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Cell 1 Regional Coastal Monitoring Programme
Analytical Report 2: 'Full Measures' Survey 2009

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Scarborough Borough Council
Final Report

March 2010

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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
m	metres
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
MSL	Mean Sea Level
ODN	Ordnance Datum Newlyn

Water Levels Used in Interpretation of Changes

Water Level Parameter	Water Level (m ODN)			
	River Tyne to Frenchman's Bay	Frenchman's Bay to Souter Point	Souter Point to Chourdon Point	Chourdon Point to Hartlepool Headland
1 in 200 year	3.41	3.44	3.66	3.91
HAT	2.85	2.88	3.18	3.30
MHWS	2.15	2.18	2.48	2.70
MLWS	-2.15	-2.12	-1.92	-1.90

Water Level Parameter	Water Level (m ODN)			
	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 ODN)			
	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 inter-tidal 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 till to varying thicknesses, softer rock cliffs, and extensive landslide complexes.

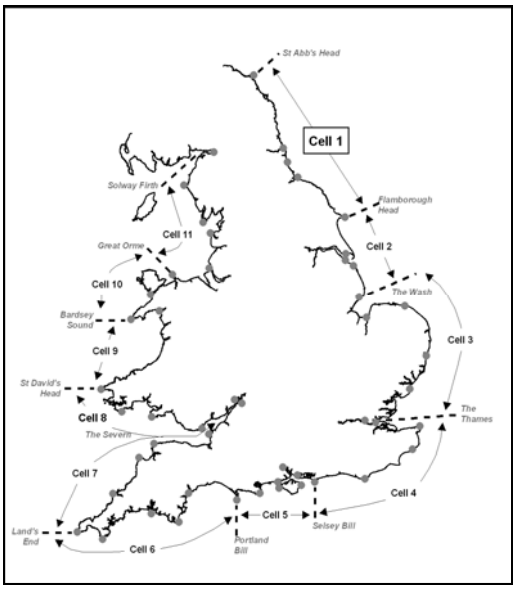


Figure 1 - Sediment Cells in England and Wales

The programme commenced in its present guise in September 2008 and is managed by Scarborough Borough Council on behalf of the North East Coastal Group. It is funded by the Environment Agency, working in partnership with the following organisations.

The data collection, analysis and reporting is being undertaken as a partnership between 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 will also be produced periodically. This will provide a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage within distinct time phases of the programme, defined by specific funding allocations. The first such report is expected to be produced in spring 2011 (covering 2008 – 2011) when the initial three year funding allocation comes towards an end.

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	June 09	-
2	2009/10	Sep-Dec 09	Mar 10 (*)			

(*) The present report is **Analytical Report 2** and provides an analysis of the 2009 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 the Table 2.

Table 2 Sub-divisions of the Cell 1 Coastline

Authority	Zone
Northumberland County Council	Spittal A Spittal B Goswick Sands Holy Island Bamburgh Beadnell Village Beadnell Bay Embelton Bay Boulmer Alnmouth Bay High Hauxley and Druridge Bay Lynemouth Bay Newbiggin Bay Cambois Bay Blyth South Beach
North Tyneside Council	Whitley Sands Cullercoats Bay Tynemouth Long Sands King Edward's Bay
South Tyneside Council	Littehaven Beach Herd Sands Trow Quarry (incl. Frenchman's Bay) Marsden Bay
Sunderland Council	Whitburn Bay Harbour and Docks Hendon to Ryhope (incl. Halliwell Banks) Featherbed Rocks
Durham County Council	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 (Filey Bay). For the purposes of this report, it 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

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

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 no. 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 no. 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
    - Cayton Bay
    - Filey

The location of these surveys is shown in Figure 2. These have also previously been provided on a digital file, which can be opened in Google Earth showing the locations of the surveys.

The current Full Measures survey was undertaken along this frontage between September and October 2009. During the surveys at Scarborough South Bay, Cayton Bay, Filey Bay, Runswick Bay (October 2009) the weather conditions were fine/ dry and sometimes breezy, with a calm sea state. The Staithes & Robin Hood's Bay surveys (September 2009) had the same conditions. In contrast the weather at Scarborough North Bay and the Sandsend to Whitby frontage (October 2009) was wet and windy with a rough sea state.

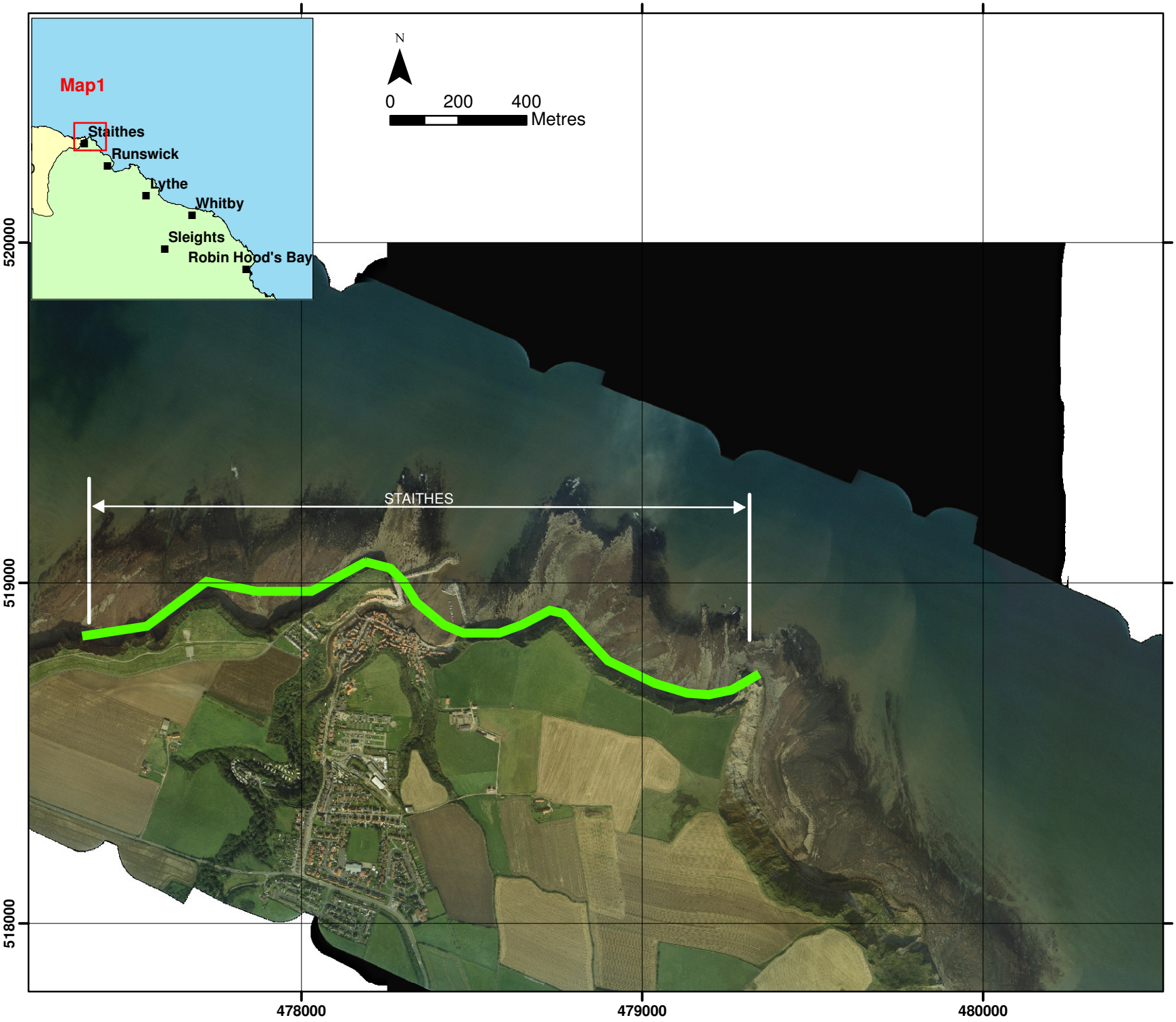
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and Arc-GIS. This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



SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 1 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:15,000 at A4

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Checked by:	RJ	Date: 25/01/2010
Approved by:	RJ	Date: 25/01/2010

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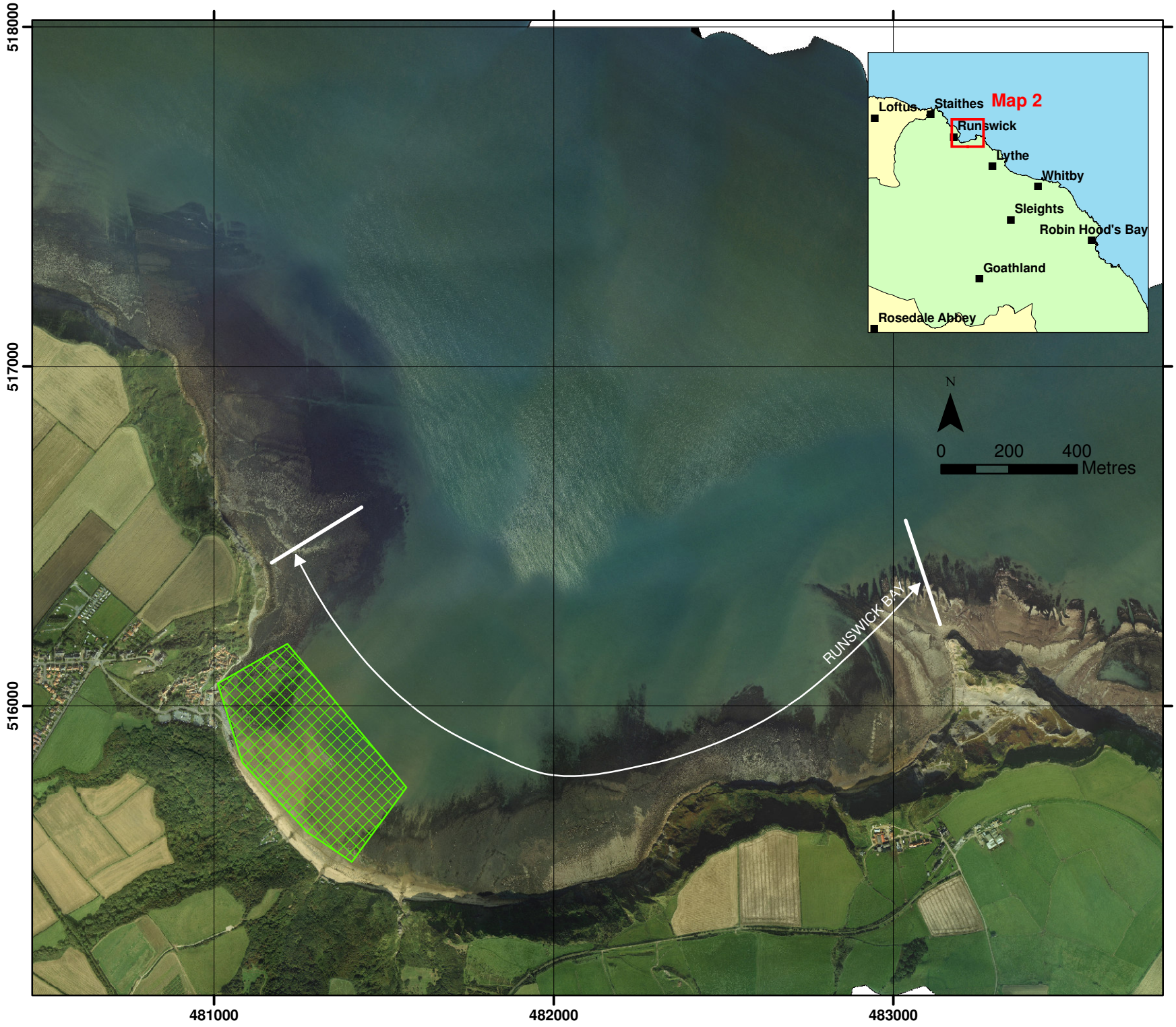

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

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Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 2 Scarborough Borough Council Frontage

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'Full Measures' Survey 2009

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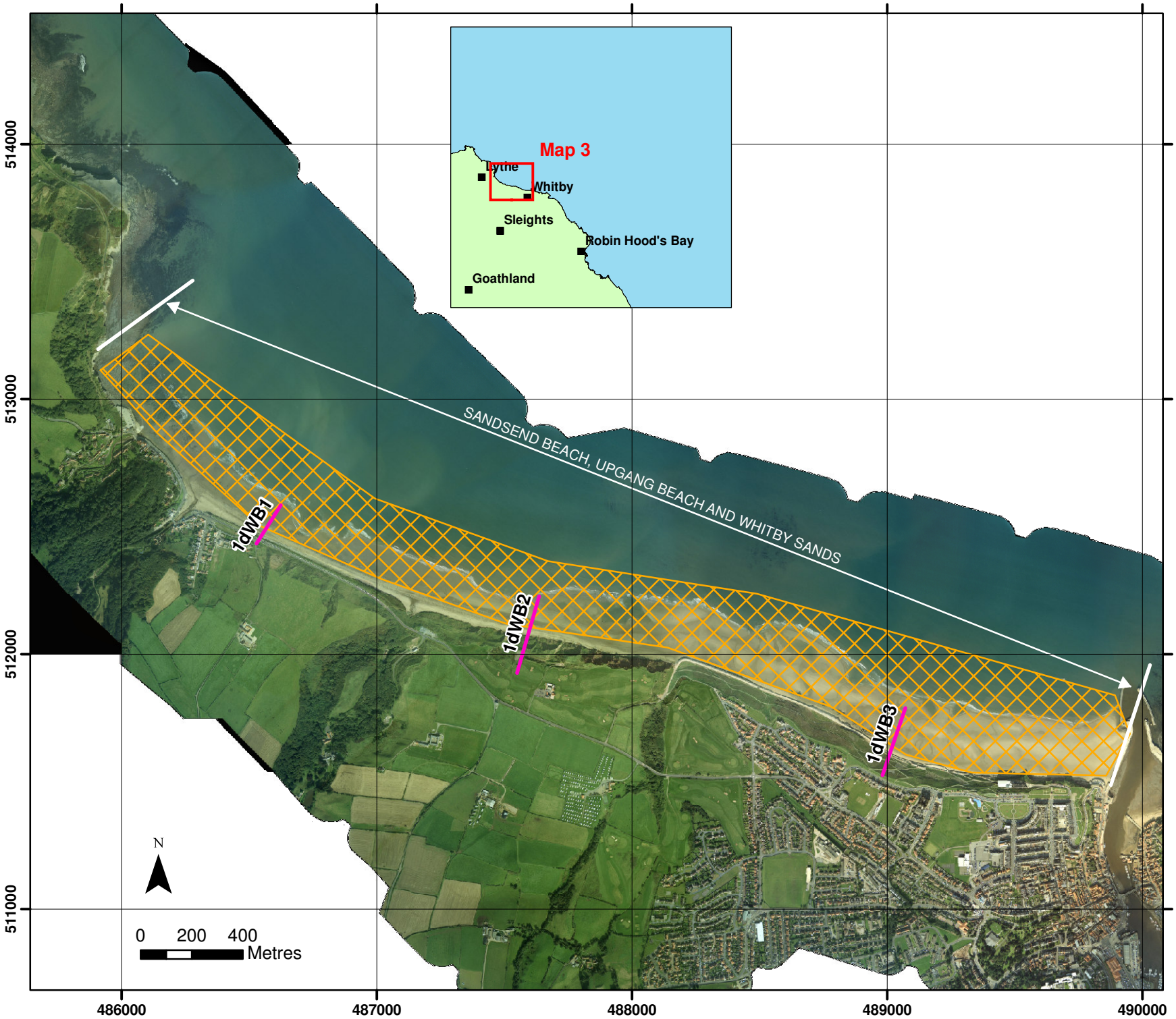

SURVEY LOCATIONS

Topographic Profiles
- Annual
- Bi-Annual

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs
- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 3 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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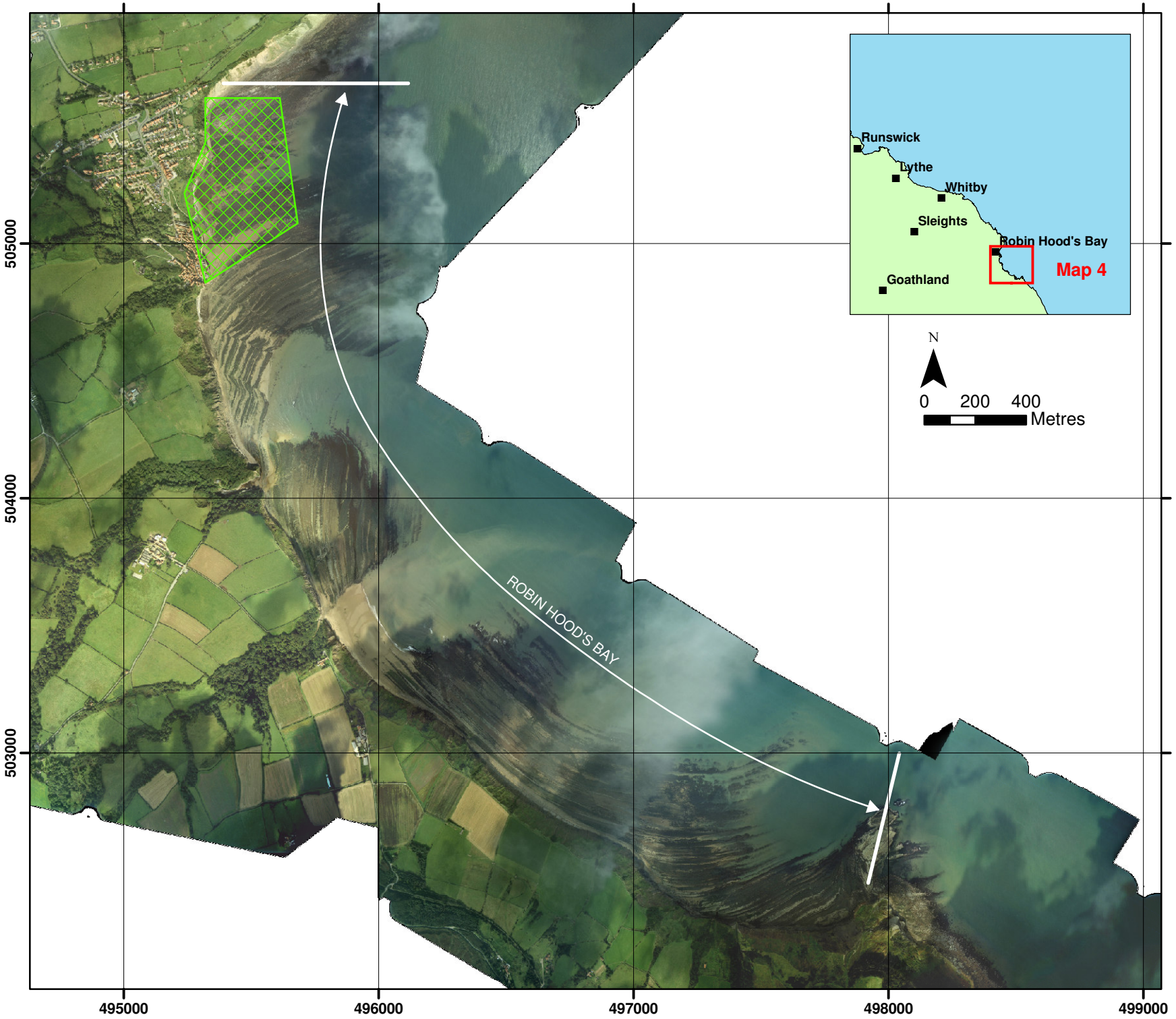

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 4 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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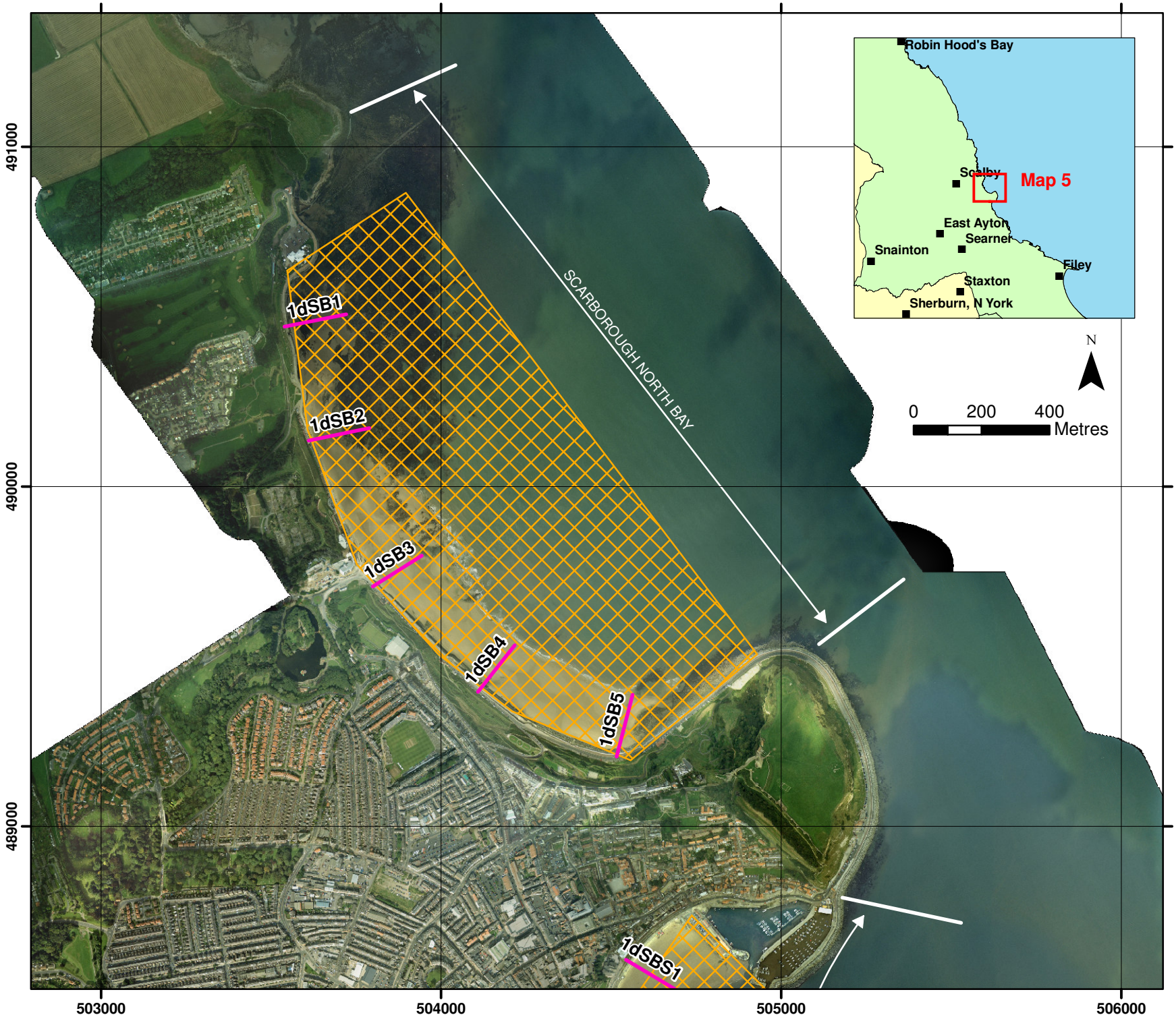

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 5 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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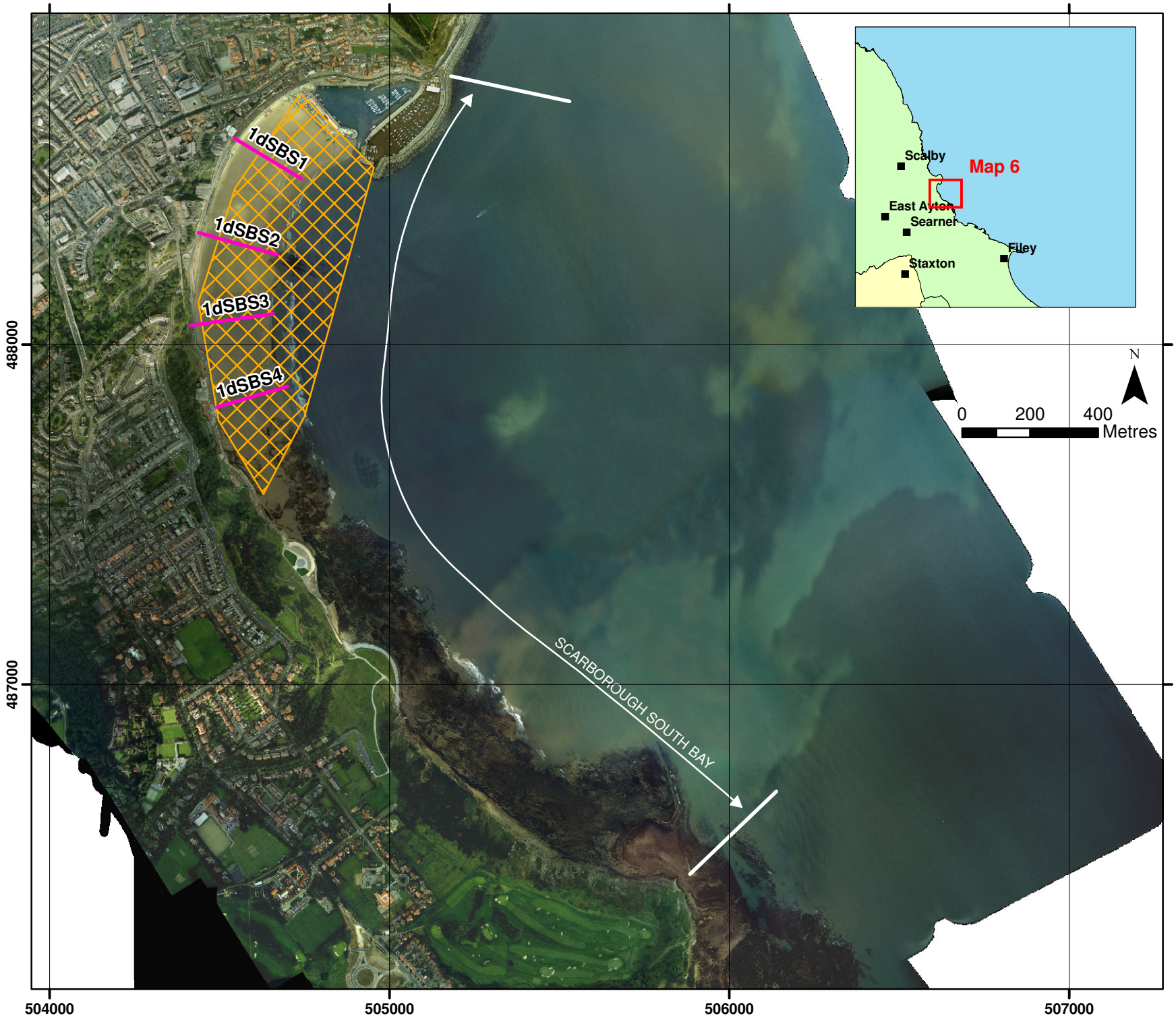

