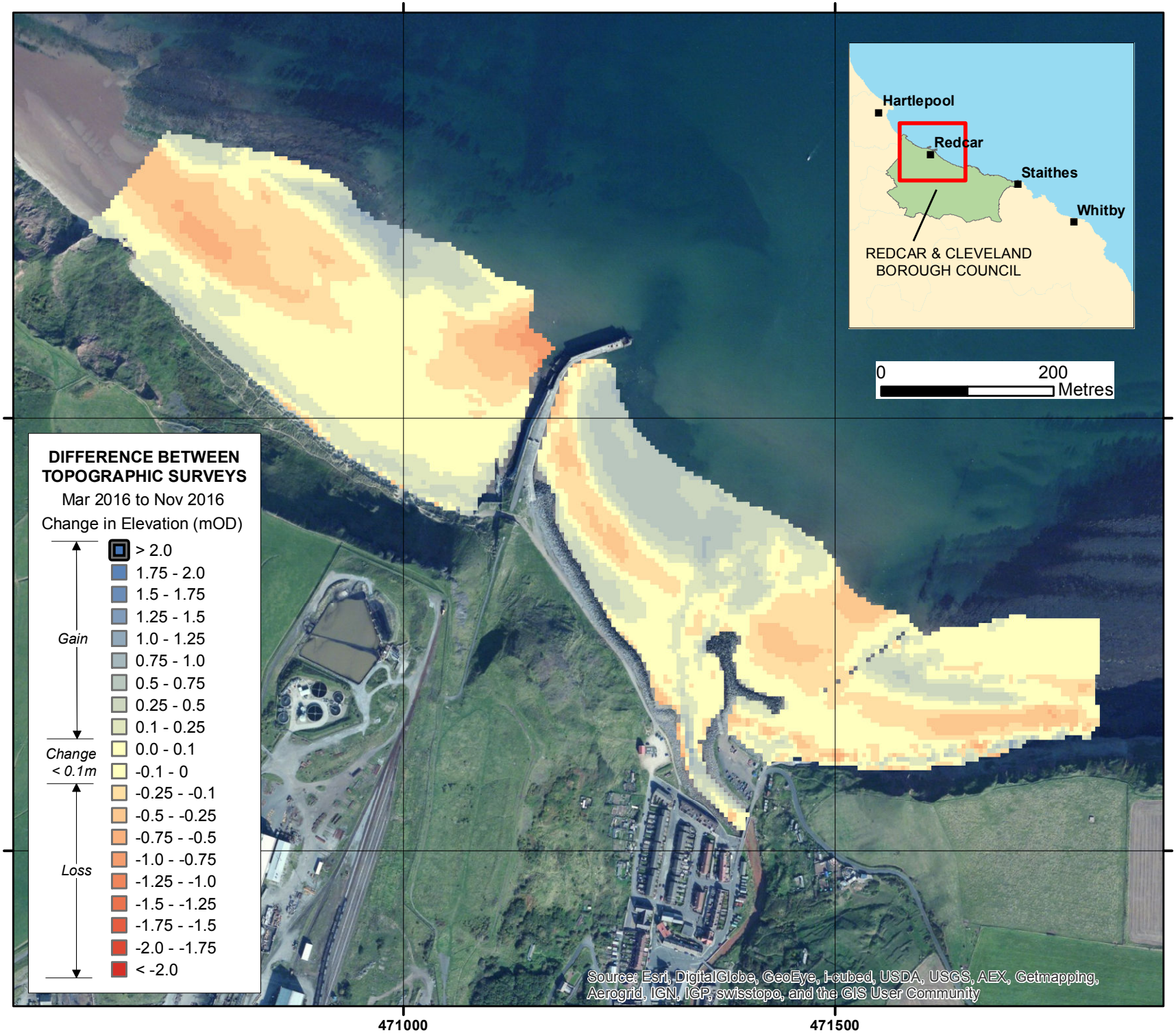

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 8

CATTERSTY SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:6,000

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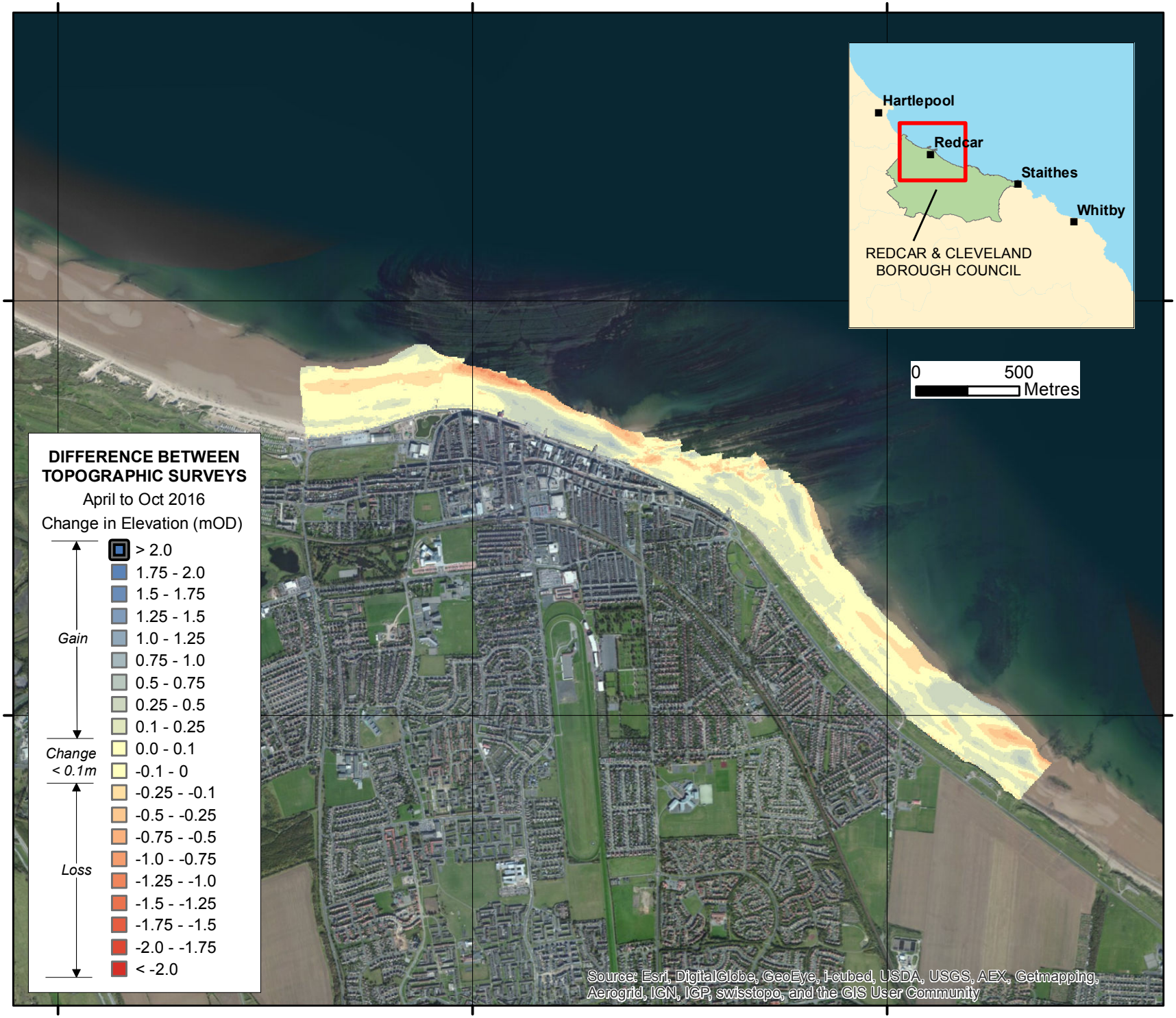