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 6 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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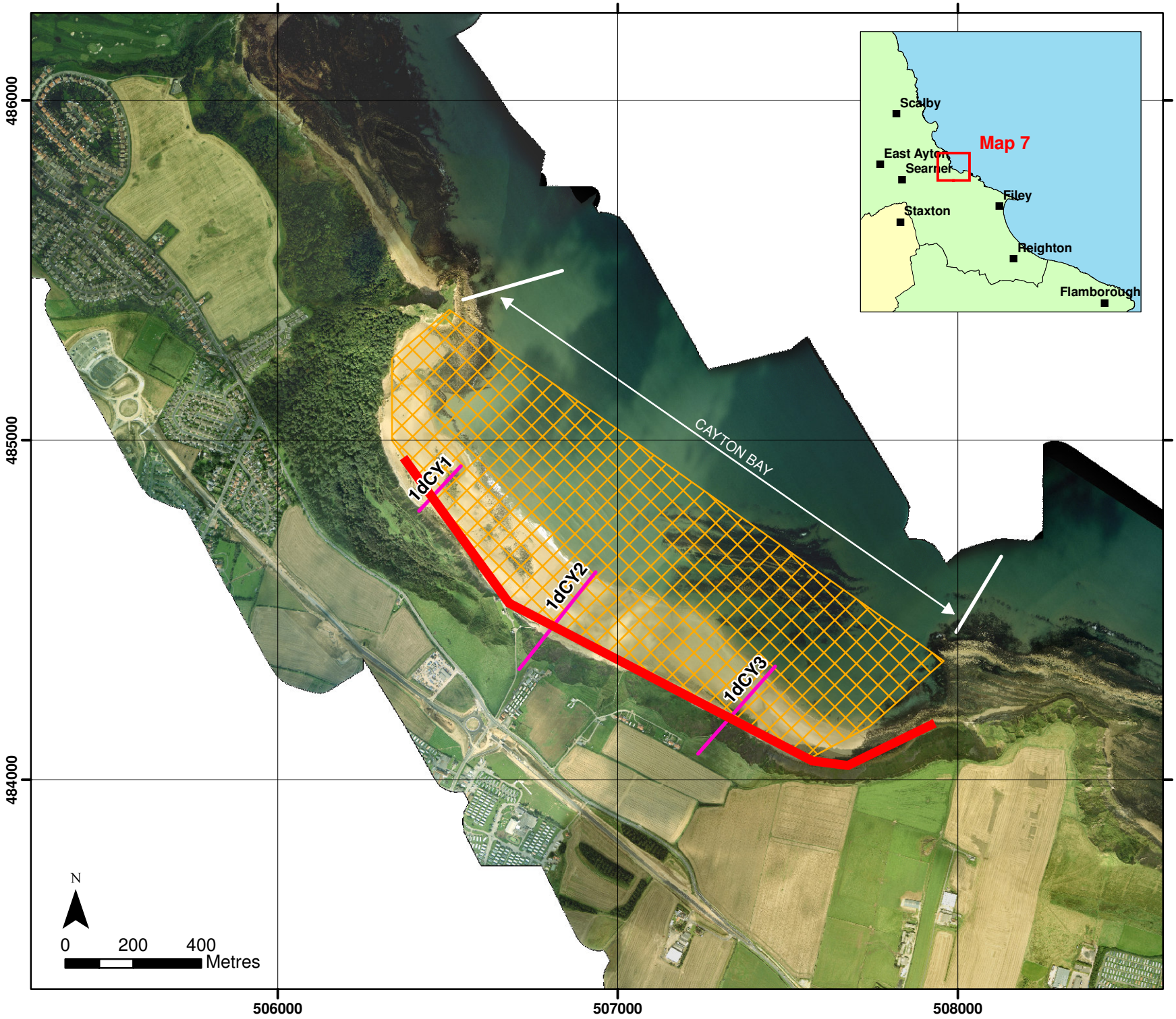

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 7 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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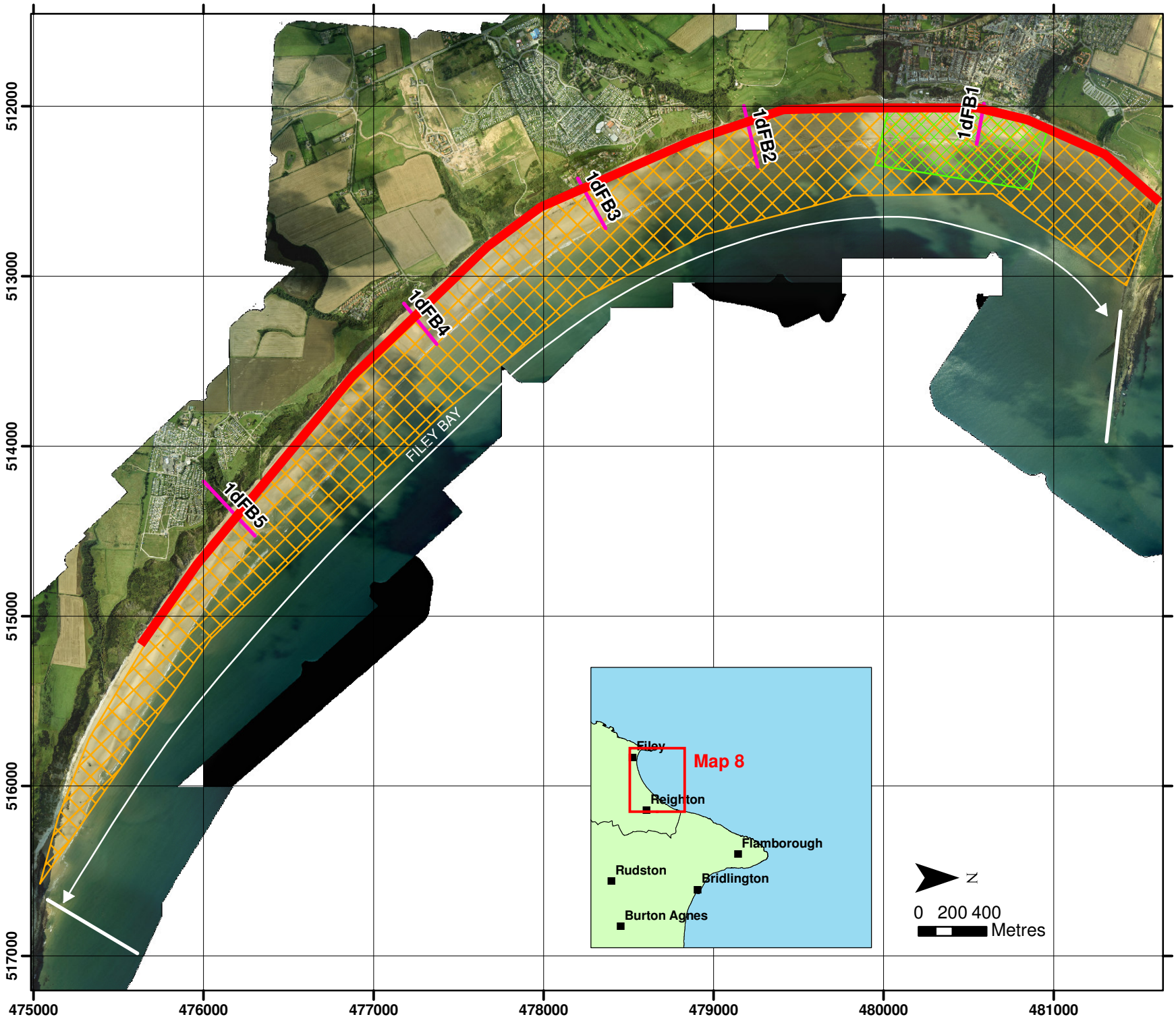

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- @ 50 centres
- @ 100 centres
- @ 300 centres

(Indicative Survey Extents shown)

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 8 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

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2. Analysis of Survey Data

2.1 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
09-2009	**Cliff Top Survey:** Twenty ground control points have been established at Staithes for the purposes of cliff top monitoring. The separation between any two points is typically around 100 m (although occasionally less). The cliff top surveys at Staithes are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Appendix D provides results from the September 2009 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.	When survey accuracy is taken into consideration, eight of the twenty points have shown no change since the November 2008 survey, indicating local stability of the cliff face. Seven locations (points 1, 2, 4, 11, 13, 17, 19) have shown cliff line recession ranging 0.2- 2.1 m (±0.1 m due to survey accuracy). The specific processes responsible for this would need to be determined by a dedicated field inspection, at a greater resolution than that provided by the walkover inspection. Five locations (points 3, 8, 9, 10, 12) have shown an increase in distance to the cliff edge (0.3- 4.3 m), whilst possibly representing a toppling failure; the more likely scenario is different interpretation of the cliff edge between successive surveys. Future surveys will reveal longer-term trends in the dynamics of this cliff line.

2.2 Runswick Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
10-2009	**Topographic Survey:** Runswick Bay is covered by a 6-monthly topographic survey. Data have been used to create a DGM (Appendix B - Map 1) using a Geographic Information System (GIS) computer software package. The GIS has also been used to calculate the differences between the current topographic survey DGM (October 2009) and the earlier topographic survey DGM (April 2009), with 5m raster grids (as shown in Appendix B – Map 2), to identify areas of erosion and accretion. Appendix B - Map 2 reveals a linear band of erosion at the seaward extent of the survey, and a clear depositional band running parallel to this at the head of beach, indicating steepening of the beach. An erosion hotspot can be observed in the vicinity of Hobs Holes (near the sailing club) between the outflows of Calais and Claymoor Becks, so that the southeastern end of the beach is dominated by erosion. The pattern of change to the north of the rock armour defences, around Runswick Bay village itself, is more complicated. Here there are bands of little change interspersed with bands of minor deposition, which run parallel to the shoreline. At the very northeast of the data extent there is an intense patch of erosion found in an area of rocky foreshore. It is not clear if this represents a real change in beach topography or if it is a result of edge effects associated with the generation of a DGM (see section 3 for further detail).	The beach at Runswick Bay over the 2009 summer period has experienced migration of material onshore, with some seasonal shore-parallel accretion at the back of the shore, as is typical of a swell dominated system. There has also been a notable loss of beach materials further seaward and beneath Hob Holes.

2.3 Sandsend Beach, Upgang Beach and Whitby Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
10-2009	**Beach Profiles:** 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). WB 1- The beach level has dropped since the last survey, by up to 0.65m along its length. Toe level is considerably lower than the baseline 2008 survey (by up to 1m). The underlying sandy beach is of lesser gradient 0.072 m m^{-1} (previously: 0.077 m m^{-1}). WB 2- The cliff face shows negligible change. The beach shows localised redistribution of sediment, with a large build-up of material at the beach toe leading to the overall gradient reducing (April 2009: 0.049 m m^{-1}, October 2009: 0.038 m m^{-1}). Small changes have occurred in the beach below MHWS (2.6m ODN), including an area of erosion of up to 0.75 m between chainage c. 150-230 m, followed by deposition from 230 m chainage (up to 1.4 m). WB 3- The stabilised face of Whitby West Cliff demonstrates negligible change, other than that anticipated with inter survey accuracy. The beach shows slight/ progressive accretion down profile (beneath MHWS), with gain up to 0.4m by 236m. Consequently the beach gradient has reduced very slightly from 0.023 m m^{-1} (April 2009) to 0.022 m m^{-1} by October 2009.	WB 1- The reduction of beach level, and gradient is a reflection of the dynamic nature of the beach processes. This has increased exposure of the seawall toe. WB 2- The erosion at the cliff toe may represent the loss of slope or upper beach deposits. The moderate changes to the beach profile are typical of this dynamic environment. WB 3- The slight accretion of the beach may suggest weak along- or on-shore sediment transfer, and may point to a seasonal realigning of the beach.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey: The Sandsend to Whitby frontage is covered by an annual topographic survey, providing continuous survey of Sandsend Beach, Upgang Beach, and Whitby Sands. Data have been used to create a DGM (Appendix B - Maps 3a & 3b) using a GIS computer software package. The GIS has also been used to calculate the differences between the current topographic survey DGM (October 2009) and the earlier topographic survey DGM (November 2008), with 5m raster grids (as shown in Appendix B – Maps 4a & 4b), to identify areas of erosion and accretion. Appendix B - Maps 4a & 4b reveal depositional wedges at the mouths of both Sandsend Beck and East Row Beck, likely to be attributable to fluvial deposition. Sandsend and Upgang beaches show extensive zones of both erosion and deposition, which are largely shore-parallel and linear. Moving alongshore, the rear of beach alternates between deposition and erosion; the former coinciding with fluvial outflows. In the region of the mudslides at Upgang, there is a notable trend to erosion particularly at the back of the beach. In contrast, the beach at Whitby Sands exhibits a significant trend towards accretion, with some erosion evident at the base of the cliffs. Beach profiles and the topographic survey were collected on different dates (23.10.09, and 19.10.09, respectively). This offset has had no significant bearing on the reported changes in beach behaviour between these two datasets.	The spatial distribution of erosion and deposition suggests a net south easterly transfer of sediment towards the West Pier at Whitby. The higher cliffs within this area (at Upgang, and just west of the pier at Whitby) exhibit a reduction of upper beach wedge volumes. The pattern of change along this entire frontage results from the impact of both marine and fluvial processes.

2.4 Robin Hood's Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
09-2009	**Topographic Survey:** Robin Hood's Bay is covered by a 6-monthly topographic survey. Data have been used to create a DGM (Appendix B - Map 5) using a GIS computer software package. The GIS has also been used to calculate the differences between the current topographic survey DGM (September 2009) and the earlier topographic survey DGM (April 2009), with 5m raster grids (as shown in Appendix B – Map 6), to identify areas of erosion and accretion. Appendix B - Map 6 reveals that there has been little significant change across this frontage during the summer of 2009. The exceptions are a couple of patches of moderate erosion at the southern end of the survey area and some areas of moderate deposition within the embayments (behind Dungeon Hole and West Scar).	It is likely that the general pattern of little change in foreshore elevation over the period of observation is a consequence of both the relative erosional resistance of the rock platforms and limited sediment supply (inhibits accretional change above the rock platform). In contrast, the erosional hotspots are likely to correspond to more mobile, local pockets of sand which previously accumulated in-between outcrops of the platform and have since dispersed (e.g. Ground Wyke Hole).

2.5 Scarborough North Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
10-2009	**Beach Profiles:** Scarborough North Bay is covered by five beach profile lines, spaced between the Oceanarium at Scalby Mills to Clarence Gardens (Appendix A). SB 1- The whole profile lies below MHWS (2.45 m ODN). It has shown erosion between 10-50 m chainage (maximum 0.5 m), and slight accretion between 50- 170 m chainage (maximum 0.15 m). SB 2- Accretion has occurred across the entirety of the measured profile, with the greatest on the upper beach where, between chainage 7.5- 50 m, there has been a maximum gain of c. 0.7 m. This deposition largely occurs beneath MHWS (2.45 m), although the beach surface now exceeds this elevation adjoining the seawall at 3.4 m ODN. The lower beach has experienced accretion of around 0.1 m. Collectively this deposition has further smoothed the beach profile. SB 3- Has experienced both erosion and accretion in different areas along its length, resulting in minimal change to the prevailing beach gradient (April 2009: 0.040 m m^{-1}, October 2009: 0.042 m m^{-1}). Three zones can be described, (1) chainage c. 12-80 m, with accretion of c. 0.7 m (maximum), which has buried a greater extent of the seawall, with the beach head now at 3.55 m ODN (above MHWS). (2) chainage c. 80-135 m, with erosion of c. 0.3 m (maximum). (3) chainage > 135 m, with accretion up to c. 0.1 m. SB 4- Has experienced both erosion and accretion in different areas along its length. Between chainage c. 35-40 m and 50 m the uneven topography is that of rock platform and boulder deposits (see survey photos), where the survey profile shows no change. The overall beach gradient is slightly reduced (April 2009: 0.012 m m^{-1}, October 2009: 0.010 m m^{-1}). Three principal zones can be described, (1) chainage c. 25-60 m, with intermittent erosion (excepting rock platform/ boulder zones noted above) of c. 0.75 m (maximum), with the beach head now at -0.7 m ODN. (2) chainage c. 60-135 m, with accretion of c. 0.5 m (maximum). (3) Chainage > 135 m erosion of c. 0.25 m (maximum). SB 5- Shows a difference to the front face of the seawall (below 5.5 m ODN)- which is likely to be a product of survey rather than real change (the photos show no recent engineering modifications). The beach profile change is largely accretional, with an overall decrease in gradient (April 0.018 m m^{-1}, October 2009: 0.013 m m^{-1}). Three zones (both below MHWS) can be described, (1) chainage c. 30-45	SB 1- Shows significant erosion immediately abutting the seawall, which reduces protection afforded to the base of this structure. SB 2- Demonstrates significant accretion immediately abutting the seawall, which lends support to its sea defence function. SB 3- Shows a typical seasonal variation, shifting sediment landwards during the summer. In doing so affording greater protection to the seawall toe. SB 4- There is erosion immediately abutting the seawall, which reduces protection afforded to the base of this structure at the time of the most recent survey. SB 5- Indicates some minor accretion immediately adjacent to the rock armour, and a significant build-up of the lower beach, and associated seaward movement of the low water line. Wave energy impacting the sea defences are therefore likely to decrease.

Survey Date	Description of Changes Since Last Survey	Interpretation
	m, with accretion of c. 0.2 m (maximum); (2) chainage c. 45-60 m, with erosion of c. 0.1 m (maximum); (3) chainage from 60 m, with seaward movement of the low water line by roughly 50m, with the beach level rising by up to 0.8 m.	
	Topographic Survey: Scarborough North Bay is covered by is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 7) using a GIS computer software package. The GIS has also been used to calculate the differences between the current topographic survey DGM (October 2009) and the earlier topographic survey DGM (November 2008), with 5m raster grids (as shown in Appendix B – Map 8), to identify areas of erosion and accretion. Appendix B - Map 8 reveals a substantial zone of erosion between the Sea Life Centre and Clarence Gardens that largely occurs below the 0m ODN contour. Further towards the back of the beach (i.e. above the 0m ODN contour) there are localised areas of accretion (e.g. in the artificial bay area just north of the Northstead Manor Gardens). The southern extent of the survey area is characterised by less significant patterns of change. There is a band of minor deposition towards the back of the beach, with small pockets of erosion at the base of the promenade. The notable difference in beach behaviour outlined here relative to that interpreted from the beach profiles is a consequence of different survey dates (i.e. beach profiles surveyed on 21.10.09, and the topographic data on 6.10.09). It follows that intervening marine process activity accounts for the differing beach morphologies.	The localised accretion at the back of the beach may reflect summer swell processes. The substantial erosional zone further seaward is a possible consequence of the subsequent rough autumnal seas (observed during the 2009 walkover inspection on 1.10.09). In areas where such patterns are observed, there has been a general steepening of the beach profile.

2.6 Scarborough South Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
10-2009 & 01-2010	**Beach Profiles:** Scarborough South Bay is covered by four beach profile lines, spaced between South Sands adjacent to the Old Harbour to The Spa Complex (Appendix A). SBS 1- A large wedge of sand has returned to the front of the seawall attaining an elevation of 3.33 m ODN (above MHWS of 2.45 m ODN); the beach profile is now similar to that recorded a year previously. Four zones of beach profile *change* can be described, (1) chainage c. 13-40 m, with accretion of c. 1.1 m (maximum); (2) chainage c. 40-65 m, with erosion of c. 0.4 m (maximum); (3) chainage c. 85-155 m, with accretion of c. 0.3 m (maximum); and (4) chainage from 155 m, with erosion of c. 0.6 m (maximum). The beach profile gradient has increased slightly (April 2009: 0.021 m m^{-1}, October 2009: 0.024 m m^{-1}). SBS 2- The beach profile has changed little over the comparison period, with maximum difference in beach level of c. 0.2m, except at the toe of the beach, where a small length (c. 25m) has experienced erosion of up to c. 0.3m. Beach gradient is largely the same (April 2009: 0.026 m m^{-1}, October 2009: 0.028 m m^{-1}). SBS 3- The previously reported wedge of sand fronting the seawall (c. 7 to 22 m chainage) has now gone, and the beach level (2.05 m ODN) is now below MHWS of 2.45 m ODN. Between c. 25 and 110 m accretion of c. 0.3 m (maximum) occurs. Further seaward there is little change in the beach profile. Beach gradient shows reduction to levels similar to that existing at the time of the baseline survey (November 2008: 0.022 m m^{-1}, October 2009: 0.021 m m^{-1}). SBS 4- Accretion between the seawall toe and 100 m chainage is observed of c. 0.2 m (maximum). Seawards of 100 m chainage erosion occurs, up to c. 0.4 m (maximum). Overall beach gradient is similar to that calculated previously (April 2009: 0.017 m $m^{-}1$, October 2009: 0.016 m m^{-1}).	SBS 1- There is a slight increase in gradient, with a gain of material underlying the seawall. SBS 2- Shows a slight recession of the beach toe from its Spring 2009 position; otherwise the beach profile shows little change. SBS 3- Demonstrates the return to a beach profile similar to that existing at the time of the baseline survey (November 2008), reducing the sand volume/ elevation abutting the seawall. SBS 4- Shows slight accretion of the upper beach, and more significant erosion towards the beach toe. These shifts are typical of summer beach morphodynamics.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey (2009): Scarborough South Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 9) using a GIS computer software package. The GIS has also been used to calculate the differences between the current topographic survey DGM (October 2009) and the earlier topographic survey DGM (November 2008), with 5m raster grids (as shown in Appendix B – Map 10), to identify areas of erosion and accretion. Appendix B - Map 10 shows the development of a trough (through erosion) and a distinct ridge (through accretion) just south of the Old Harbour. This is confirmed by a comparison of profiles extracted from the DGMs in this area. Further south, an erosional trend dominates much of the area below 0m ODN. DGM profiles of this area indicate a general pattern of beach steepening and variable depths of erosion relative to the former beach surface, leaving a ridge feature present on the 2009 DGM. Much of the area above 0m ODN in the southern part of the data coverage has not experienced any significant change in elevation; however there are some localised, minor patches of accretion and erosion at the back of the beach. Beach profiles and the topographic survey were collected at the same time dates (5.10.09), and therefore data underlying interpretations of beach change are consistent.	The erosion and deposition bands evident in the north of the bay indicate the development of bar and trough beach morphology. Such a pattern is typical of a winter profile and thus may reflect recent storm events of autumn 2009. The widespread erosion to the south also supports this storm based process-form model.
	Topographic Survey (January 2010): Appendix C provides description and interpretation of beach changes occurring in the period 5th October 2009 to 14th January 2010. The latter was performed as an ad hoc survey, to help understand the impact of beach material mining conducted by the local authority during this period. Sand was used to supplement the local highways department rock salt supplies during the sustained December-January 2010 cold period. The key reported findings are: 1. net loss of 34,000 m^3; 2. loss reflecting the combined impact of removal and natural processes. It should be noted that because the January 2010 survey did not extend to similar levels to the October 2009 survey it is not possible to say whether beach material has been dragged down the profile (a typical winter beach response) and what percentage of the overall volume change this might account for.	

2.7 Cayton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
10-2009	**Beach Profiles:** Cayton is covered by three beach profile lines, spaced between Tenants' Cliff and the south of Cayton Sands (Appendix A). CY 1- The relative profile positions down Tenant's Cliff would suggest significant cliff retreat; however the survey photos reveal a largely vegetated cliff face, it follows that the apparent difference is therefore a product of survey positioning rather than real change. At the base of the cliff the photos show the continuing presence of a small active face with fresh rockfall, which in conjunction with the survey profile reveal the building of a cone of boulder sized debris. The beach between 25- 125 m and 130- 150 m chainage largely shows accretion (c. 0.3 m maximum). Whereas localised erosion is noted between chainage 125-130 m and seaward of 150 m (c. 0.4 maximum). CY 2- The seacliff survey is similar to that attained by the baseline survey (November 2008), i.e. fewer points have been measured on the cliff face than in the Spring 2009 survey. The cliff top shows no recession between surveys. The beach profile shows only minor change, with accretion (between c. 140 and 240 m chainage, maximum c. 0.3m). Overall beach gradient has changed slightly (November 2008: 0.022 m m^{-1}, April 2009: 0.026 m m^{-1}, October 2009: 0.022 m m^{-1}). CY 3- The survey of the cliff face remains interpolated. The cliff top and toe are static. The beach shows two principal zones of change: (1) c. 145-180 m chainage with erosion < 0.7m; (2) c. 260m chainage with accretion of < 0.4m. Other areas of the beach are broadly unchanged in elevation. The calculated beach gradient is slightly steeper (April 2009: 0.026 m m^{-1}, October 2009: 0.032 m m^{-1}).	CY 1- Shows active rockfall (cliff recession) at the rear of the beach and a largely accretional beach surface. CY 2- Shows limited change in the beach profile. CY 3- Shows zones of erosion and accretion. The former comprises slight lowering of the upper beach potentially exposing the cliff toe to greater wave energy.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey: Cayton Bay is covered by is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 11) using a GIS computer software package. The GIS has also been used to calculate the differences between the current topographic survey DGM (October 2009) and the earlier topographic survey DGM (November 2008), with 5m raster grids (as shown in Appendix B – Map 12), to identify areas of erosion and accretion. Appendix B - Map 12 reveals a complex pattern of beach elevation change between 2008 and 2009. The south-east area is characterised by a fairly extensive pattern of minor deposition which runs parallel to the shoreline. There are also localised patches of erosion evident both further landward and further seaward, again in a generally shore parallel pattern. In the northern part of Cayton Bay there are areas of localised erosion and deposition, which are interspersed with areas of little and no significant change. Beneath Cayton Cliff itself there is a strong trend towards erosion at the very back of the beach. DGM profiles for much of Cayton Bay indicate a general steepening of the beach profile. Beach profiles and the topographic survey were collected on different dates (7.10.09, and 8.10.09, respectively). This offset has had no significant bearing on the reported changes in beach behaviour between these two datasets.	The shore-parallel patterns of erosion and accretion to the south of the bay indicate a typical marine process regime. The more complicated patterns of elevation change to the north of the bay may relate to recent landslide activity at Cayton Cliff. For example, in April 2008, the cliff toe was uplifted at beach level. Since then, marine action has been gradually eroding away this raised area. This may be responsible for the pattern of erosion observed at the back of the beach here.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Cliff Top Survey: 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 300 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. Appendix D provides results from the October 2009 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.	When survey accuracy is taken into consideration, three of the eight points have shown no change since the November 2008, indicating general stability of the cliff face amongst the surveyed localities. Three locations (points 1, 2 & 4) have shown cliff line recession ranging 0.2- 1.0 m (±0.1 m due to survey accuracy). The specific processes responsible for this would need to be determined by a dedicated field inspection, at a greater resolution than that provided by the walkover inspection. Two locations (points 3 & 5) have shown an increase in distance to the cliff edge (0.2 to 1.4 m); whilst possibly representing a toppling failure, the more likely scenario is different interpretation of the cliff edge between successive surveys. Future surveys will reveal longer-term trends in the dynamics of this cliff line.

2.8 Filey Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
10-2009	**Beach Profiles:** Filey Bay is covered by five beach profile lines, spaced between Filey Sands and Speeton Sands (Appendix A). FB 1- There has been more marked change below the seawall than previously reported, and an overall increase in undulation along the profile. This comprises: (1) accretion between c. 18-110 m chainage (maximum c. 0.3m); (2) erosion between c. 110-165 m chainage (maximum c. 0.4 m); & (3) accretion following 165 m chainage of c. 0.3 m (maximum). The overall beach gradient shows no change (0.018 m m^{-1}). FB 2- The survey of the cliff face was conducted at greater resolution than previously. The cliff top and toe are static during this period. The beach profile tends towards accretion (65- 110 m & 150- 260 m chainage; maximum 0.7 m), with smaller extents of erosion (110-140 m & seaward of 260 m chainage, maximum 0.5 m). The overall beach gradient shows a slight increase in overall gradient (April 2009: 0.017 m m-1, October 2009: 0.020 m m^{-1}). FB 3- The cliff remains unchanged. The pre existing ridge and trough morphology has been smoothed out (in contrast to FB 1 & 2), largely due to extensive zones of accretion (c. 40- 105 m & 155-255 m chainage, maximum c. 0.75 m), and smaller zones of erosion (c. 105- 155 m & seaward of 255m chainage, maximum c. 0.4 m). The overall beach gradient remains unchanged (April 2009: 0.024 m m^{-1}, October 2009: 0.024 m m^{-1}). FB 4- The survey of the cliff face remains interpolated, and at this coarse level shows no change. The beach alike FB 3 shows a smoothing of the profile. The most significant changes are accretion c. 75-135 m & seawards of 180 m chainage (maximum c.1 m), and erosion 135 -180 m chainage (maximum c. 0.5 m). The beach toe has prograded seawards over the summer period, leading to an overall gradient reduction (November 2008: 0.023 m m^{-1}, April 2009: 0.033 m m^{-1}, October 2009: 0.019 m m^{-1}). FB 5- The current (October 2009) cliff top survey prior to the beach, appears to follow a different survey route (60-220 m chainage), given the survey photos reveal no recent retreat of the cliff. The beach shows a smoothing of the pre-existing ridge and trough morphology, which can be separated	FB 1- The profile shows zones of accretion and erosion. The former is more extensive fronting the seawall, but still below MHWS (2.50 m ODN) and therefore is likely to be insufficient to alter exposure to wave attack. FB 2- This shows increase in subtle ridge and trough morphology, comprising upper beach accretion either side of MHWS (2.50 m ODN), and a slight gradient increase. Protection to the base of the cliffs from wave attack may marginally increase. FB 3- The pre existing ridge and trough morphology has been smoothed, creating a more typical summer (swell) beach profile. The overall gradient remains unchanged. FB 4- shows a beach gradient reduction, with a smoothing of the pre-existing ridge and trough morphology. FB 5- shows a beach gradient reduction, due to seaward movement of the beach toe. The beach has also experienced a smoothing of the pre-existing ridge and trough morphology.

Survey Date	Description of Changes Since Last Survey	Interpretation
	into three zones of change: (1) chainage 220-250 m shows accretion (c. <1 m) either side of MHWS (2.5 m ODN); (2) chainage 260-305 m shows minor erosion (c. <0.2 m); and (3) and extensive accretion from 305 m onwards, of c. <1.5m. The overall beach gradient has reduced slightly (April 2009: 0.028 m m^{-1}, October 2009: 0.026 m m^{-1}). **Topographic Survey (Filey Bay):** Filey Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Maps 13a, 13b, & 13c) using a GIS computer software package. The GIS has also been used to calculate the differences between the current topographic survey DGM (October 2009) and the earlier topographic survey DGM (November 2008), with 5m raster grids (as shown in Appendix B – Maps 14a, 14b, & 14c), to identify areas of erosion and accretion. Appendix B - Map 14a reveals shore parallel change between Filey Brigg and Muston Sands. Between Filey Brigg and the Coble Landing there are large areas of no significant change however there is notable erosion at the very back of the beach (potentially modelling edge effects), immediately beneath the undefended soft cliffs. In contrast, south of the Coble Landing (including the frontage of Filey town itself) the upper beach is characterised by accretion and the lower beach by a continuous, shore-parallel band of erosion. This suggests a steepening of the beach profile at this location, and is confirmed by profile data extracted from the two DGMs. Appendix B – Map 14b (Hunmanby Sands) shows a diagonally aligned sequence of subtle depositional and erosional bands, with the depositional trend dominating in terms of spatial extent. In the Reighton Sands/ Speeton Sands area (as shown by Appendix B – Map 14c) there is a dominant trend towards deposition. Smaller pockets of erosion are also evident, which may represent the development of cuspate embayments. Beach profiles and the topographic survey were collected on different dates (20.10.09, and 19.10.09, respectively). This offset has had no significant bearing on the reported changes in beach behaviour between these two datasets.	<u>Filey Bay: (Full measures only)</u> The large beach at Filey Bay is displaying a complex pattern of elevation change between 2008 and 2009. To the north, the beach profile has become steeper, perhaps as a result of summer swell activity. A range of beach morphologies are developing in the southern part of the bay including shore diagonal subtle ridge and trough systems (smoother than which existed previously) and cuspate embayments, as are typical of marine processes. The evidence of extensive and significant deposition in the southern half of the bay may also indicate net transfer of sediment down coast.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey (Filey Town): Further to the spatially comprehensive annual survey of Filey Bay, a smaller (selected) area within this extent (i.e. fronting Filey Town) is also surveyed in the partial measures programme, enabling further analysis of change, but specifically for the shorter spring to early autumn period fronting this asset. The GIS has been used to calculate the differences between the current (full measures) topographic survey DGM (October 2009) and the earlier (partial measures) topographic survey DGM (April 2009), with 5m raster grids reflecting (as shown in Appendix B – Maps 14d), to identify areas of erosion and accretion during the defined time period. Appendix B - Map 14d reveals change similar to that reported from the longer period in Appendix B- Map 14a (which included the preceding winter season). That is a trend to accretion in the upper beach (excepting small areas to the south which are erosional) and a linear band of erosion further seawards. In this case the deposition is more prominent over the summer of 2009 than it was from autumn 2008 to autumn 2009, and the spatial extent of the erosion band is reduced in size. **Cliff Top Survey:** Twenty-three ground control points have been established within Filey Bay for the purposes of cliff top monitoring. The maximum separation between any two points is nominally 300 m. The cliff top surveys at Filey 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. Appendix D provides results from the October 2009 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.	<u>Filey Town: (Full and partial measures)</u> The upper beach at Filey town is showing a clear trend of accretion, with erosion observed further seaward. It is likely that this pattern of elevation change results from the 2009 summer period of swell activity. When survey accuracy is taken into consideration, fourteen of the twenty-three points have shown no change since the November 2008, indicating general stability of the cliff face amongst the surveyed localities. Three locations (points 5, 11, 20) have shown cliff line recession ranging 0.2- 3.5 m (±0.1 m due to survey accuracy). The specific processes responsible for this would need to be determined by a dedicated field inspection, at a greater resolution than that provided by the walkover inspection. Six locations (points 1, 3, 4, 7, 9, 19) have shown an increase in distance to the cliff edge (0.2 to 0.5 m), whilst possibly representing a toppling failure; the more likely scenario is different interpretation of the cliff edge between successive surveys. Future surveys will reveal longer-term trends in the dynamics of this cliff line.

3. Problems Encountered and Uncertainty in Analysis

Topographic survey
It is important to be aware that the interpolation method employed to convert the topographic point data to a DGM will introduce some minor errors and is less reliable at the edges of the data coverage. These are normal and accepted issues of interpolating data and therefore do not present any problems for this assessment. It is, however, beneficial to take into account edge effects and errors when interpreting the difference between topographic surveys.

Survey accuracy of beach profiles
- The apparent resolution between successive surveys at a given location is variable. For example, on some occasions rock platforms are included, but not on others; or they provide differential coverage of cliff faces. Therefore post-survey interpretation has to be carefully conducted to best isolate real change versus that derived from differential survey resolution. A consistent, high-resolution survey would reduce the occurrence of this issue.
- The profile orientation may be slightly offset in a few cases, as shown by apparent shifts in cliff faces which photos show to be unchanged between surveys. Duplication of exact survey orientation between successive surveys is of high importance to accurately determine cliff and beach change.
- Some profile lengths vary between successive surveys; therefore they don't equally show beach change to MLWS. It may be the case that careful consideration is afforded to survey timing in respect to tide and weather conditions; in order to further optimize survey data collection.

Cliff top erosion errors
The cliff top surveys are in general assumed to have a limit of accuracy of ± 0.1m due to the techniques used. At a sizeable number of locations apparent cliff advance is calculated, which is highly unlikely excepting a toppling mechanism of failure. It is more likely that this is due to a different point being identified as the edge of the cliff, especially with different seasonal vegetation covers. This problem is now marked at both Staithes & Filey, which suggests that this is not just a problem at a single site, but perhaps the product of the adopted technique. A visit to all measurement locations by a cliff geomorphologist would provide a useful means to evaluate this issue further, providing the basis for recommendations on the improved capture of these data.

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

The following recommendations are suggested:

- Consider and implement measures to improve the accuracy of cliff top survey data capture, as pre-existing concerns remain. Photography at the time of each survey (alike beach profiles) and a site visit by a cliff geomorphologist would increase understanding and value of these data at all sites. Planned analysis of forthcoming orthophotos may well be equally useful in this regard.

- Perform beach profile measurements to a consistent and high-resolution. This may include further attention given to: survey timing coincident with optimum tide and weather conditions, profile orientation, and enhanced transparency in the recording of survey dates.

5. Conclusions and Areas of Concern

- The Staithes frontage has shown areas of localised cliff top stasis, advance (erroneous survey), and recession. Hotspots for cliff top retreat at this time are to the west adjacent to Cowbar Lane and Cowbar Nab, the cliff backing Penny Steel, and the Old Nab.

- The pattern of beach elevation change at Runswick Bay is dominated by two shore parallel bands of change: accretion (at head of the beach) and erosion (further seaward) and is typical of a summer swell type system. There is also notable loss of material beneath Hobs Holes.

- The Sandsend to Whitby frontage shows dynamic shifts in the beach profile with zones of accretion and erosion reflecting the combination of marine and fluvial influences. At Sandsend and Upgang zones of erosion are notable; further towards Whitby, deposition becomes dominant and may indicate net transfer of sediment to the southeast.

- Robin Hood's Bay shows a largely stable foreshore, especially in areas dominated by rock platforms. Small erosional hotspots coincide with pocket beaches, most especially at Ground Wyke Hole.

- The topographic survey on 6.10.09 shows a significant and substantial zone of erosion within the northern part of Scarborough North Bay below the 0m ODN contour line; however by 21.10.09 beach profiles demonstrate the return of beach sediments with an overall tendency towards aggradation; which at a number of profiles affords greater protection to the seawall toe.

- The shore parallel bands of erosion and accretion in the northern part of Scarborough's South Bay indicate the development of a trough and bar morphology, which is typical of a winter storm profile. Further south (fronting the Spa), erosion is observed below the 0m ODN contour line and results in a steepening of the beach profile. Beach profiles are now similar to that existing at the time of the baseline survey.

- The ad hoc survey of Scarborough South Bay in January 2010 reveals significant loss of material from the survey area since the October 2009 survey (in the order of 34,000m^3). This is likely to result from a combination of natural processes and extraction of sand by the local authority.

- Cayton Bay shows dynamic shifts in the beach profile with zones of accretion and erosion. Patches of erosion in the north of the bay locally relate to erosion of the uplifted toe of the Cayton Cliff landslide, which reactivated in April 2008. In respect of cliff tops, surveying from ground control points establishes a largely stable frontage, with areas of localised retreat. These data of course exclude known instability at Cayton Cliff/ Knipe Point further north.

- The pattern of beach elevation change within Filey Bay suggests a net transfer of material down coast. To the south there has been a smoothing of pre-existing beach ridge/ trough systems and the formation of cuspate embayments, and a general gradient reduction. In front of Filey town itself, there is a clear trend towards accretion of material, affording increased protection to the seawall. This has resulted in a steeper beach profile and possibly results from summer swell activity since the partial measures survey in spring 2009. The cliff top survey generally shows positional stasis, advance (erroneous survey), and a number of locations display recession, particular hotspots are the undefended cliff immediately south of the Filey seawall (location 5), and Hunmanby Moor (location 11).

Appendices

Appendix A

Beach Profiles

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

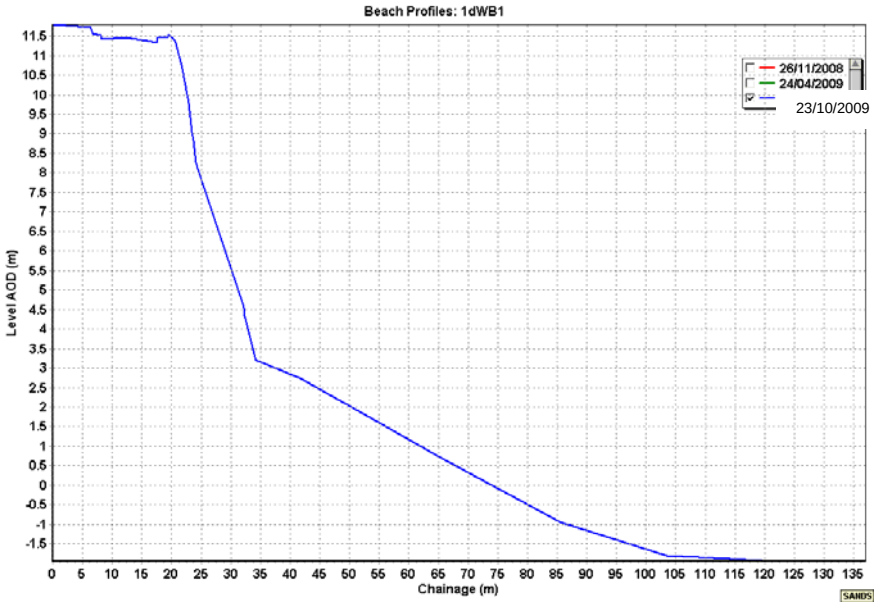
Code	Description
M	Mud
S	Sand
G	Gravel
GS	Gravel & Sand
GM	Gravel & Mud
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Salt Marsh
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
W	Water Body
ZZ	Unknown

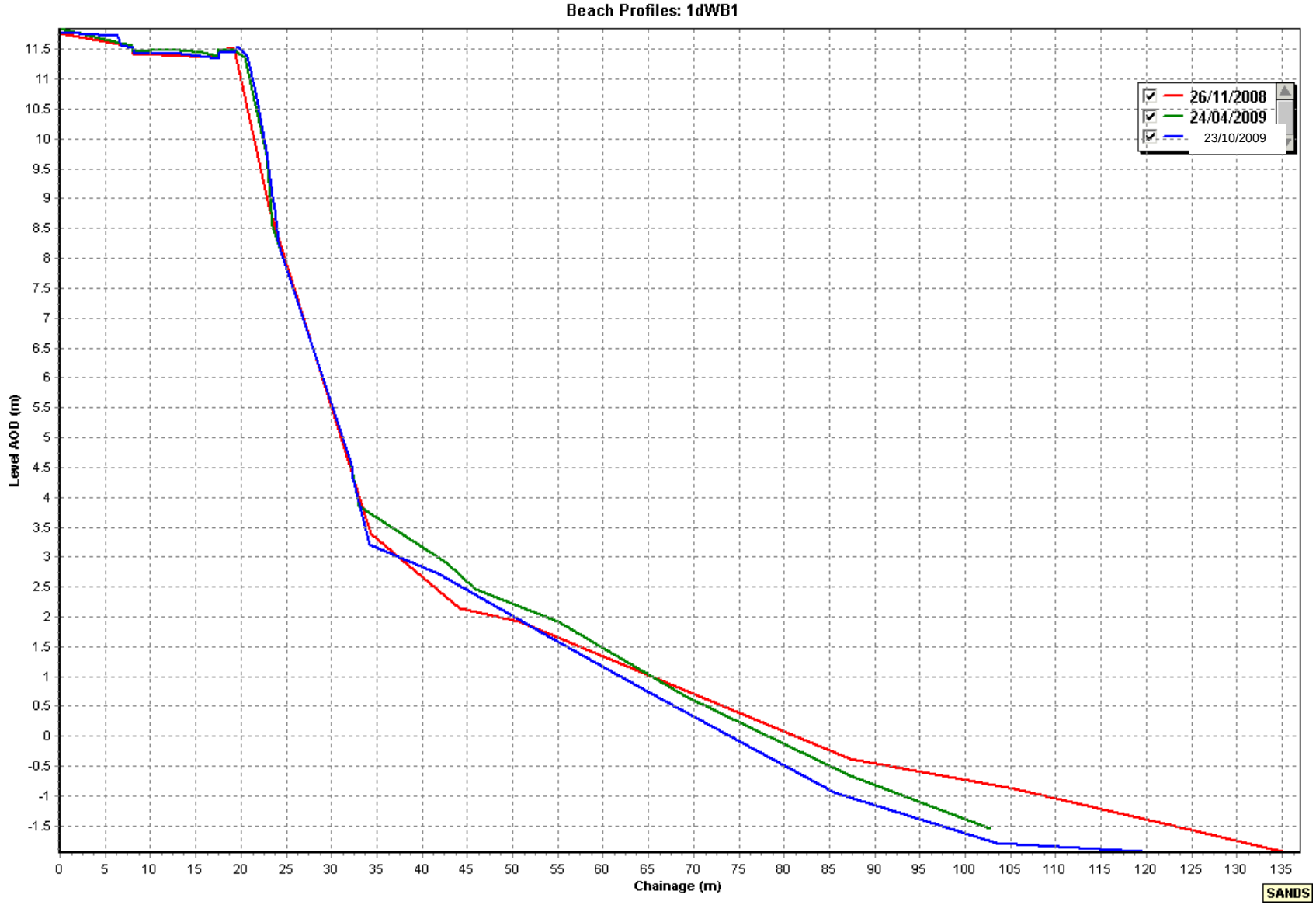
Beach Profile

1dWB1

Date 23/10/2009 **Wind** **Summary** Windy	**Inspector** **Sea State** Rough	**Low Tide (m)** **Visibility** -	**Low Tide Time** 10.56 – 13.12 **Rain** Yes
Easting 486535.075	**Northing** 512437.797	**Bearing** 32	

Chainage (from base station)	Level AOD (m)
0	11.788
0.024	11.788
6.303	11.721
6.764	11.569
8.143	11.521
8.198	11.416
12.352	11.455
17.657	11.346
17.673	11.454
19.387	11.466
19.599	11.542
20.633	11.388
21.63	10.774
22.846	9.79
23.454	9.04
23.734	8.835
24.076	8.276
24.382	8.127
32.184	4.545
32.383	4.326
34.194	3.2
41.721	2.733
54.427	1.646
65.074	0.729
85.542	-0.947
103.404	-1.796
119.494	-1.921
137.001	-1.943



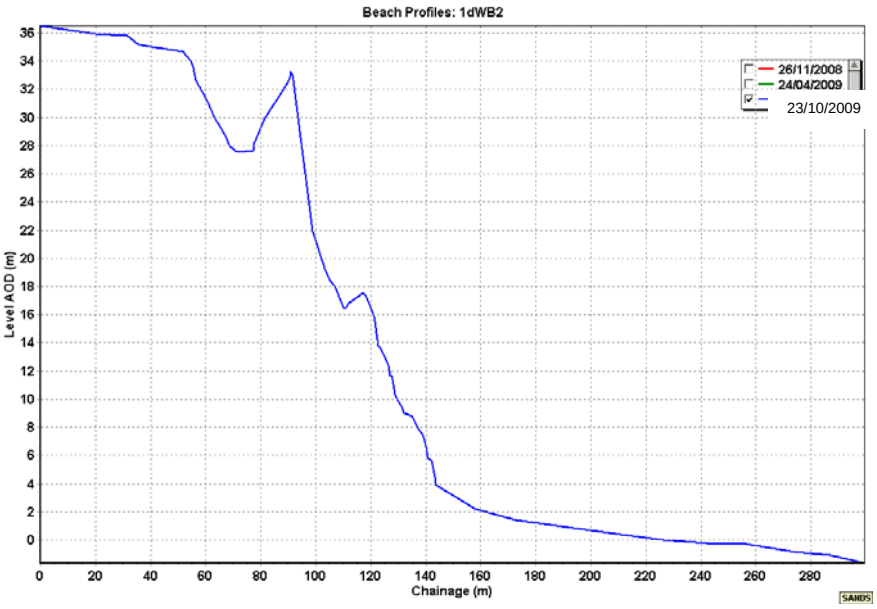

Beach Profiles: 1dWB1
26/11/2008
24/04/2009
23/10/2009
Level AOD (m)
Chainage (m)
SANDS

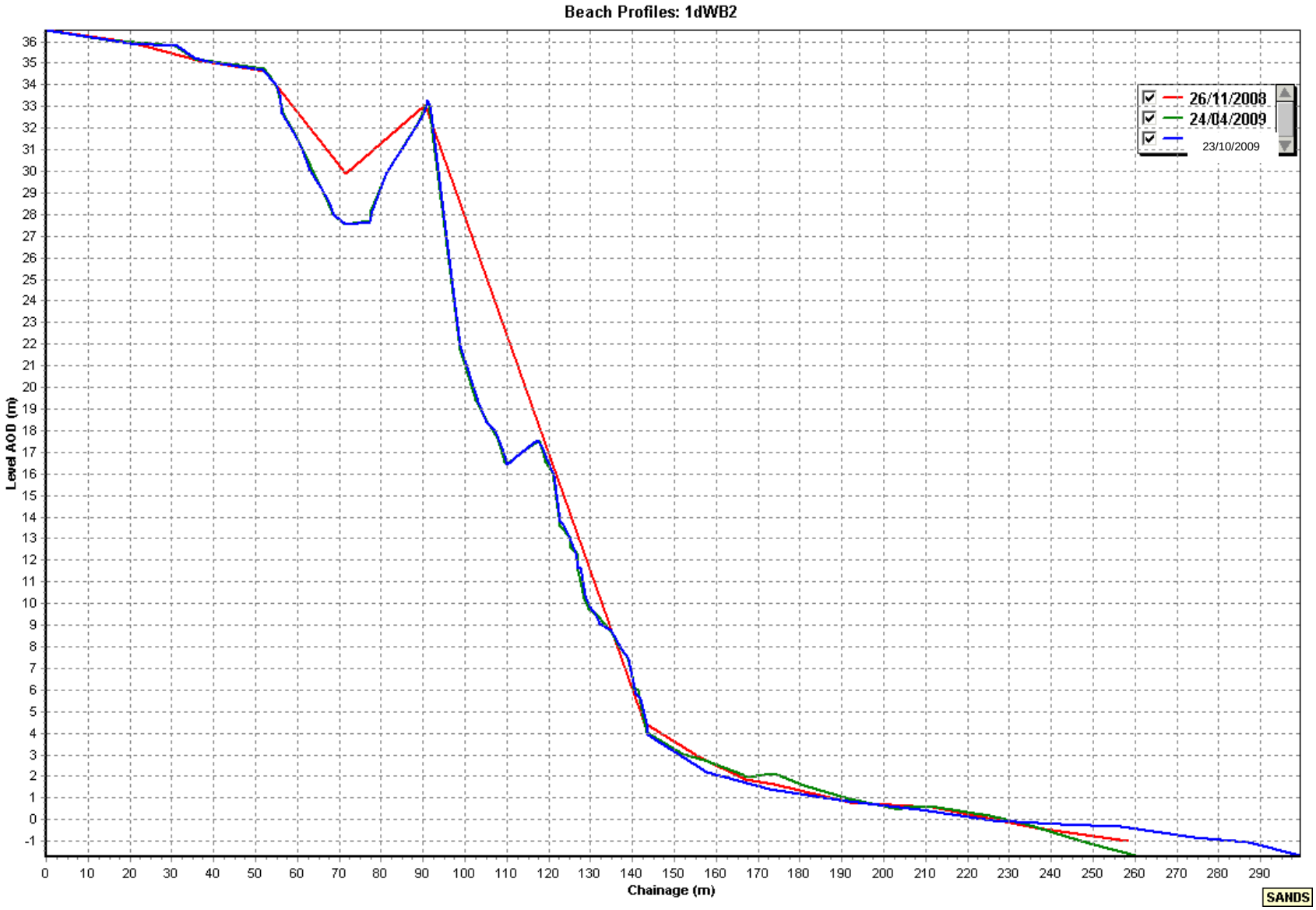
Beach Profile

1dWB2

Date 23/10/2009 **Wind** **Summary** Windy	**Inspector** **Sea State** Rough	**Low Tide (m)** **Visibility** -	**Low Tide Time** 10.56 – 13.12 **Rain** Yes
Easting 487550.221	**Northing** 511927.902	**Bearing** 32	