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 9

REDCAR SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

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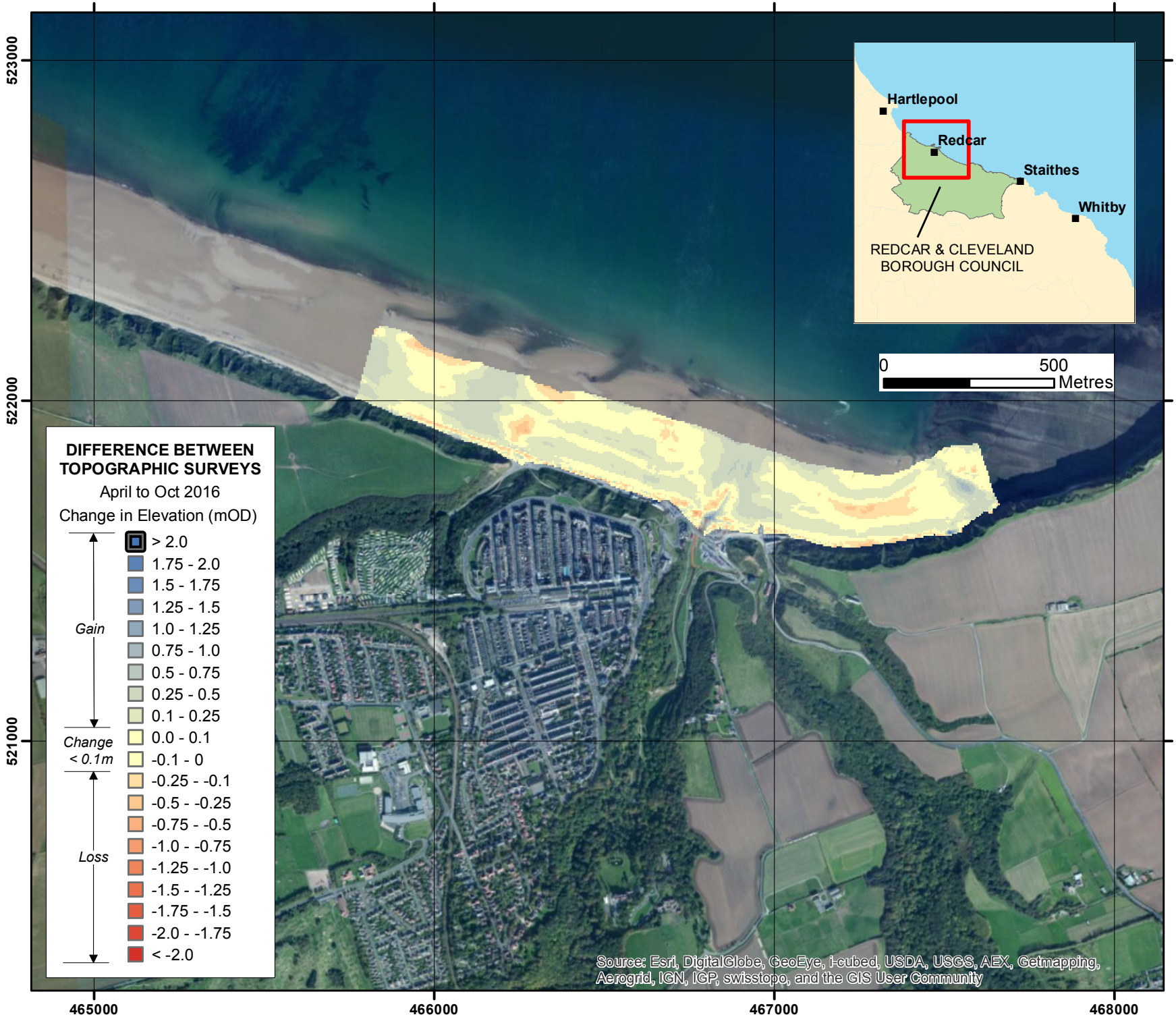

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 10

SALTBURN SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:15,000

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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
			(°)	Nov 2008	April 2016	Sept 2016	Nov 2008 - Sep 2016	Apr 2016 - Sep 2016	Nov 2008 - Sep 2016
1	477228	518769	320	1.9	1.6	1.62	0.28	-0.02	0.04
2	477334	518798	0	10.9	10.8	10.73	0.17	0.07	0.02
3	477487	518789	350	7.1	8.4	8.14	-1.04	0.26	0.00
4	477594	518801	340	5.9	4.5	4.48	1.42	0.02	0.20
5	477683	518911	350	8.4	8.5	8.75	-0.35	-0.25	0.00
6	477792	518867	30	8.6	8.6	8.39	0.21	0.21	0.03
7	477891	518828	60	7.7	7.6	7.31	0.39	0.29	0.06
8	477959	518873	350	8.7	9.7	9.6	-0.90	0.10	0.00
9	478088	518950	350	7.6	8.1	No Access	-0.50		0.00
10	478191	519023	340	8.4	8.8	No Access	-0.40		0.00
11	478237	519007	60	6.9	6.7	No Access	0.20		0.03
12	478213	518988	150	6.1	7.4	No Access	-1.30		0.00

13	478501	518809	15	11.4	9.2	9.07	2.33	0.13	0.33
14	478624	518807	20	7.5	7.5	7.44	0.06	0.06	0.01
15	478737	518858	60	6.1	6.3	6.33	-0.23	-0.03	0.00
16	478823	518757	60	8	8.6	8.58	-0.58	0.02	0.00
17	478944	518671	30	9.3	9.2	9.24	0.06	-0.04	0.01
18	479052	518630	20	9.2	8.7	8.87	0.33	-0.17	0.05
19	479147	518610	0	14.2	13.8	13.79	0.41	0.01	0.06
20	479274	518618	20	11.4	11	11.33	0.07	-0.33	0.01

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. 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.