Chainage (from base station)	Level AOD (m)
0	36.507
0.031	36.507
19.989	35.915
31.375	35.799
35.403	35.227
38.406	35.109
51.831	34.694
54.749	33.998
55.626	33.572
56.463	32.656
58.865	31.86
60.842	31.108
63.033	30.051
65.54	29.279
67.464	28.602
68.6	27.997
71.487	27.537
77.332	27.63
77.763	28.161
81.405	29.948
85.201	31.057
89.982	32.597
90.909	33.04
91.071	33.293
91.607	33.063
98.726	21.967
103.083	19.328
105.125	18.379
107.103	18.01
109.057	17.05
110.147	16.439
110.922	16.529
112.022	16.777
115.973	17.356
117.274	17.523
118.391	17.29
119.49	16.73
121.288	15.914
122.709	13.805
123.303	13.703
124.514	13.28
126.545	12.377
127.139	11.648
127.544	11.67
128.661	10.399
129.166	10.239
129.868	9.862
131.407	9.432
132.081	9.044
134.846	8.798
137.591	7.822
138.946	7.44
140.013	6.624
140.794	5.845
142.019	5.603
143.443	4.459
143.726	3.924
157.761	2.215
172.789	1.42
191.473	0.881
208.736	0.462
226.121	-0.023
242.272	-0.231
256.502	-0.307
274.007	-0.825
286.944	-1.069
299.425	-1.648



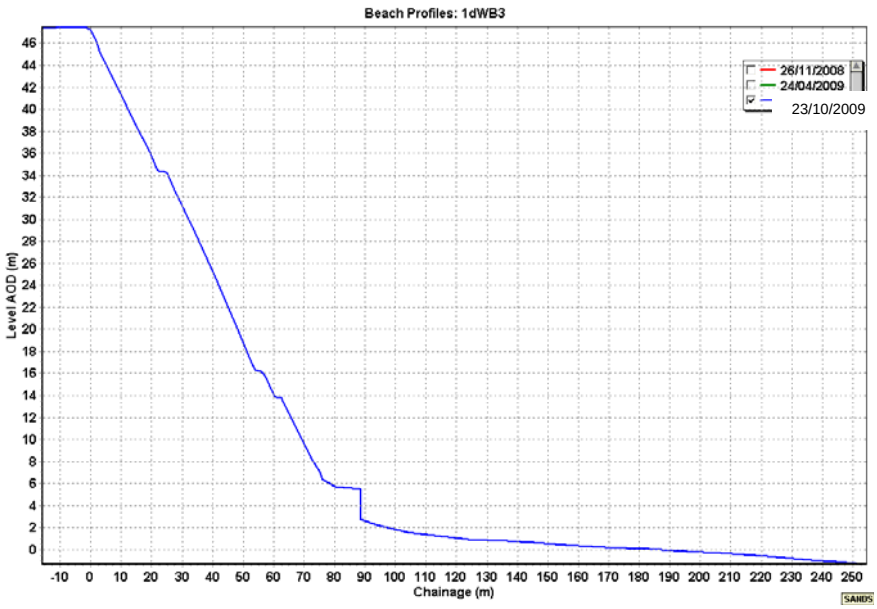

Beach Profiles: 1dWB2
26/11/2008
24/04/2009
23/10/2009
Level AOD (m)
Chainage (m)
SANDS

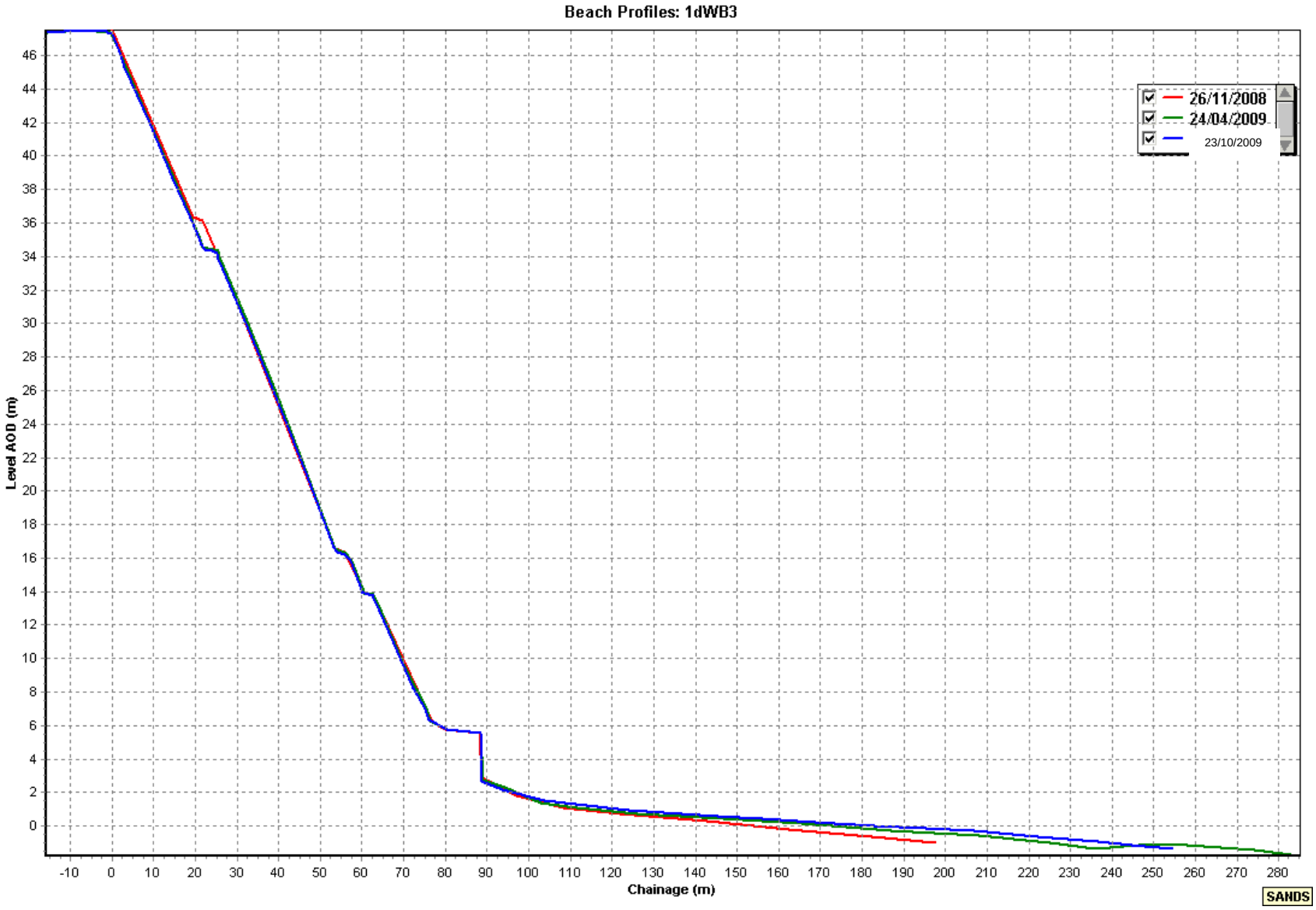
Beach Profile

1dWB3

Date 23/10/2009 **Wind** **Summary** Windy	**Inspector** **Sea State** Rough	**Low Tide (m)** **Visibility** -	**Low Tide Time** 10.56 – 13.12 **Rain** Yes
Easting 488983.57	**Northing** 511527.047	**Bearing** 19	

Chainage (from base station)	Level AOD (m)
0	47.272
1.704	46.242
2.883	45.282
8.928	41.938
14.589	38.636
18.976	36.286
21.283	34.928
21.593	34.731
22.37	34.447
24.038	34.34
25.154	34.229
25.539	33.862
27.605	32.681
34.207	28.781
40.891	24.726
47.12	20.662
53.107	16.661
54.101	16.321
55.855	16.212
57.262	15.846
60.221	13.893
60.736	13.87
62.646	13.773
62.856	13.586
66.621	11.545
72.391	8.243
75.267	7.032
76.081	6.338
80.252	5.754
88.366	5.525
88.41	5.552
88.674	2.705
93.774	2.205
103.846	1.544
123.821	0.929
136.559	0.774
145.231	0.628
155.951	0.415
168.626	0.225
182.987	0.034
195.381	-0.134
206.788	-0.304
222.004	-0.635
236.489	-0.947
244.538	-1.13
254.492	-1.327



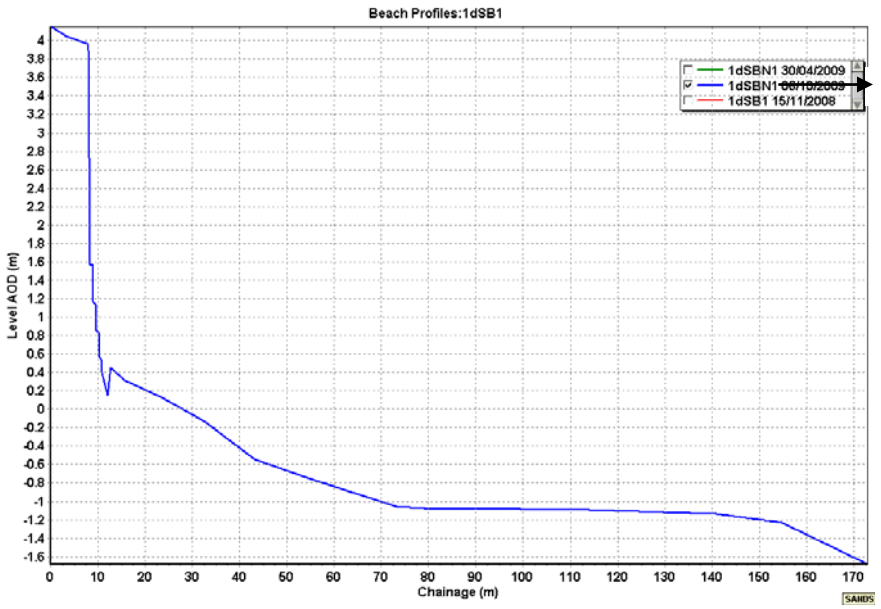

Beach Profiles: 1dWB3
Level AOD (m)
Chainage (m)
26/11/2008
24/04/2009
23/10/2009
SANDS

Beach Profile

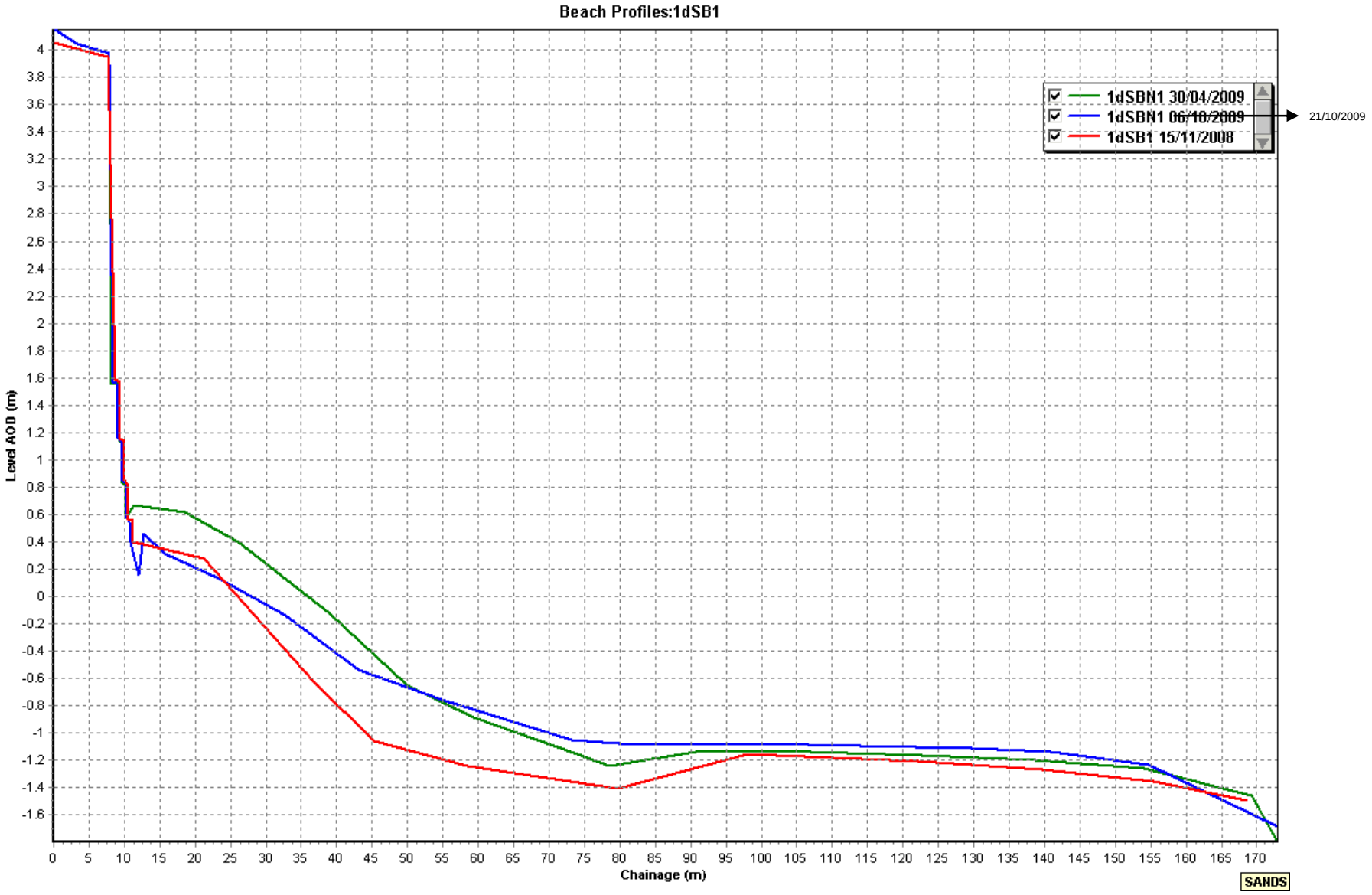
1dSB1

Date 21/10/2009 **Wind** **Summary** Windy	**Inspector** **Sea State** Rough	**Low Tide (m)** **Visibility** -	**Low Tide Time** 11.26 – 13.18 **Rain** Yes
Easting 503543.363	**Northing** 490470.74	**Bearing** 79	

Chainage (from base station)	Level AOD (m)
0	4.15
0.111	4.15
3.328	4.045
7.775	3.972
7.891	3.902
8.282	1.572
8.905	1.561
9.006	1.164
9.628	1.131
9.658	0.854
10.237	0.832
10.291	0.57
10.839	0.533
10.887	0.402
12.031	0.152
12.78	0.456
15.65	0.313
23.383	0.129
32.668	-0.139
43.135	-0.54
54.803	-0.753
73.189	-1.052
81.994	-1.084
99.475	-1.078
113.978	-1.092
129.702	-1.113
140.85	-1.135
154.74	-1.231
172.917	-1.681



21/10/2009

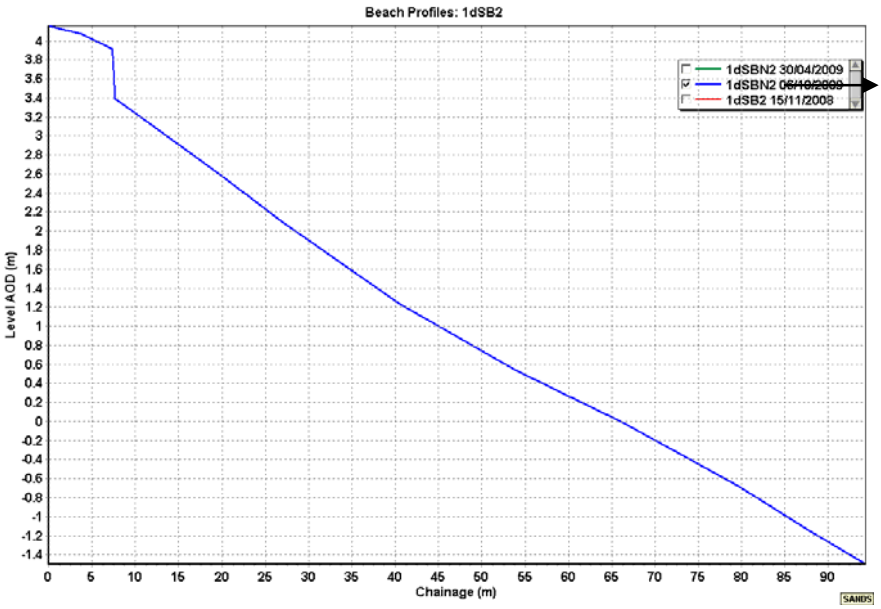

Beach Profiles:1dSB1
1dSBN1 30/04/2009
1dSBN1 06/10/2009
1dSB1 15/11/2008
21/10/2009
Level AOD (m)
Chainage (m)
SANDS

Beach Profile

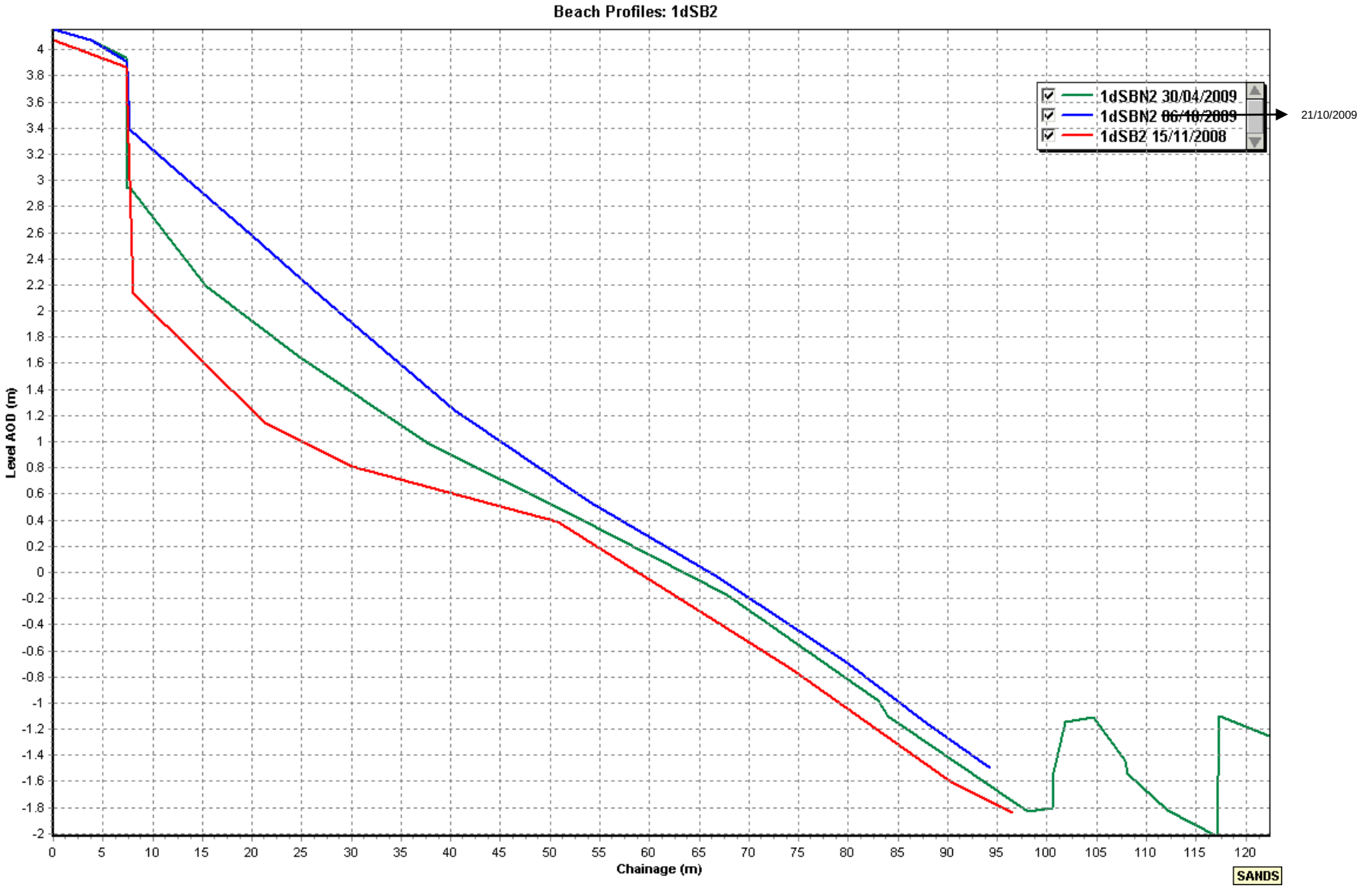
1dSB2

Date 21/10/2009 **Wind** **Summary** Windy	**Inspector** **Sea State** Rough	**Low Tide (m)** **Visibility** -	**Low Tide Time** 11.26 – 13.18 **Rain** Yes
Easting 503616.346	**Northing** 490135.674	**Bearing** 78	

Chainage (from base station)	Level AOD (m)
0	4.156
0.016	4.156
3.744	4.075
7.345	3.912
7.431	3.843
7.641	3.392
11.509	3.139
19.989	2.582
26.92	2.105
40.361	1.247
53.9	0.538
66.421	-0.021
79.56	-0.673
87.897	-1.156
94.295	-1.498



21/10/2009

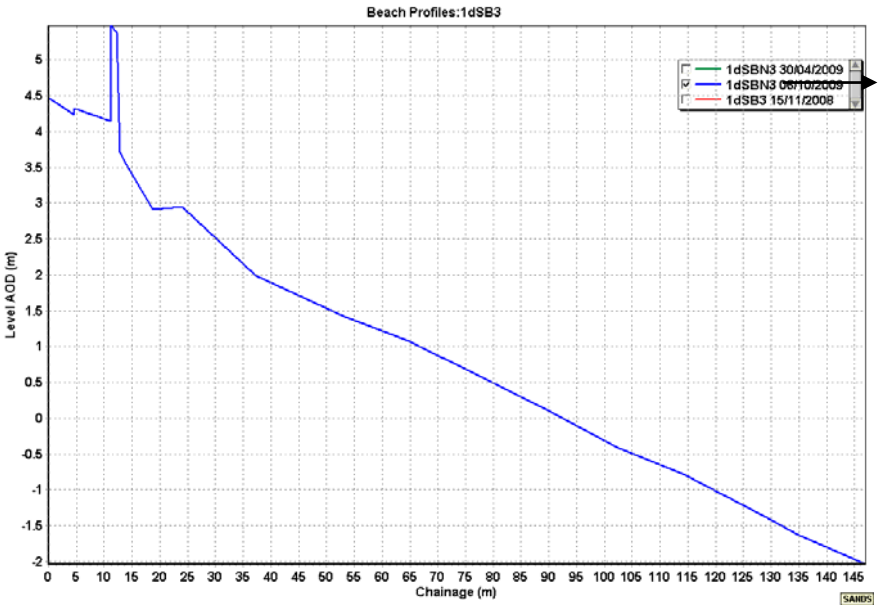

Beach Profiles: 1dSB2
1dSBN2 30/04/2009
1dSBN2 06/10/2009
1dSB2 15/11/2008
21/10/2009
Level AOD (m)
Chainage (m)
SANDS

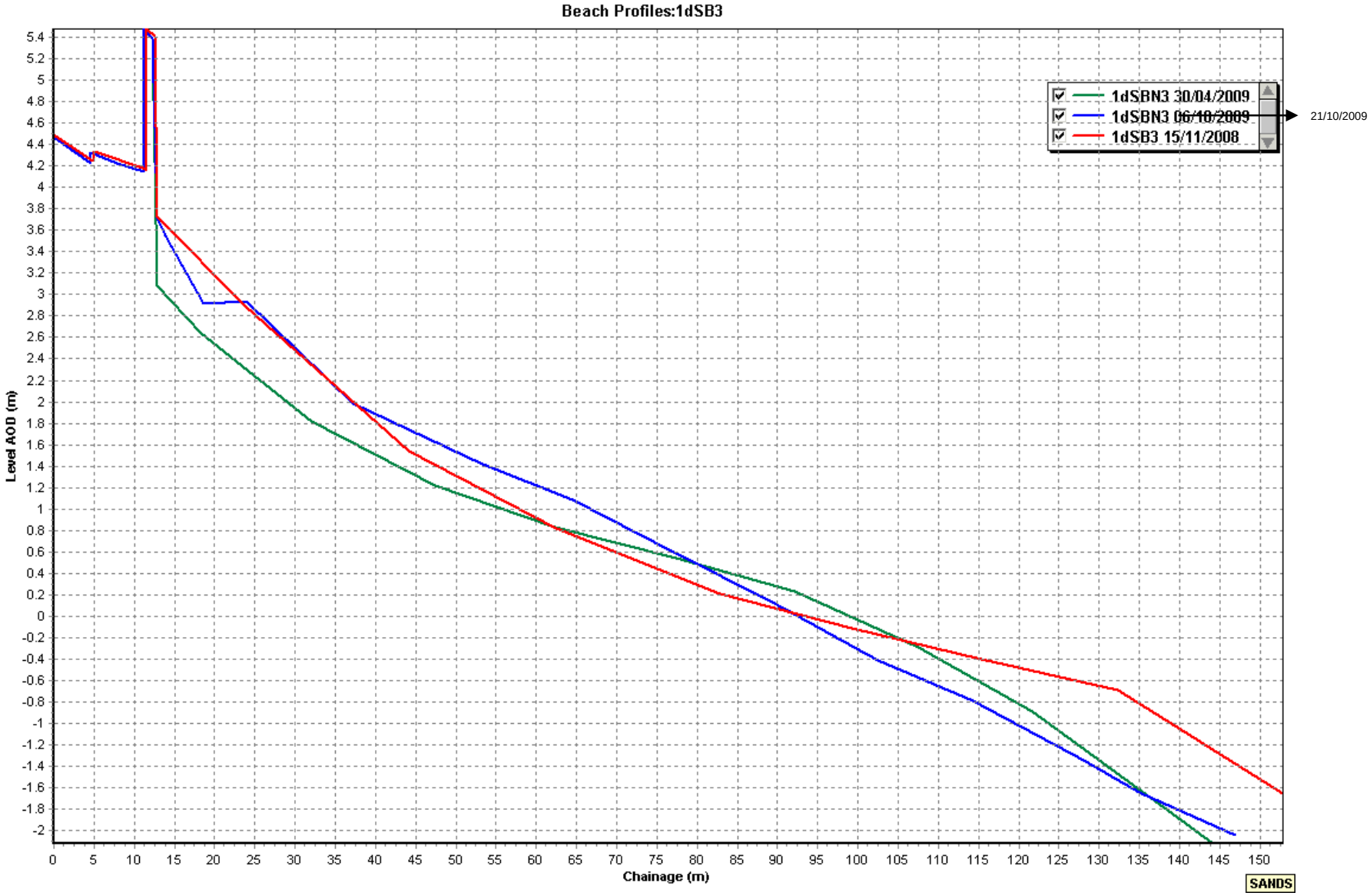
Beach Profile

1dSB3

Date 21/10/2009 **Wind** **Summary** Windy	**Inspector** **Sea State** Rough	**Low Tide (m)** **Visibility** -	**Low Tide Time** 11.26 – 13.18 **Rain** Yes
Easting 503803.958	**Northing** 489708.316	**Bearing** 58	

Chainage (from base station)	Level AOD (m)
0	4.464
0.017	4.464
4.546	4.229
4.585	4.325
7.851	4.228
11.219	4.141
11.282	5.473
12.215	5.389
12.88	3.713
13.949	3.545
18.68	2.918
23.985	2.943
37.217	1.989
53.29	1.416
64.615	1.082
76.85	0.612
89.291	0.127
102.448	-0.413
114.257	-0.79
128.354	-1.353
134.973	-1.639
146.979	-2.036



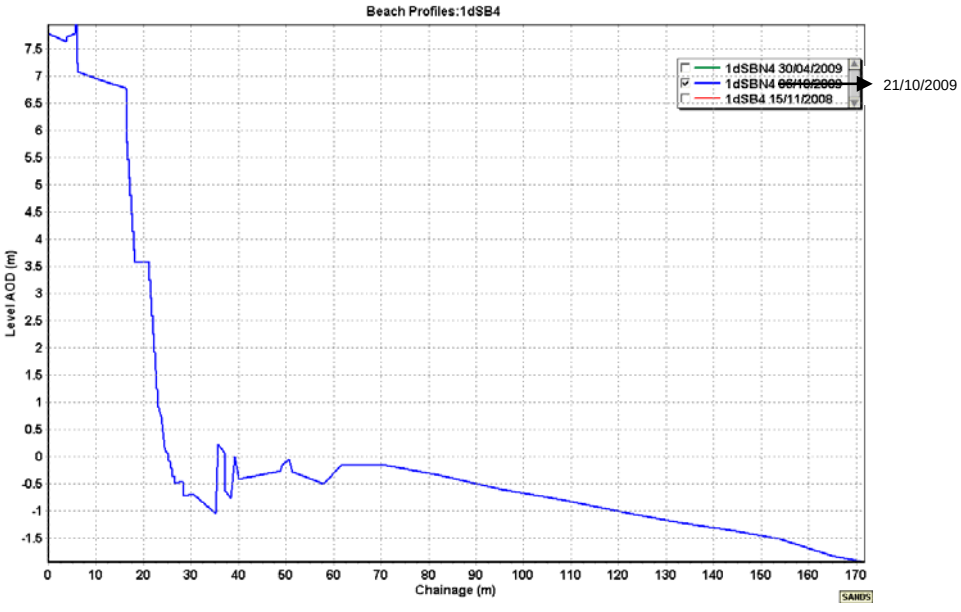

Beach Profiles:1dSB3
1dSBN3 30/04/2009
1dSBN3 06/10/2009
1dSB3 15/11/2008
21/10/2009
Level AOD (m)
Chainage (m)
SANDS

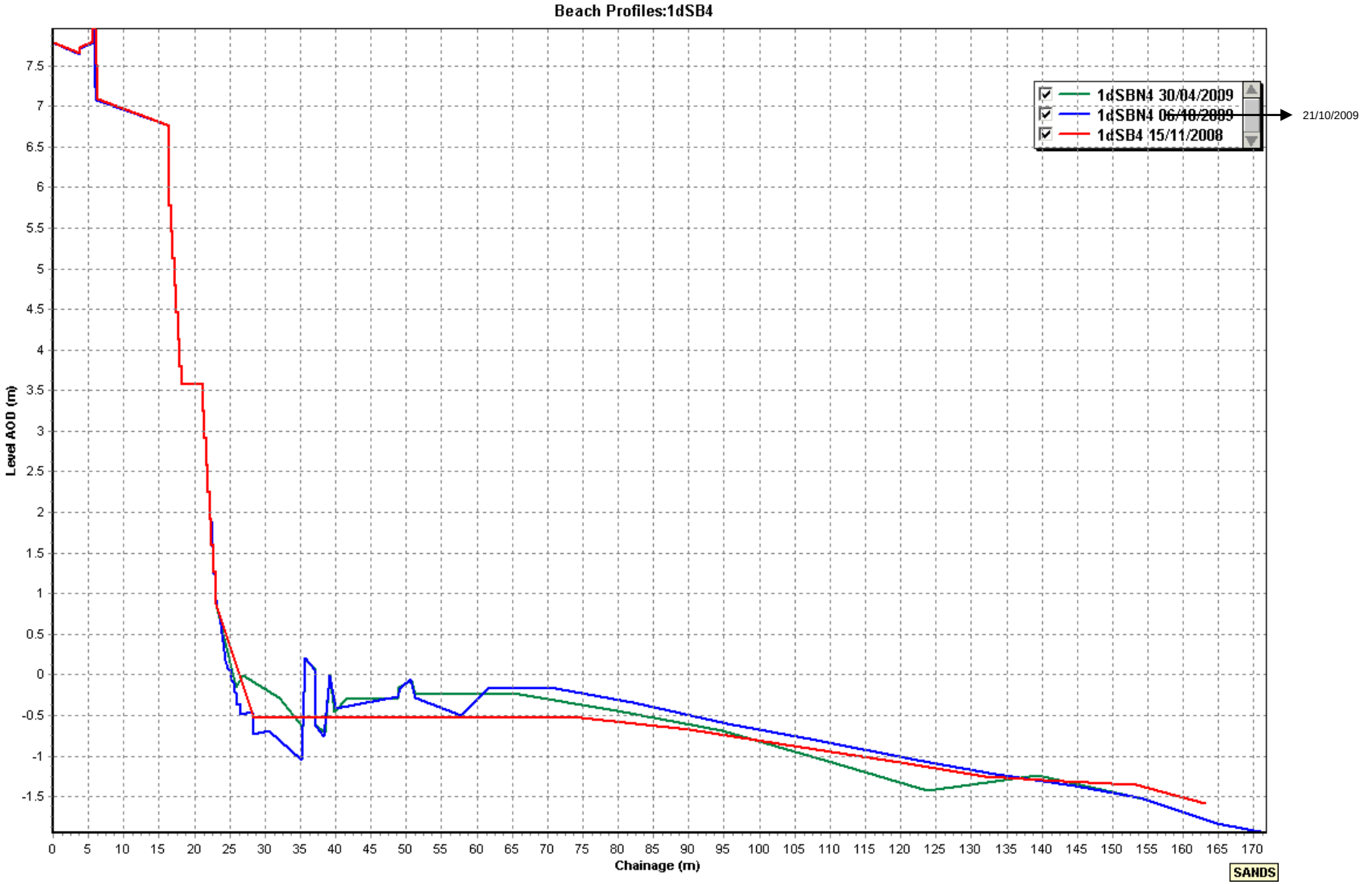
Beach Profile

1dSB4

Date 21/10/2009 **Wind** **Summary** Windy	**Inspector** **Sea State** Rough	**Low Tide (m)** **Visibility** -	**Low Tide Time** 11.26 – 13.18 **Rain** Yes
Easting 504111.79	**Northing** 489397.699	**Bearing** 38	

Chainage (from base station)	Level AOD (m)
0	7.781
0.007	7.781
3.744	7.638
3.785	7.717
5.615	7.784
5.69	7.945
5.915	7.94
6.03	7.239
6.115	7.246
6.22	7.072
11.017	6.929
16.156	6.776
16.474	6.757
16.479	5.781
16.678	5.45
16.678	5.78
16.927	5.45
16.928	5.12
17.178	4.79
17.178	5.12
17.428	4.46
17.428	4.79
17.678	4.46
17.679	4.13
17.928	4.13
17.929	3.8
18.178	3.57
18.178	3.8
21.228	3.57
21.229	3.24
21.476	3.24
21.478	2.91
21.727	2.91
21.729	2.58
21.977	2.58
21.979	2.25
22.227	2.25
22.266	1.924
22.482	1.898
22.54	1.584
22.782	1.54
22.79	1.242
22.945	1.229
23.129	0.906
23.29	0.896
23.301	0.826
23.635	0.726
24.465	0.172
24.754	0.078
25.194	0.046
25.278	-0.074
25.558	-0.092
25.654	-0.216
26.038	-0.236
26.088	-0.367
26.527	-0.355
26.534	-0.49
28.219	-0.463
28.35	-0.732
30.531	-0.696
35.173	-1.05
35.658	0.21
37.058	0.069
37.24	-0.635
38.407	-0.763
39.151	-0.008
39.969	-0.421
48.727	-0.276
49.198	-0.166
50.585	-0.052
51.357	-0.283
57.789	-0.5
61.789	-0.158
71.201	-0.173
82.087	-0.338
95.442	-0.601
107.991	-0.801
122.312	-1.048
133.384	-1.23
144.731	-1.375
153.845	-1.513
164.852	-1.835
171.752	-1.947



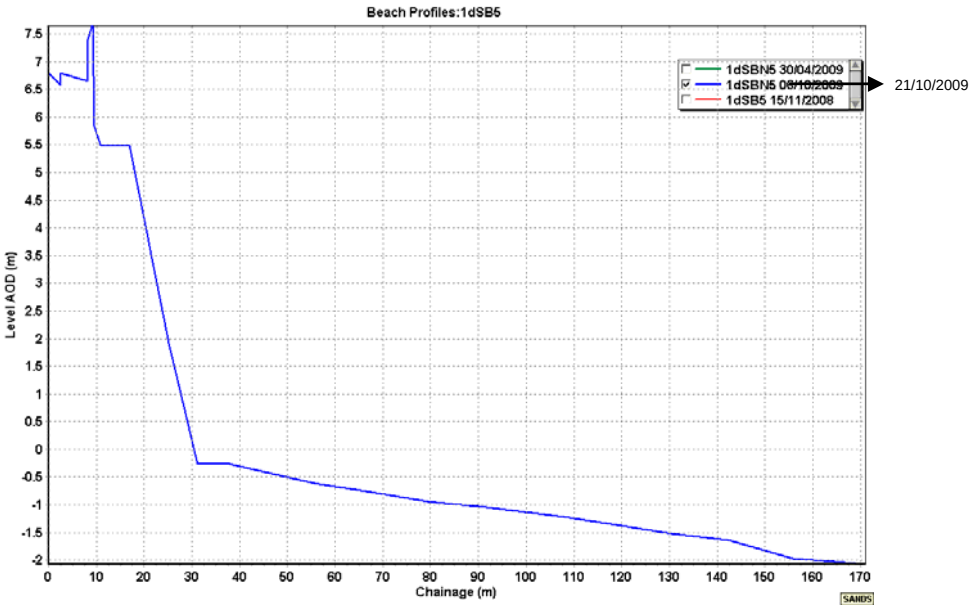

Beach Profiles:1dSB4
1dSBN4 30/04/2009
1dSBN4 06/10/2009
1dSB4 15/11/2008
21/10/2009
Level AOD (m)
Chainage (m)
SANDS

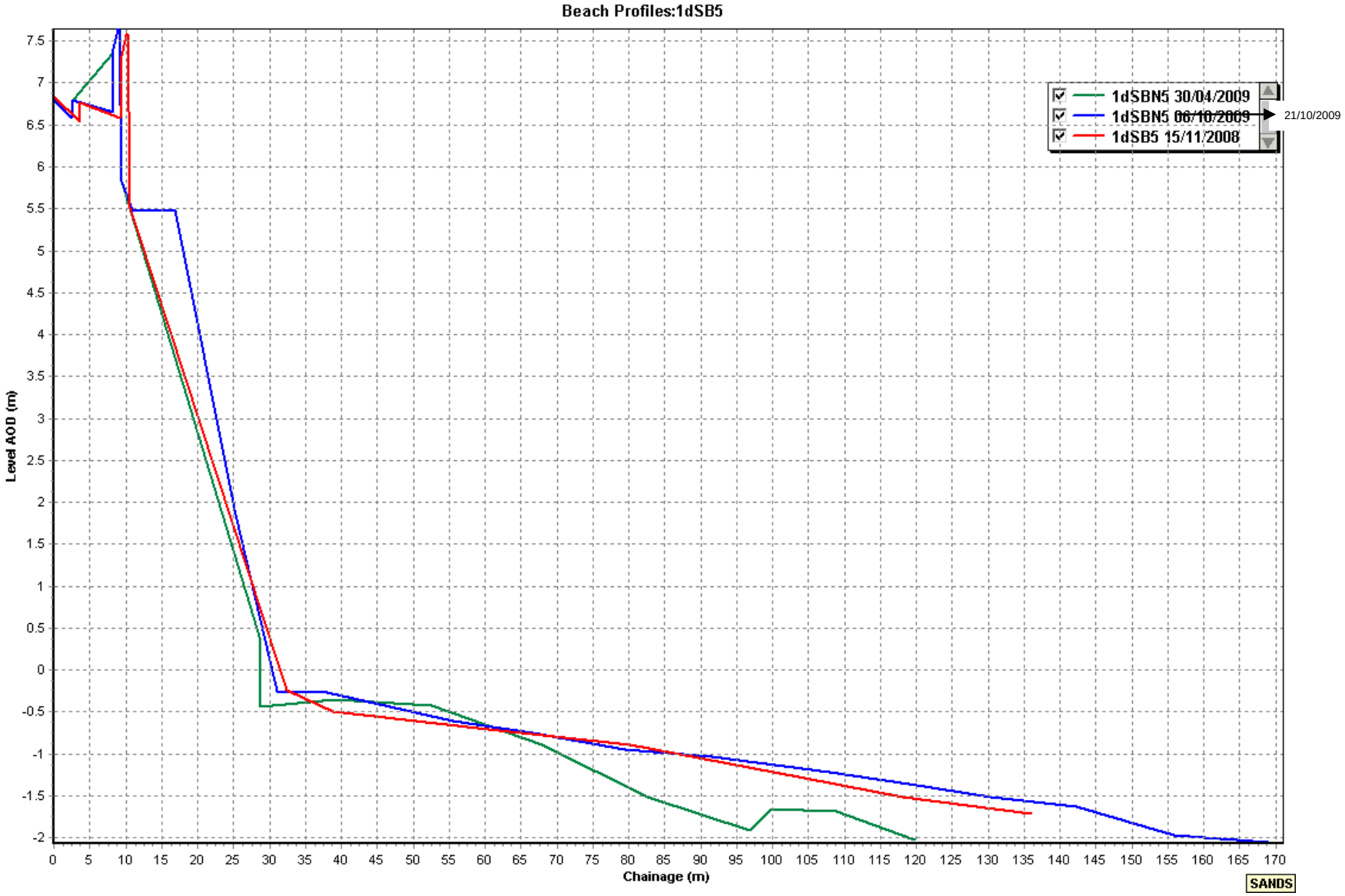
Beach Profile

1dSB5

Date 21/10/2009 **Wind** **Summary** Windy	**Inspector** **Sea State** Rough	**Low Tide (m)** **Visibility** -	**Low Tide Time** 11.26 – 13.18 **Rain** Yes
Easting 504515.599	**Northing** 489205.723	**Bearing** 14	

Chainage (from base station)	Level AOD (m)
0	6.793
0.001	6.793
2.504	6.58
2.576	6.796
8.228	6.646
8.231	6.652
8.235	7.361
8.283	7.397
8.986	7.645
9.164	7.645
9.489	5.833
10.856	5.495
14.148	5.474
16.925	5.496
25.081	1.919
31.109	-0.257
37.935	-0.263
55.596	-0.612
66.561	-0.755
79.434	-0.944
91.616	-1.037
107.868	-1.217
118.982	-1.367
130.45	-1.522
142.235	-1.635
155.821	-1.967
171.058	-2.069



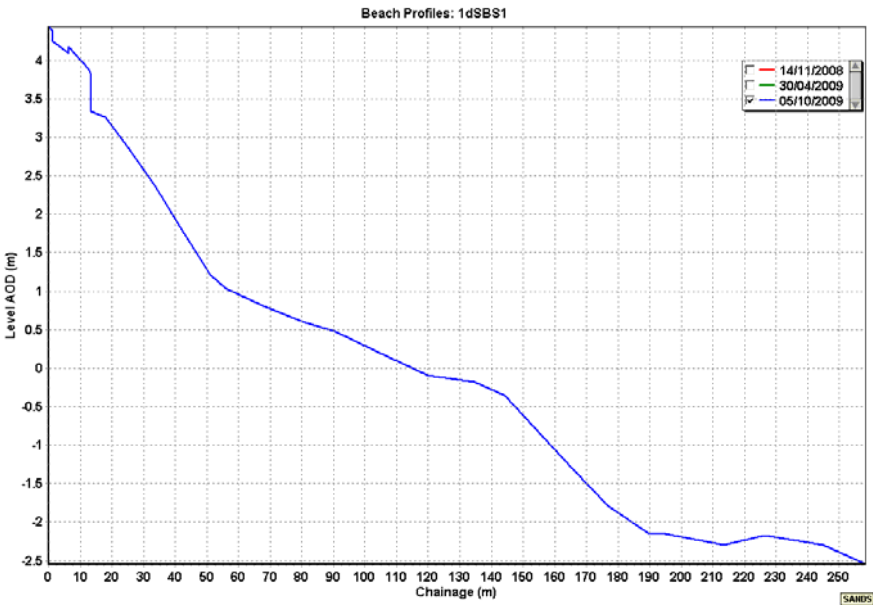

Beach Profiles:1dSB5
1dSBN5 30/04/2009
1dSBN5 06/10/2009
1dSB5 15/11/2008
21/10/2009
Level AOD (m)
Chainage (m)
SANDS

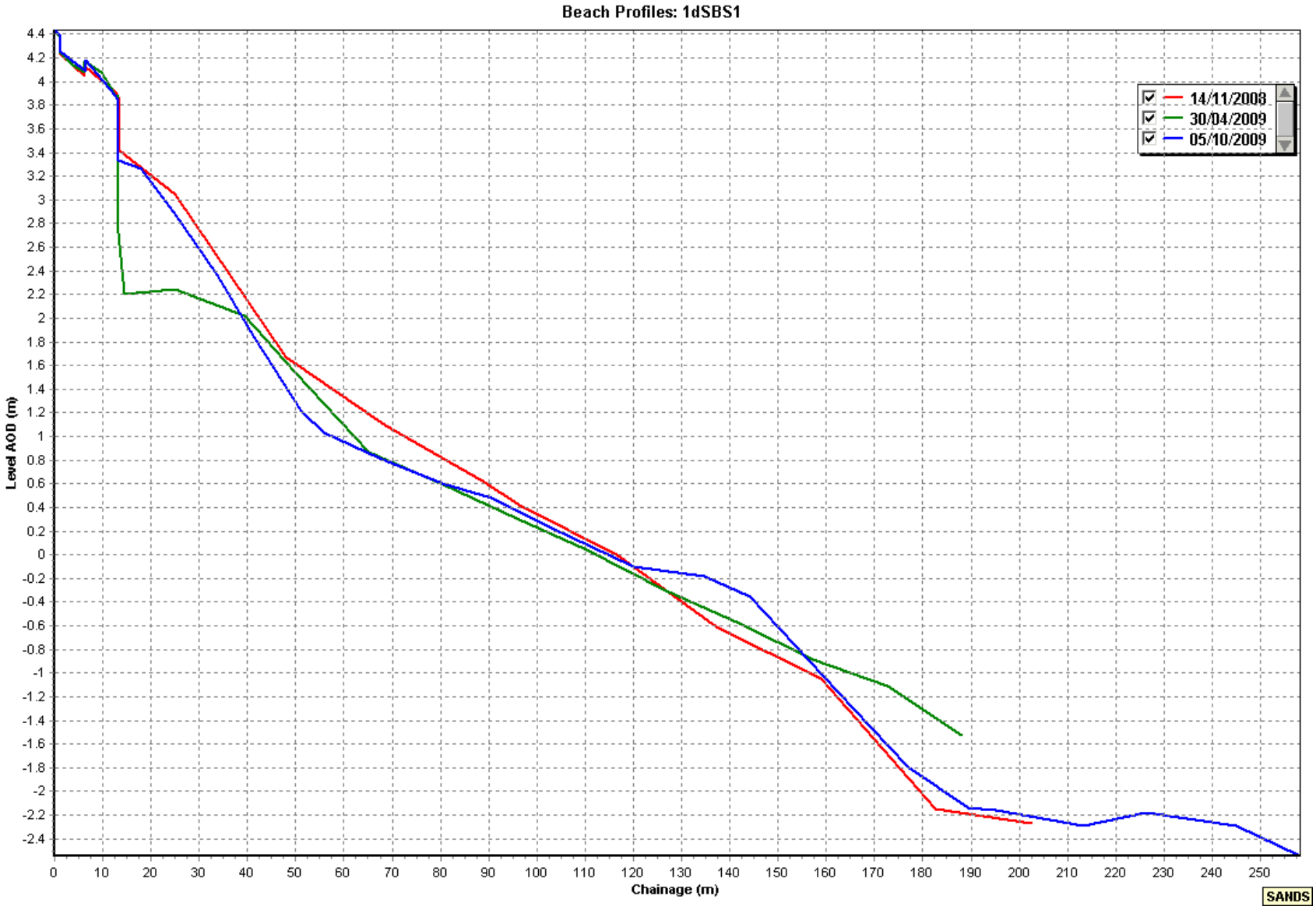
Beach Profile

1dSBS1

Date 05/10/2009 **Wind** **Summary** Fine	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility** -	**Low Tide Time** 10.58 **Rain** No
Easting 504544.727	**Northing** 488604.814	**Bearing** 120	

Chainage (from base station)	Level AOD (m)
0	4.367
0.004	4.367
0.064	4.434
1.145	4.386
1.177	4.25
6.369	4.093
6.424	4.177
12.561	3.887
13.22	3.84
13.323	3.333
17.868	3.265
24.646	2.894
33.682	2.368
41.507	1.836
51.192	1.21
55.991	1.036
67.385	0.816
80.334	0.601
90.54	0.476
102.66	0.233
120.004	-0.096
134.658	-0.181
144.267	-0.352
156.38	-0.895
165.641	-1.305
176.829	-1.791
189.309	-2.136
195.117	-2.155
213.415	-2.295
226.311	-2.176
244.878	-2.293
258.222	-2.546



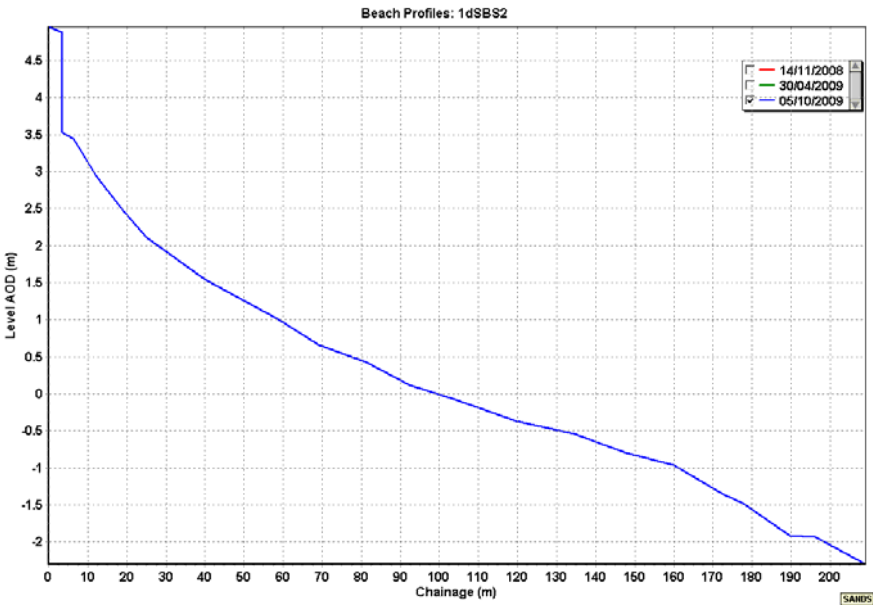

Beach Profiles: 1dSBS1
14/11/2008
30/04/2009
05/10/2009
Level AOD (m)
Chainage (m)
SANDS

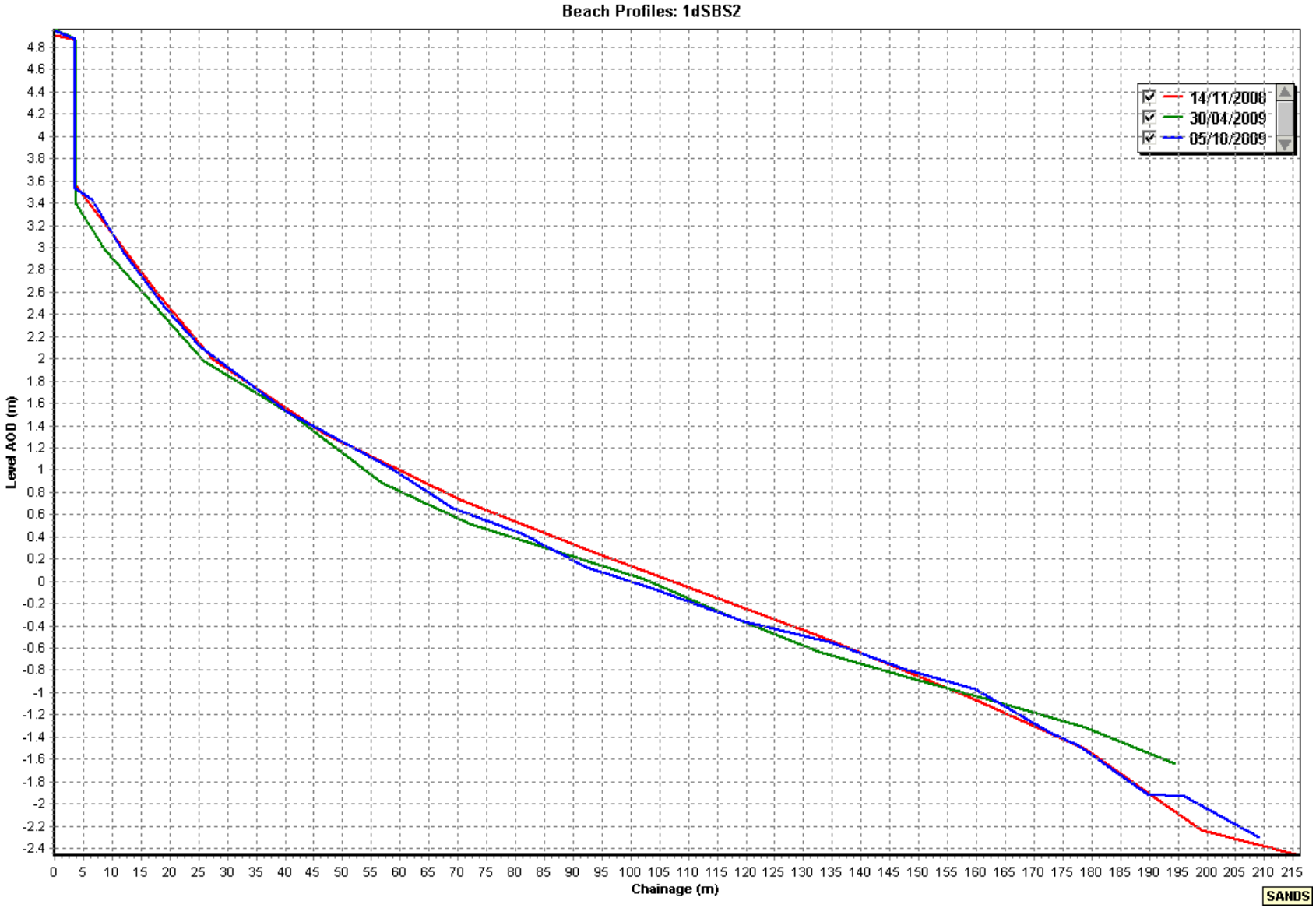
Beach Profile

1dSBS2

Date 05/10/2009 **Wind** **Summary** Fine	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility** -	**Low Tide Time** 10.58 **Rain** No
Easting 504443.218	**Northing** 488326.371	**Bearing** 105	

Chainage (from base station)	Level AOD (m)
0	4.953
0.015	4.953
3.498	4.873
3.565	3.527
6.435	3.437
12.019	2.942
19.29	2.461
25.199	2.107
40.284	1.528
58.169	1.025
69.161	0.66
80.973	0.434
92.302	0.123
103.964	-0.073
119.652	-0.365
134.597	-0.542
147.851	-0.797
159.847	-0.966
172.676	-1.356
177.739	-1.481
189.557	-1.911
196.074	-1.934
209.012	-2.3



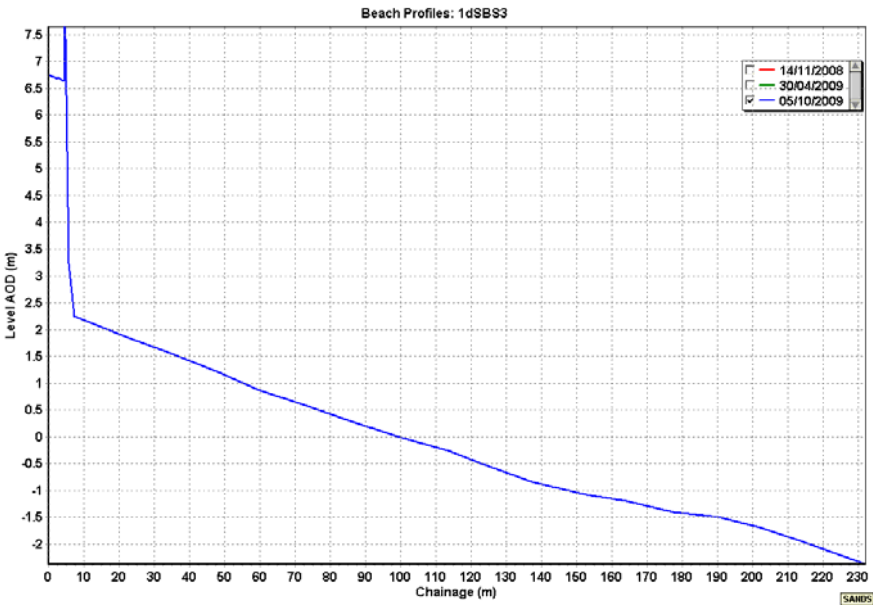

Beach Profiles: 1dSBS2
14/11/2008
30/04/2009
05/10/2009
Level AOD (m)
4.8 4.6 4.4 4.2 4 3.8 3.6 3.4 3.2 3 2.8 2.6 2.4 2.2 2 1.8 1.6 1.4 1.2 1 0.8 0.6 0.4 0.2 0 -0.2 -0.4 -0.6 -0.8 -1 -1.2 -1.4 -1.6 -1.8 -2 -2.2 -2.4
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215
Chainage (m)
SANDS

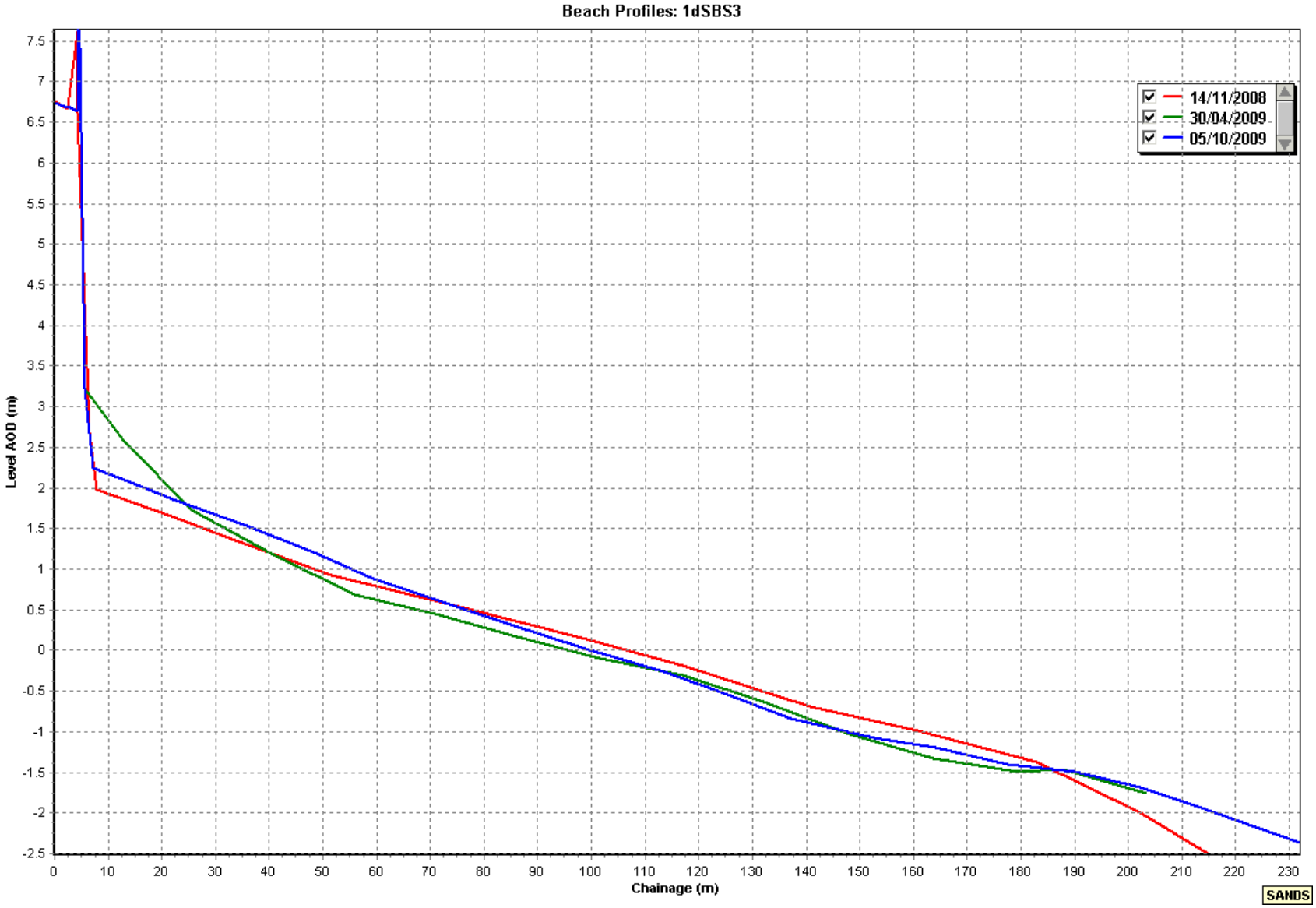
Beach Profile

1dSBS3

Date 05/10/2009 **Wind** **Summary** Fine	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility** -	**Low Tide Time** 10.58 **Rain** No
Easting 504423.086	**Northing** 488057.66	**Bearing** 83	

Chainage (from base station)	Level AOD (m)
0.000	6.745
0.012	6.745
2.456	6.673
2.493	6.698
4.287	6.633
4.434	7.579
4.516	7.644
4.773	7.425
5.644	3.227
7.177	2.246
14.740	2.049
22.692	1.851
35.121	1.551
47.652	1.215
59.459	0.877
72.152	0.602
84.373	0.330
98.843	0.014
113.367	-0.259
123.431	-0.503
137.281	-0.835
152.664	-1.076
164.091	-1.199
177.580	-1.407
190.137	-1.491
202.111	-1.690
213.008	-1.926
232.023	-2.372



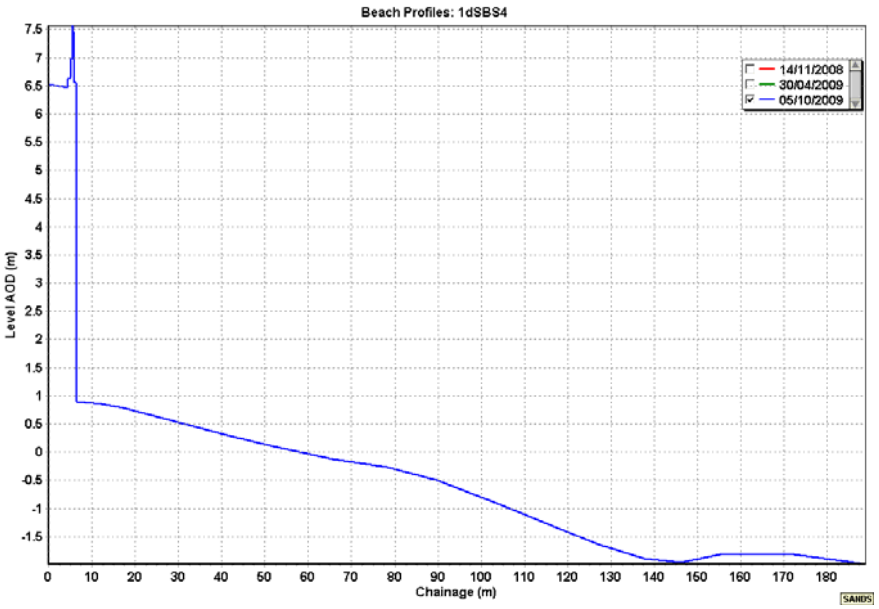

Beach Profiles: 1dSBS3
14/11/2008
30/04/2009
05/10/2009
Level AOD (m)
Chainage (m)
SANDS

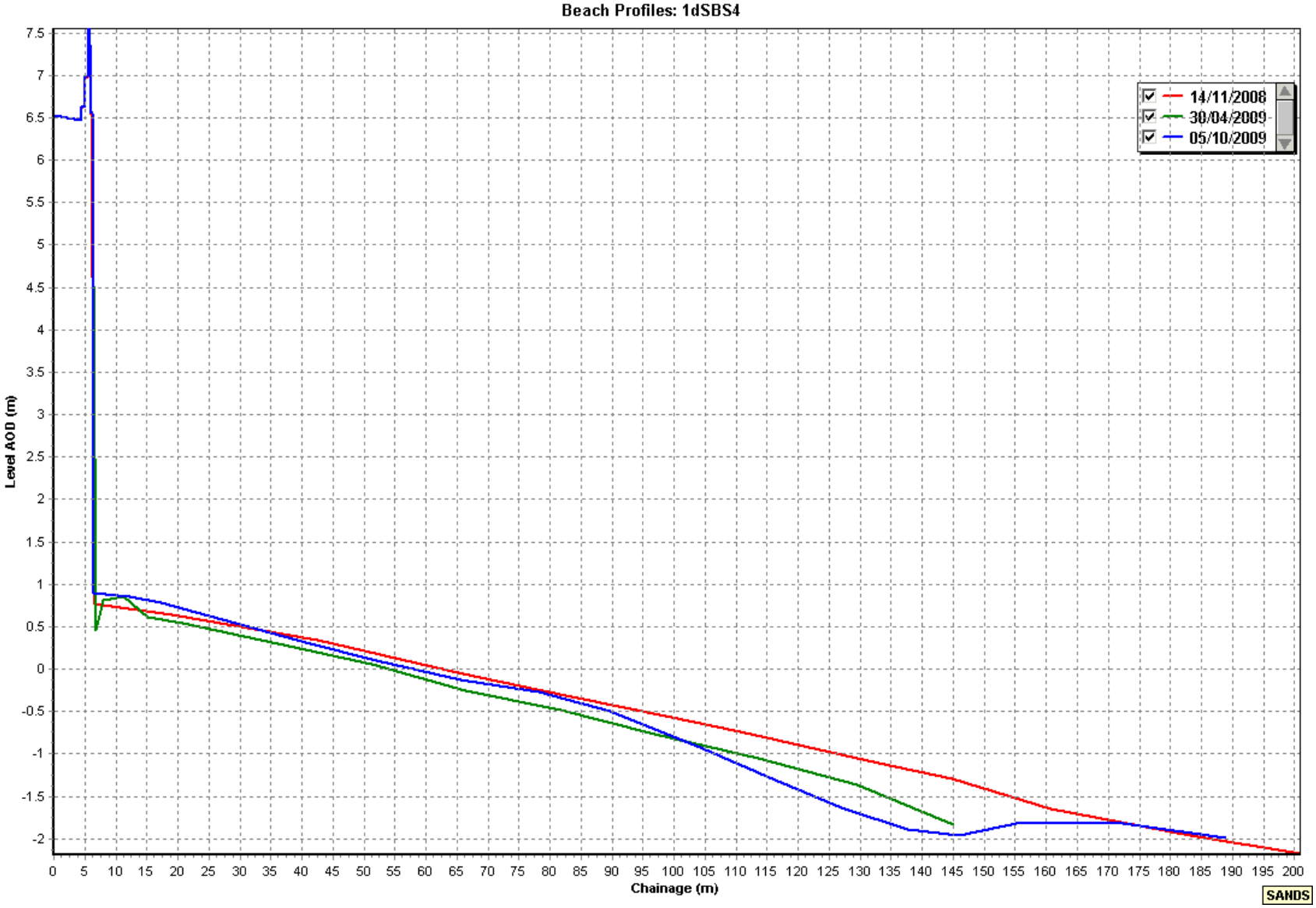
Beach Profile

1dSBS4

Date 05/10/2009 **Wind** **Summary** Fine	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility** -	**Low Tide Time** 10.58 **Rain** No
Easting 504494.785	**Northing** 484816.983	**Bearing** 74	

Chainage (from base station)	Level AOD (m)
0	6.523
0.017	6.523
4.441	6.474
4.489	6.627
5.084	6.64
5.12	6.979
5.525	6.982
5.556	7.51
5.632	7.563
5.914	7.359
5.975	6.552
6.211	6.56
6.495	0.896
12.204	0.858
17.252	0.786
27.147	0.585
41.3	0.304
52.009	0.103
65.609	-0.124
78.179	-0.265
89.677	-0.499
104.55	-0.933
116.353	-1.308
126.928	-1.633
137.613	-1.884
146.035	-1.955
156.039	-1.799
172.293	-1.822
188.838	-1.986



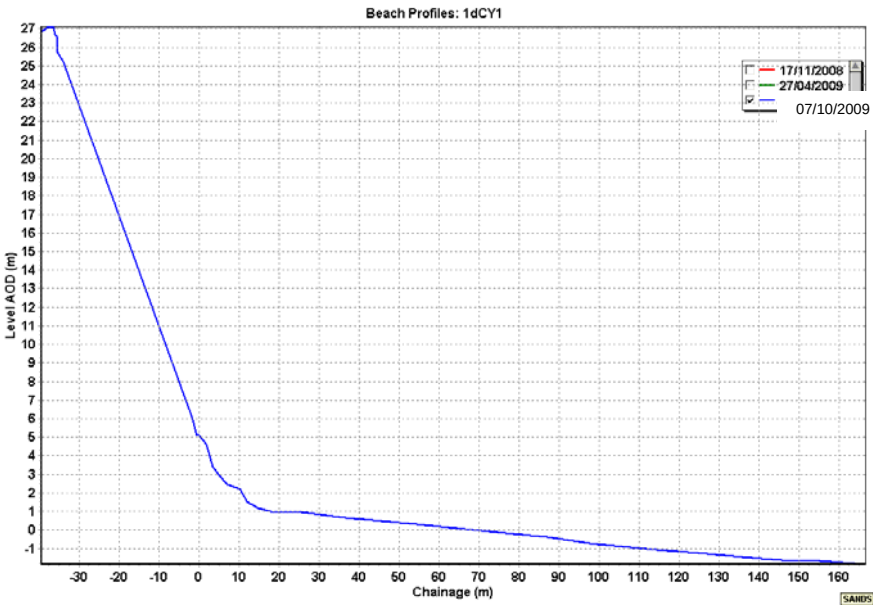

Beach Profiles: 1dSBS4
14/11/2008
30/04/2009
05/10/2009
Level AOD (m)
Chainage (m)
SANDS

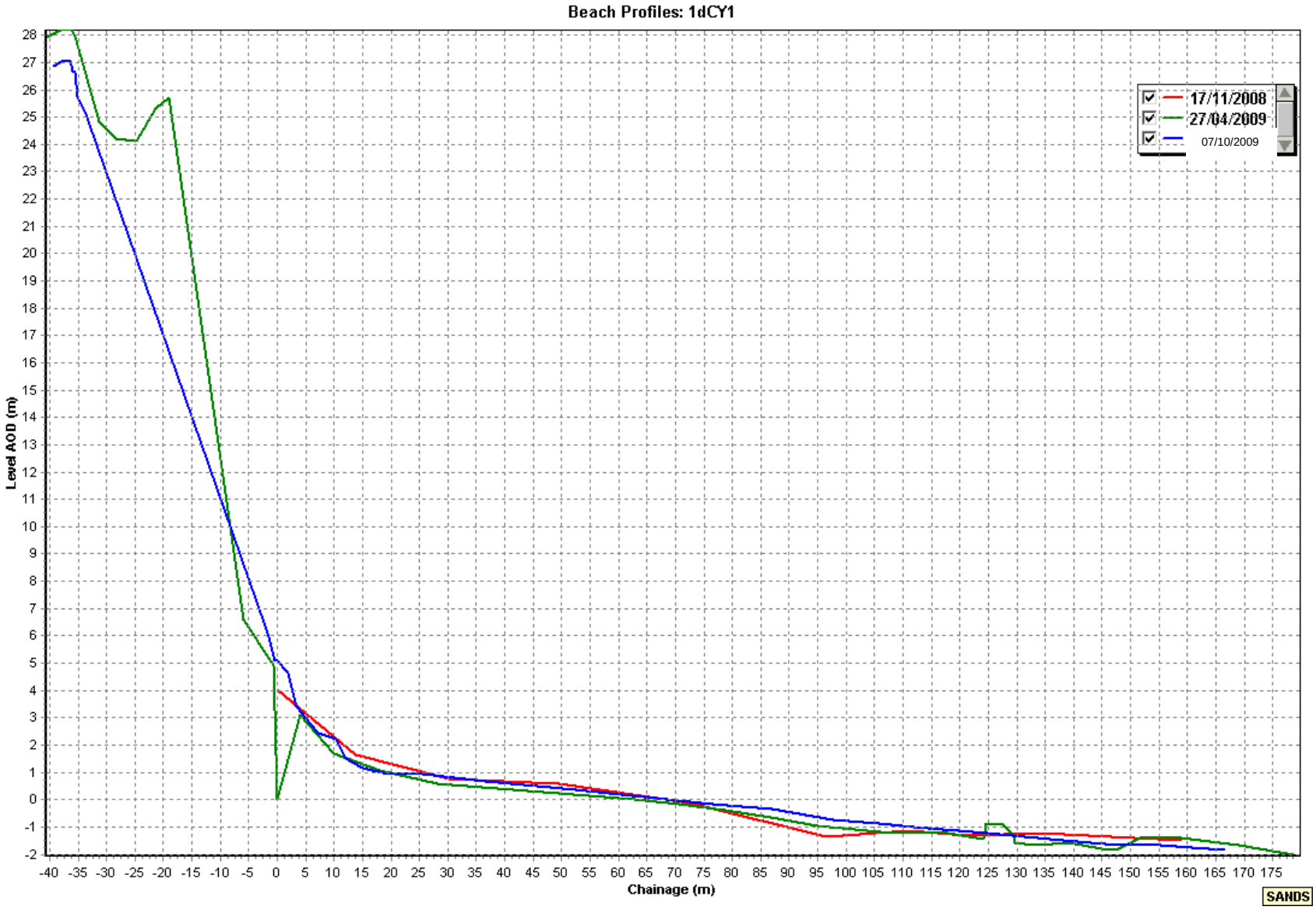
Beach Profile

1dCY1

Date 07/10/2009 **Wind** **Summary** Fine	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility -**	**Low Tide Time** 12.38 **Rain** No
Easting 506420.411	**Northing** 484793.941	**Bearing** 43	

Chainage (from base station)	Level AOD (m)
-39.295	26.855
-37.907	27.051
-36.299	27.102
-35.97	26.692
-35.491	26.648
-35.214	25.745
-33.866	25.239
-1.446	5.977
-0.48	5.105
0	5.105
1.885	4.64
3.443	3.42
5.131	2.95
7.167	2.452
10.31	2.215
12.143	1.527
14.946	1.182
18.573	0.972
25.702	0.946
36.693	0.668
52.539	0.347
62.392	0.123
76.567	-0.177
86.933	-0.356
97.676	-0.734
105.814	-0.886
111.802	-1.001
124.722	-1.226
135.714	-1.458
145.584	-1.625
155.239	-1.683
166.57	-1.839



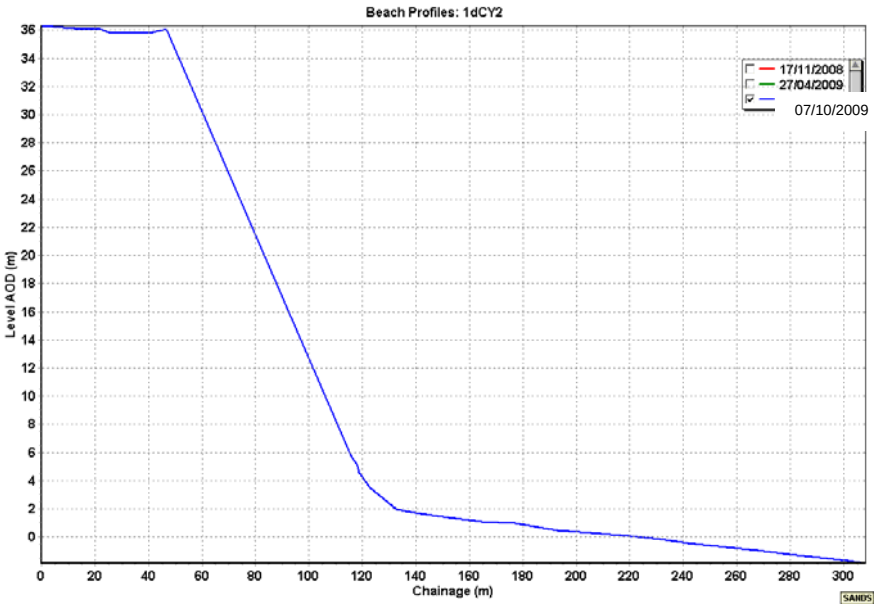

Beach Profiles: 1dCY1
17/11/2008
27/04/2009
07/10/2009
Level AOD (m)
Chainage (m)
SANDS

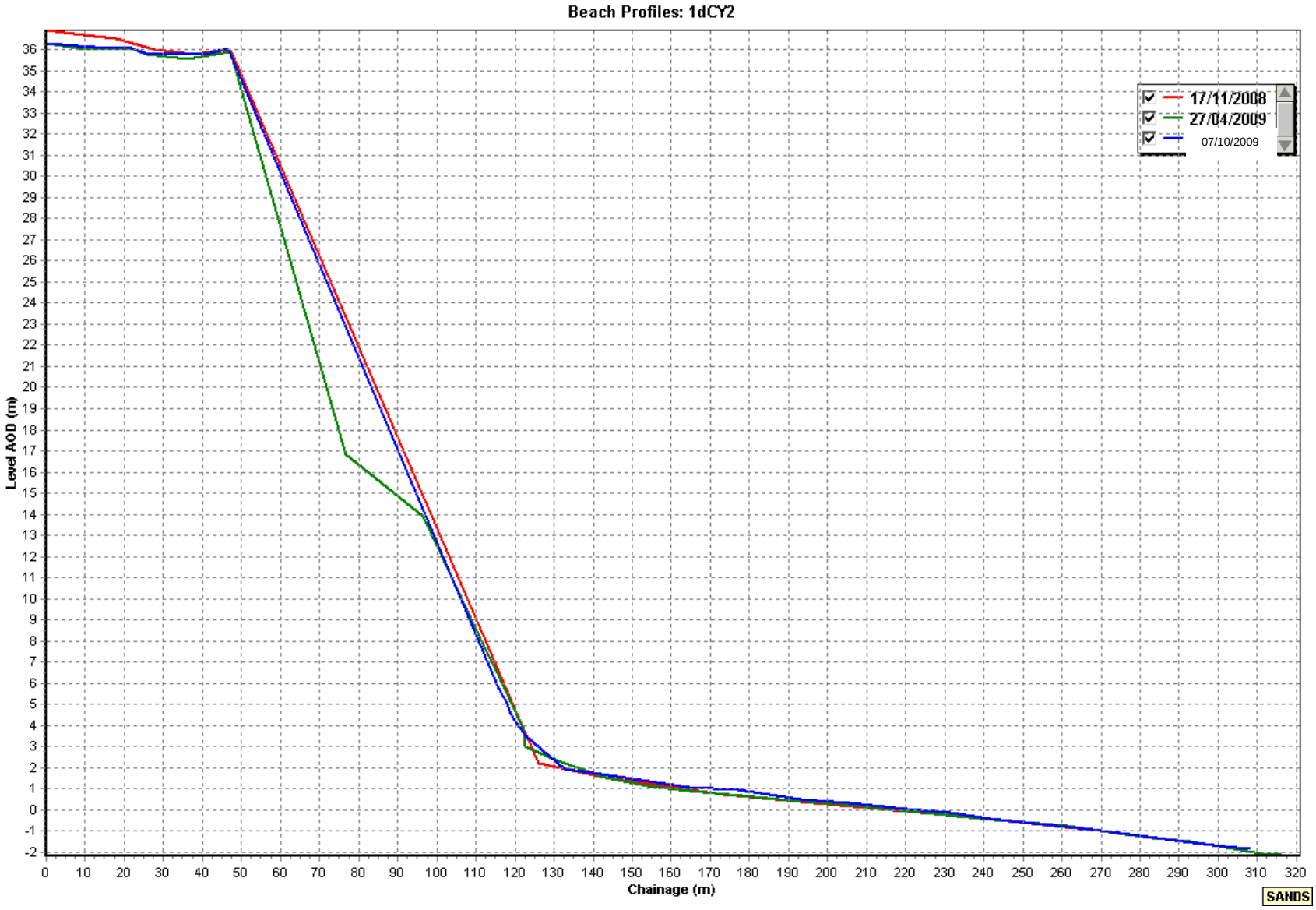
Beach Profile

1dCY2

Date 07/10/2009 **Wind** **Summary** Fine	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility -**	**Low Tide Time** 12.38 **Rain** No
Easting 506712.583	**Northing** 484325.966	**Bearing** 38	

Chainage (from base station)	Level AOD (m)
0	36.301
0.016	36.301
16.431	36.079
20.926	36.146
26.112	35.797
40.508	35.809
46.652	36.068
115.809	5.774
118.026	5.097
118.909	4.574
119.91	4.282
122.668	3.519
132.871	1.924
139.713	1.738
152.3	1.389
164.557	1.085
177.007	0.963
193.025	0.5
205.487	0.319
220.175	0.049
231.28	-0.141
241.624	-0.421
253.024	-0.661
267.651	-0.953
279.603	-1.221
291.148	-1.486
301.434	-1.704
308.146	-1.856



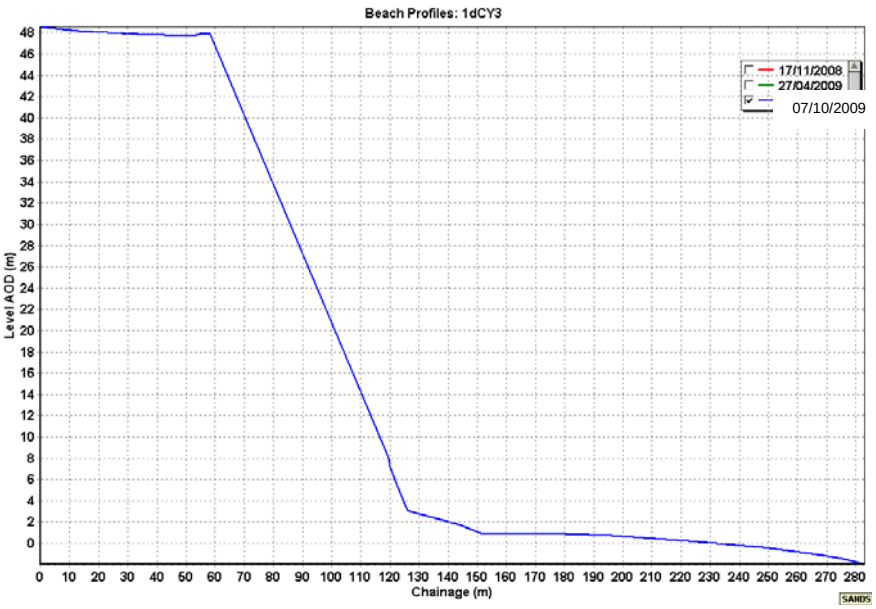

Beach Profiles: 1dCY2
17/11/2008
27/04/2009
07/10/2009
Level AOD (m)
Chainage (m)
SANDS

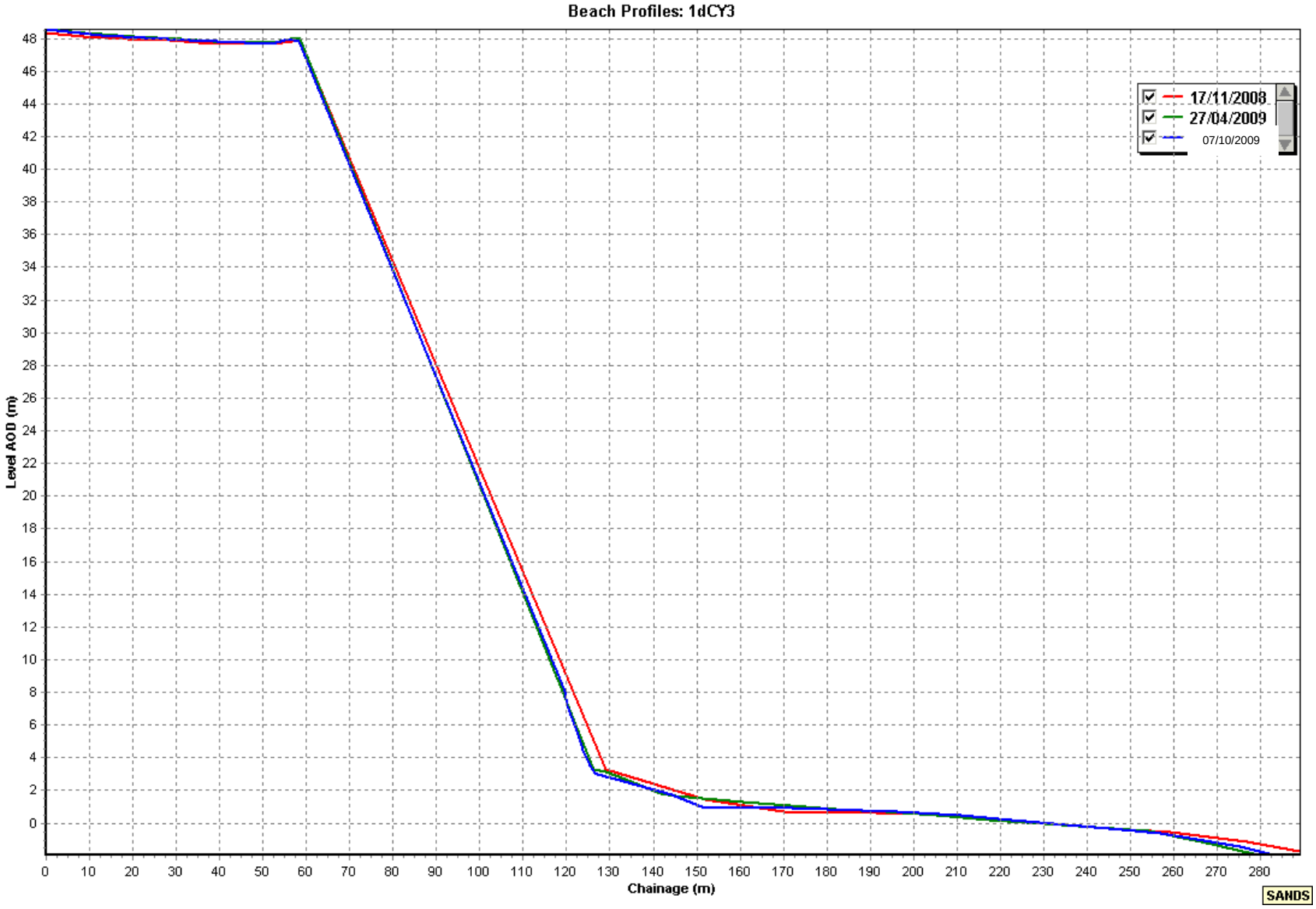
Beach Profile

1dCY3

Date 07/10/2009 **Wind** **Summary** Fine	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility -**	**Low Tide Time** 12.38 **Rain** No
Easting 507242.203	**Northing** 484080.896	**Bearing** 42	

Chainage (from base station)	Level AOD (m)
0	48.557
0.021	48.557
12.896	48.186
33.145	47.906
52.089	47.693
55.932	47.94
58.328	47.848
119.584	8.068
120.181	7.196
122.627	5.425
123.858	4.491
125.389	3.53
126.514	3.037
127.047	2.995
131.123	2.698
144.274	1.762
151.714	0.939
163.874	0.985
180.141	0.88
196.301	0.731
210.988	0.487
222.628	0.216
235.451	-0.083
248.099	-0.406
256.901	-0.657
268.663	-1.131
275.201	-1.402
282.989	-1.95



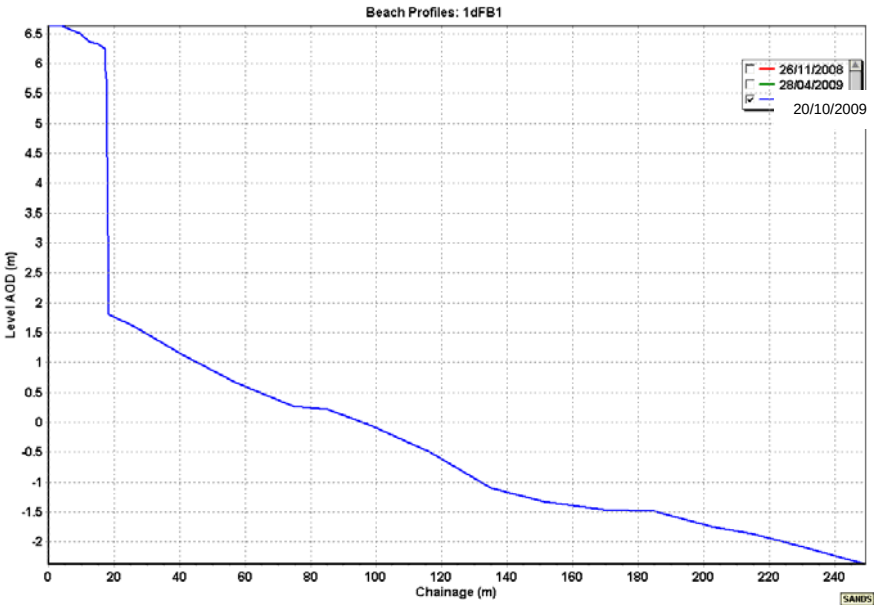

Beach Profiles: 1dCY3
Level AOD (m)
Chainage (m)
17/11/2008
27/04/2009
07/10/2009
SANDS

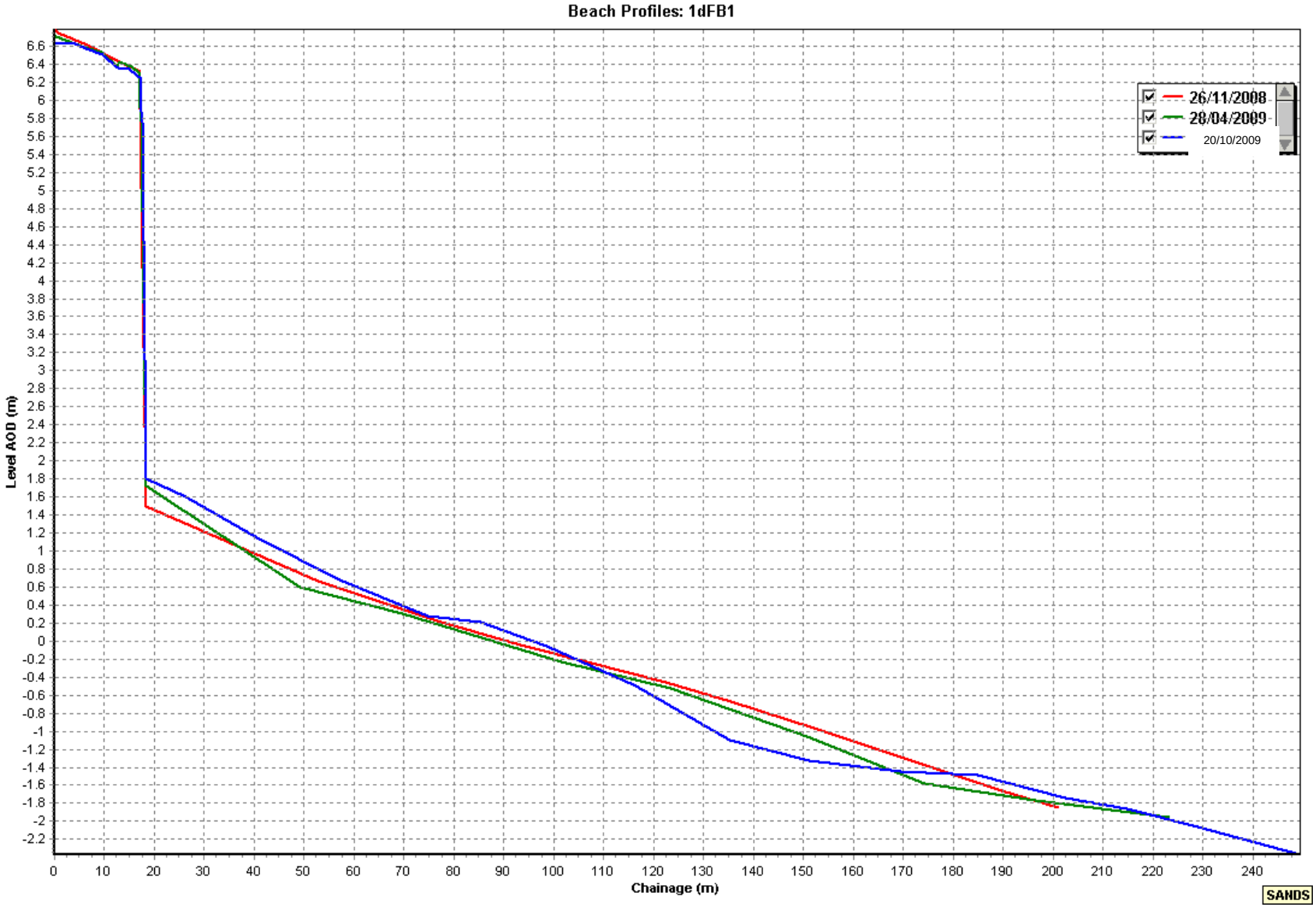
Beach Profile

1dFB1

Date 20/10/2009 **Wind** **Summary** Breezy	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility -**	**Low Tide Time** 10.56 – 13.12 **Rain** No
Easting 511989.528	**Northing** 480590.964	**Bearing** 100	

Chainage (from base station)	Level AOD (m)
0	6.631
4.137	6.631
6.257	6.574
6.373	6.578
9.713	6.501
12.571	6.366
12.667	6.361
14.834	6.343
16.398	6.283
17.252	6.242
17.313	5.88
17.59	5.759
18.281	1.803
26.351	1.601
40.949	1.132
57.026	0.676
74.72	0.274
85.189	0.21
98.489	-0.058
116.304	-0.493
135.07	-1.102
151.139	-1.323
169.369	-1.453
184.917	-1.484
202.313	-1.739
214.632	-1.856
229.003	-2.062
243.072	-2.275
249.402	-2.369



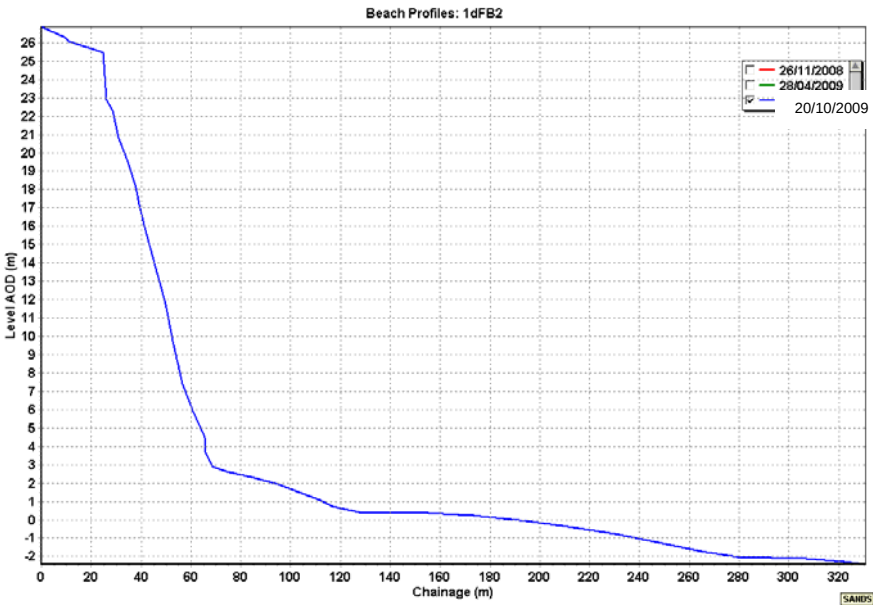

Beach Profiles: 1dFB1
26/11/2008
28/04/2009
20/10/2009
Level AOD (m)
Chainage (m)
SANDS

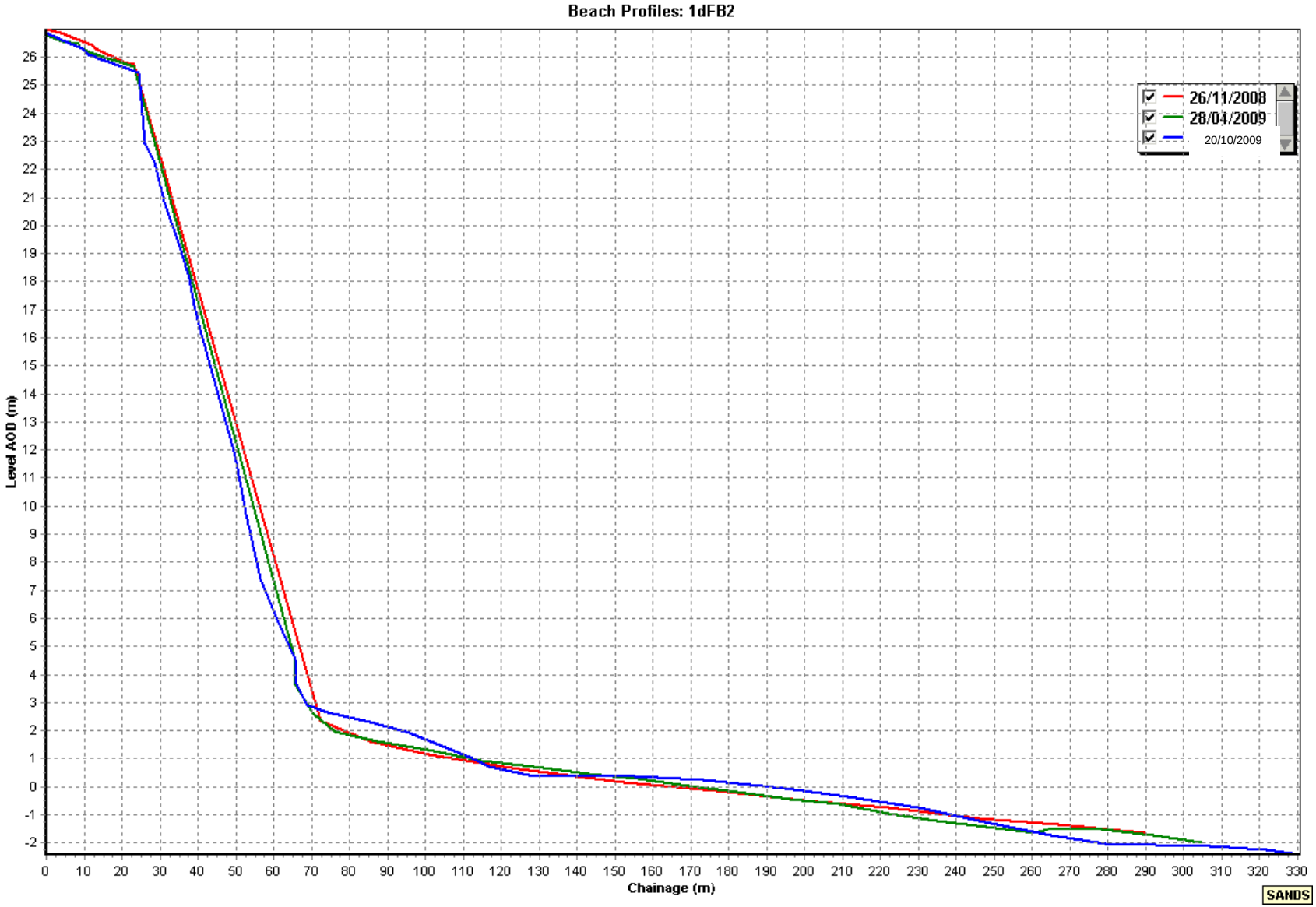
Beach Profile

1dFB2

Date 20/10/2009 **Wind** **Summary** Breezy	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility -**	**Low Tide Time** 10.56 – 13.12 **Rain** No
Easting 512005.564	**Northing** 479181.575	**Bearing** 77	

Chainage (from base station)	Level AOD (m)
0	26.865
0.03	26.865
5.81	26.505
9.395	26.302
10.995	26.073
24.568	25.454
26.155	22.903
28.615	22.281
30.984	20.853
34.905	19.39
37.809	18.115
39.189	17.18
41.09	16.118
45.741	13.83
49.781	11.805
52.627	9.741
56.382	7.418
60.832	5.94
65.661	4.517
65.978	3.684
68.857	2.887
74.168	2.641
85.513	2.295
95.023	1.948
111.773	1.08
116.883	0.721
128.992	0.374
138.088	0.43
155.164	0.361
173.339	0.238
194.724	-0.05
211.265	-0.359
230.266	-0.743
247.463	-1.243
265.057	-1.714
279.43	-2.012
292.682	-2.067
306.851	-2.114
321.975	-2.265
330.728	-2.417



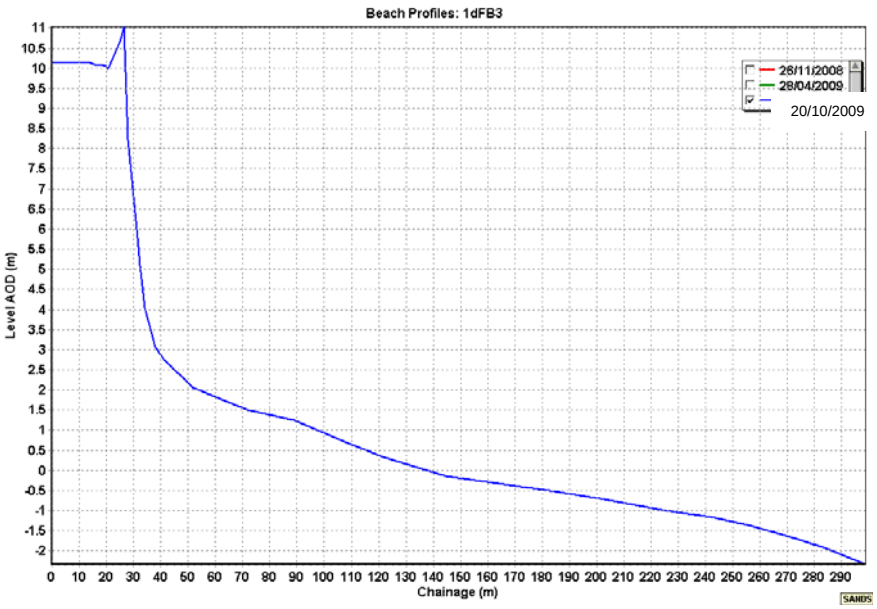

Beach Profiles: 1dFB2
26/11/2008
28/04/2009
20/10/2009
Level AOD (m)
Chainage (m)
SANDS

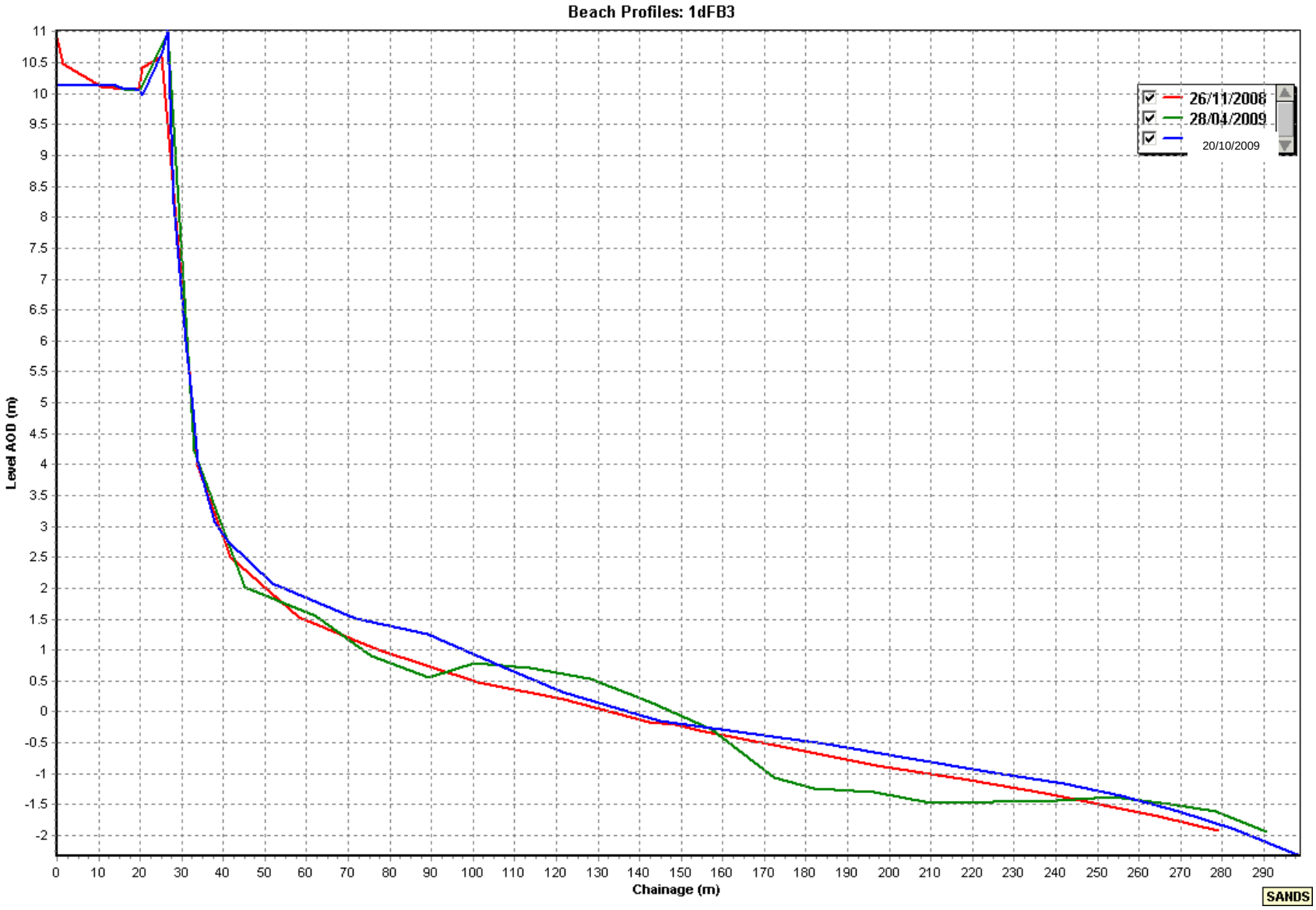
Beach Profile

1dFB3

Date 20/10/2009 **Wind** **Summary** Breezy	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility -**	**Low Tide Time** 10.56 – 13.12 **Rain** No
Easting 512429.303	**Northing** 478202.148	**Bearing** 61	

Chainage (from base station)	Level AOD (m)
0	10.126
14.109	10.126
16.056	10.074
16.209	10.079
17.746	10.085
19.974	10.059
20.617	9.972
25.365	10.706
26.578	11.028
27.995	8.229
31.057	5.989
32.411	5.108
33.968	4.054
37.98	3.074
41.075	2.751
51.617	2.069
71.644	1.508
88.962	1.252
107.016	0.729
121.579	0.328
144.767	-0.146
163.78	-0.317
184.88	-0.525
202.904	-0.727
225.25	-0.995
242.041	-1.161
255.626	-1.349
269.432	-1.616
283.017	-1.911
298.707	-2.332



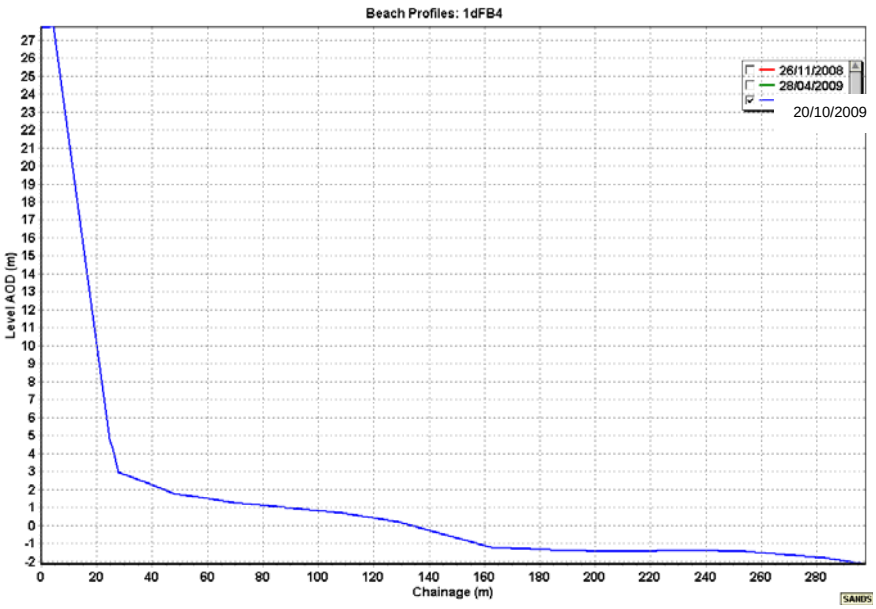

Beach Profiles: 1dFB3
Level AOD (m)
Chainage (m)
26/11/2008
28/04/2009
20/10/2009
SANDS

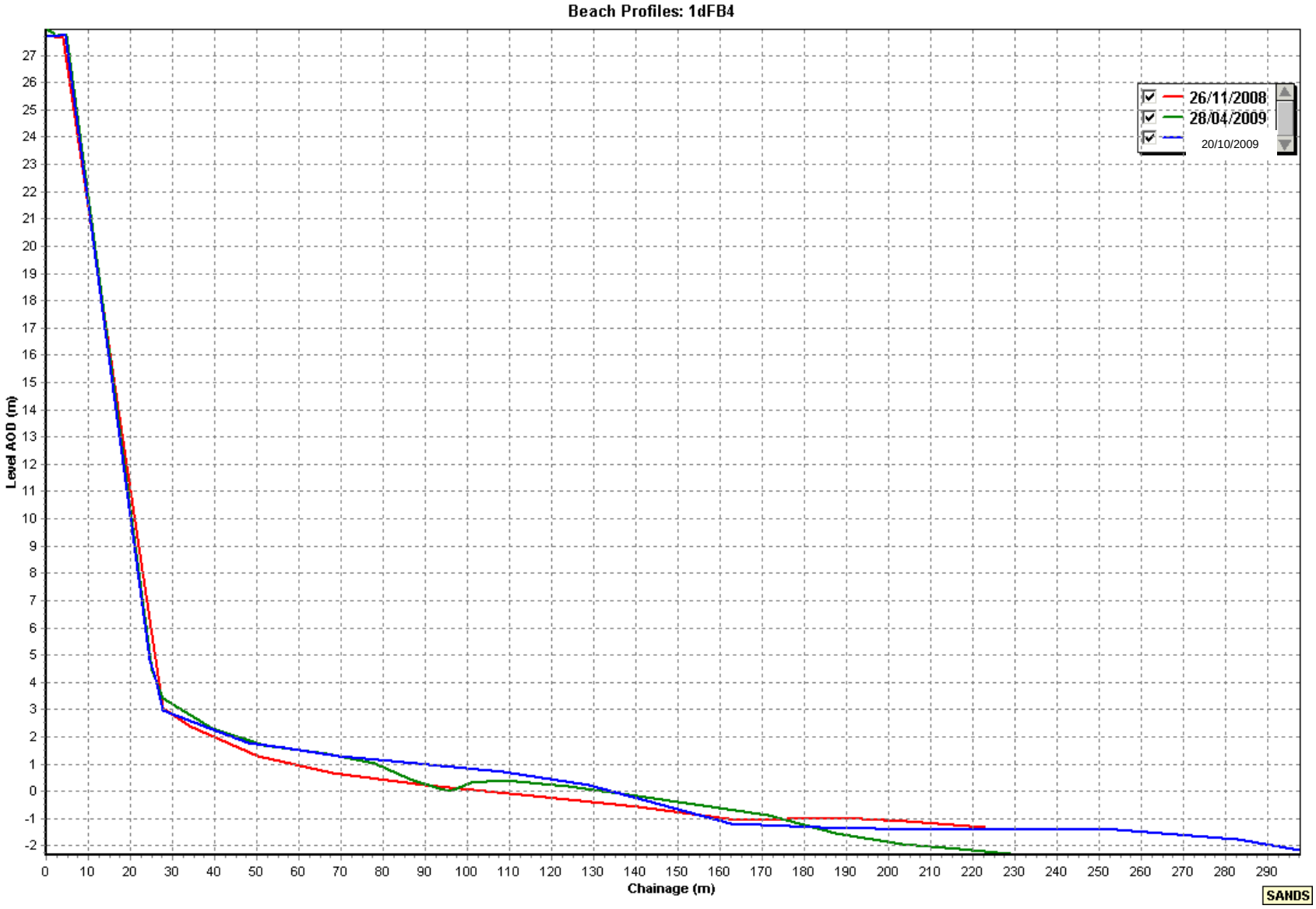
Beach Profile

1dFB4

Date 20/10/2009 **Wind** **Summary** Breezy	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility -**	**Low Tide Time** 10.56 – 13.12 **Rain** No
Easting 513165.53	**Northing** 477182.418	**Bearing** 51	

Chainage (from base station)	Level AOD (m)
0	27.734
0.037	27.734
2.271	27.704
3	27.729
4.435	27.739
24.624	4.843
25.729	4.285
27.741	2.988
38.806	2.331
48.016	1.782
56.553	1.596
69.291	1.278
82.059	1.119
108.648	0.709
128.885	0.216
162.437	-1.199
183.61	-1.335
209.776	-1.415
234.466	-1.355
254.156	-1.423
282.742	-1.769
297.58	-2.147



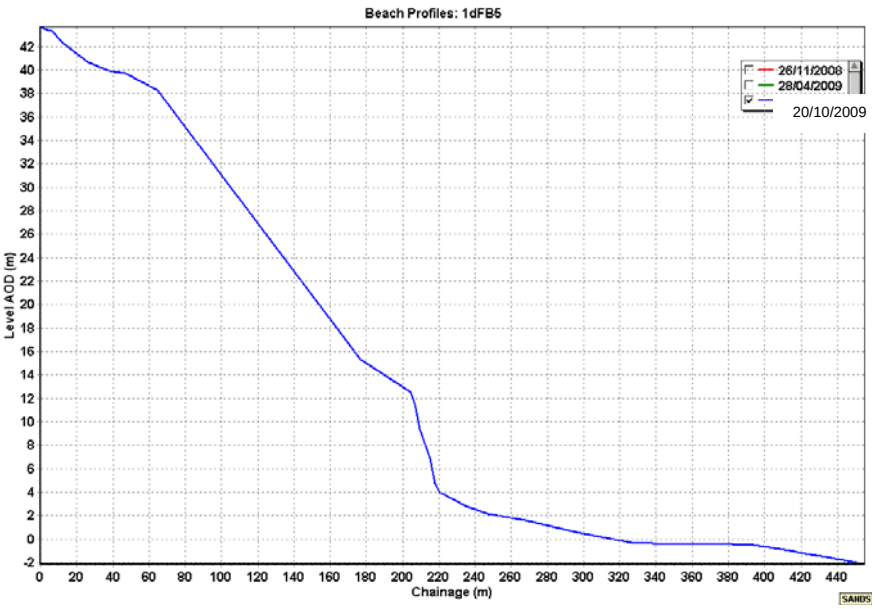

Beach Profiles: 1dFB4
26/11/2008
28/04/2009
20/10/2009
Level AOD (m)
Chainage (m)
SANDS

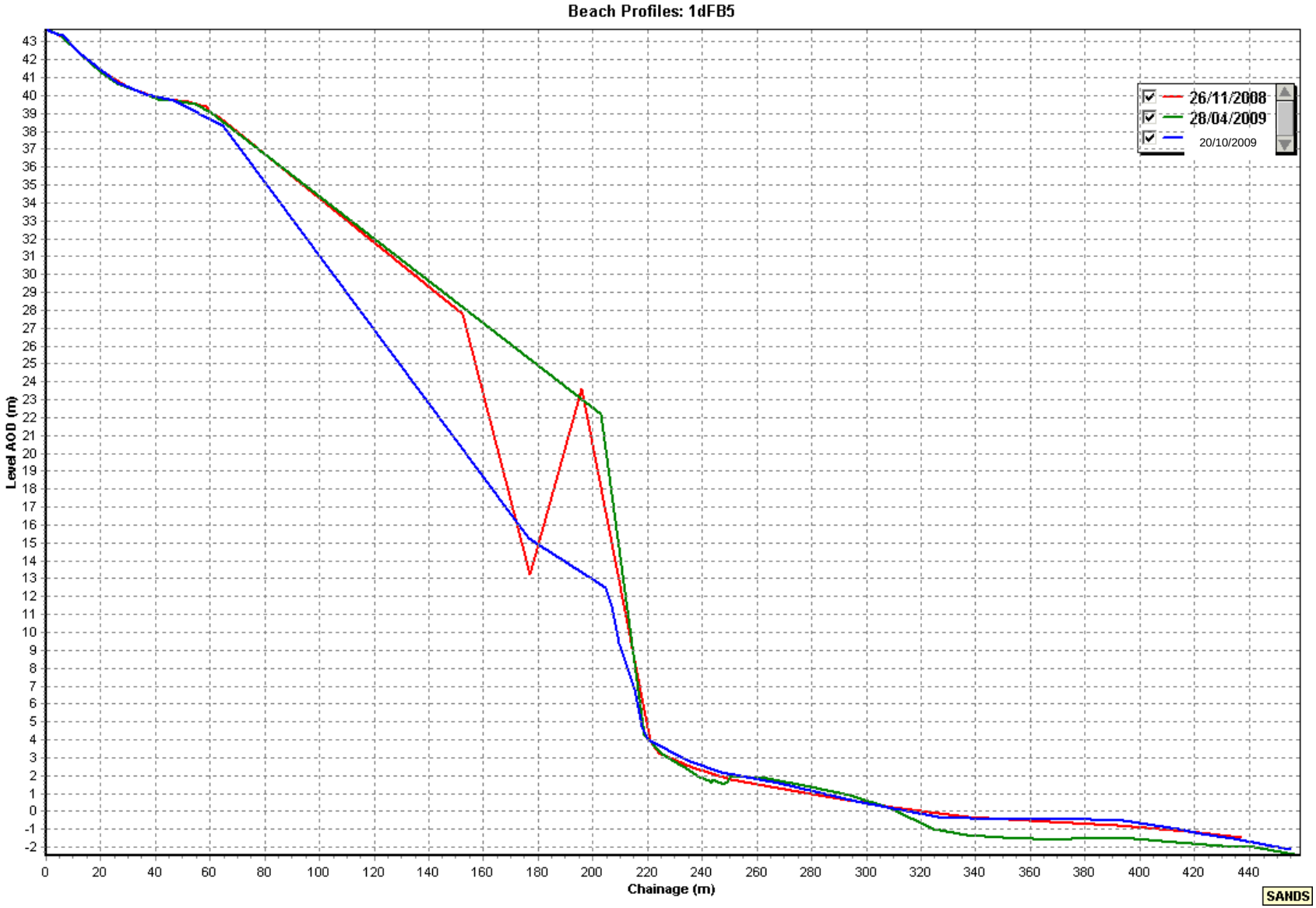
Beach Profile

1dFB5

Date 20/10/2009 **Wind** **Summary** Breezy	**Inspector** **Sea State** Calm	**Low Tide (m)** **Visibility -**	**Low Tide Time** 10.56 – 13.12 **Rain** No
Easting 514207.792	**Northing** 476001.334	**Bearing** 47	

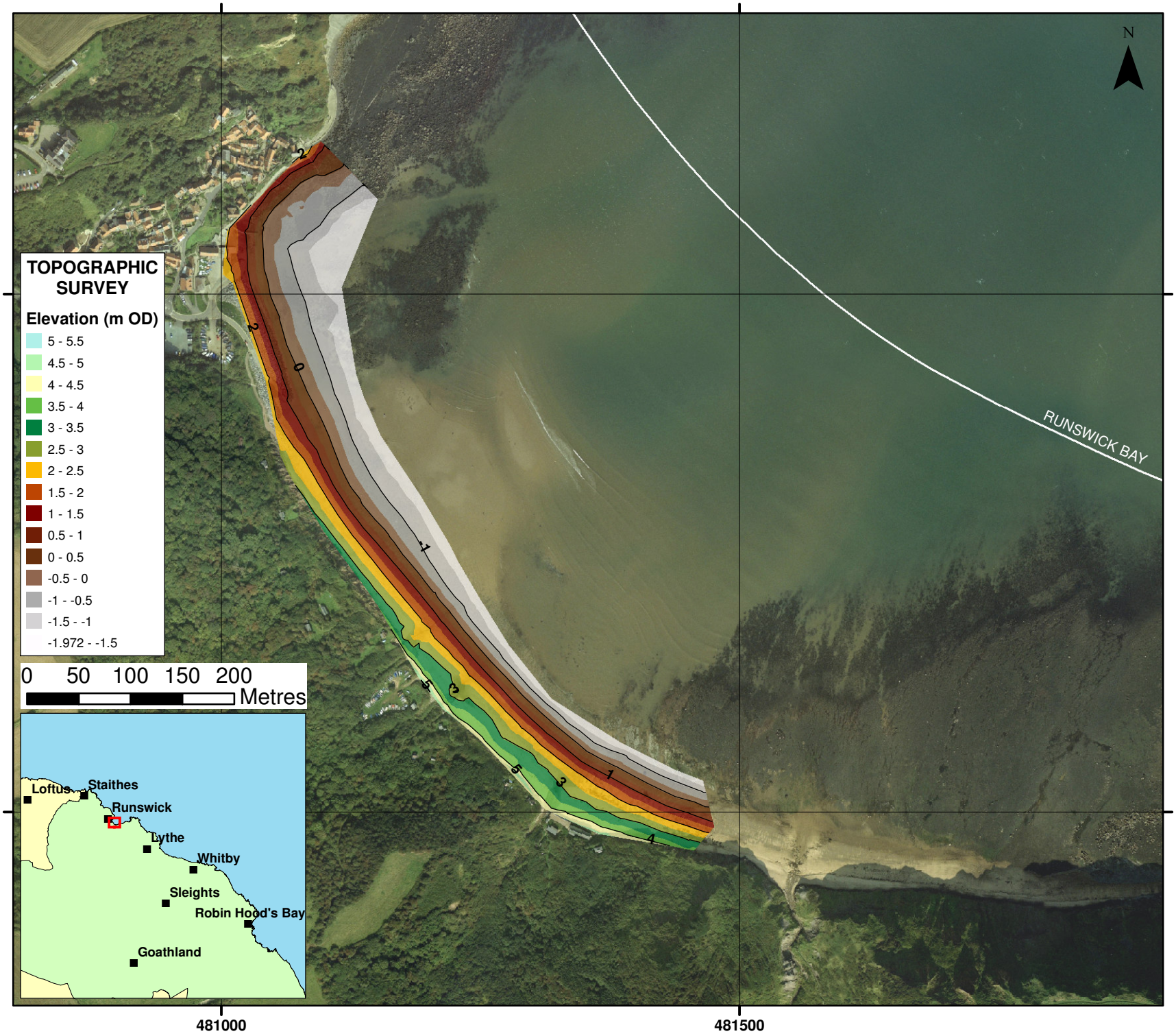
Chainage (from base station)	Level AOD (m)
0	43.692
0.004	43.692
4.822	43.382
5.687	43.393
12.525	42.344
26.011	40.711
36.513	40.042
40.8	39.905
46.767	39.743
64.533	38.304
176.679	15.286
204.635	12.512
206.824	11.465
209.629	9.384
215.371	6.853
217.992	4.772
220.302	4.015
235.585	2.772
246.92	2.153
267.873	1.574
296.139	0.558
326.023	-0.307
350.349	-0.431
370.655	-0.383
393.867	-0.537
414.14	-1.016
422.629	-1.255
434.536	-1.532
455.127	-2.146




Beach Profiles: 1dFB5
Level AOD (m)
Chainage (m)
26/11/2008
28/04/2009
20/10/2009
SANDS

Appendix B

Topographic Survey



Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:5,000 at A4

Drawn by:	ES	Date:	15/01/2010
Checked by:	RJ	Date:	25/01/2010
Approved by:	RJ	Date:	25/01/2010

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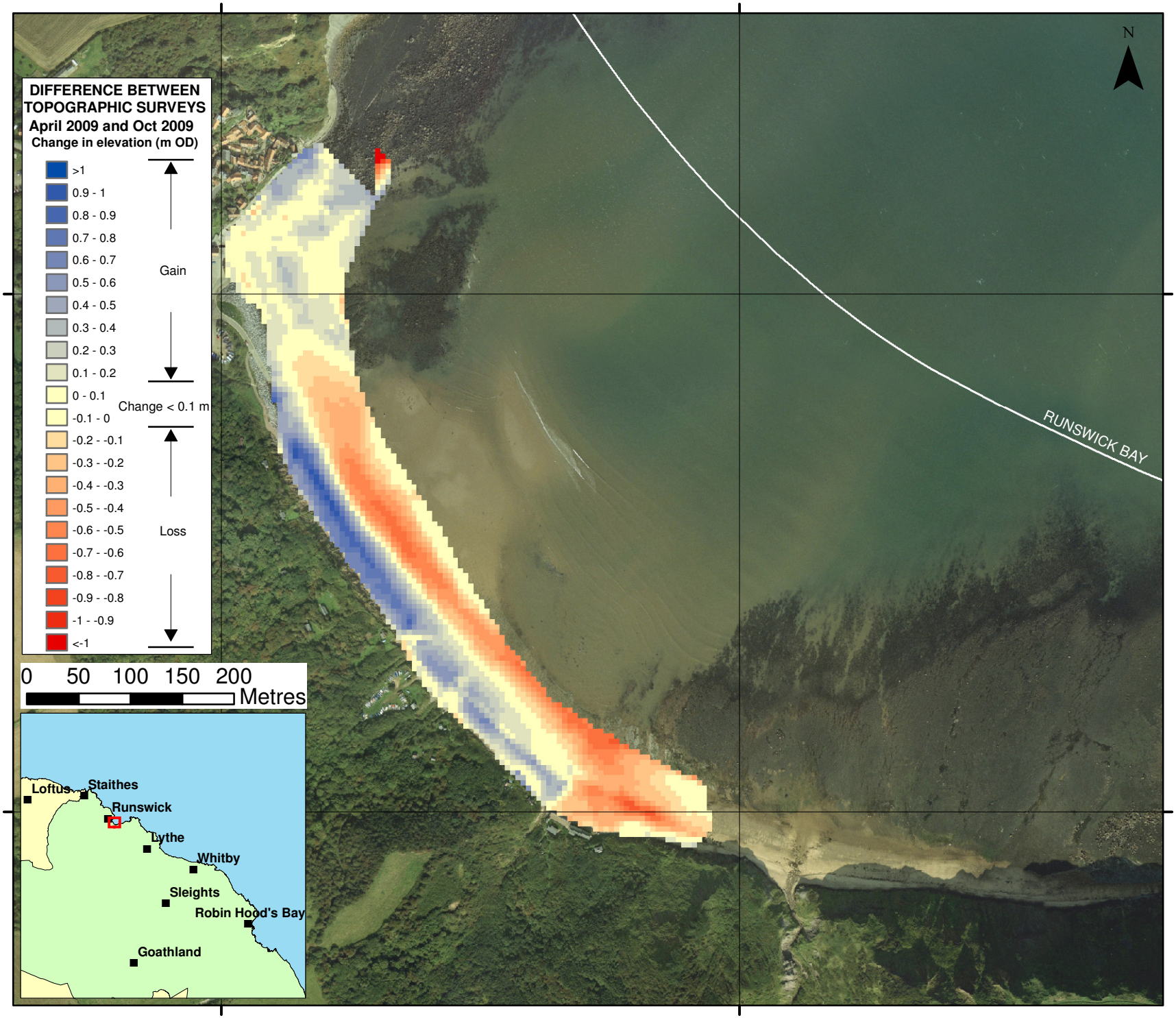

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:5,000 at A4

Drawn by:	ES	Date:	15/01/2010
Checked by:	RJ	Date:	25/01/2010
Approved by:	RJ	Date:	25/01/2010

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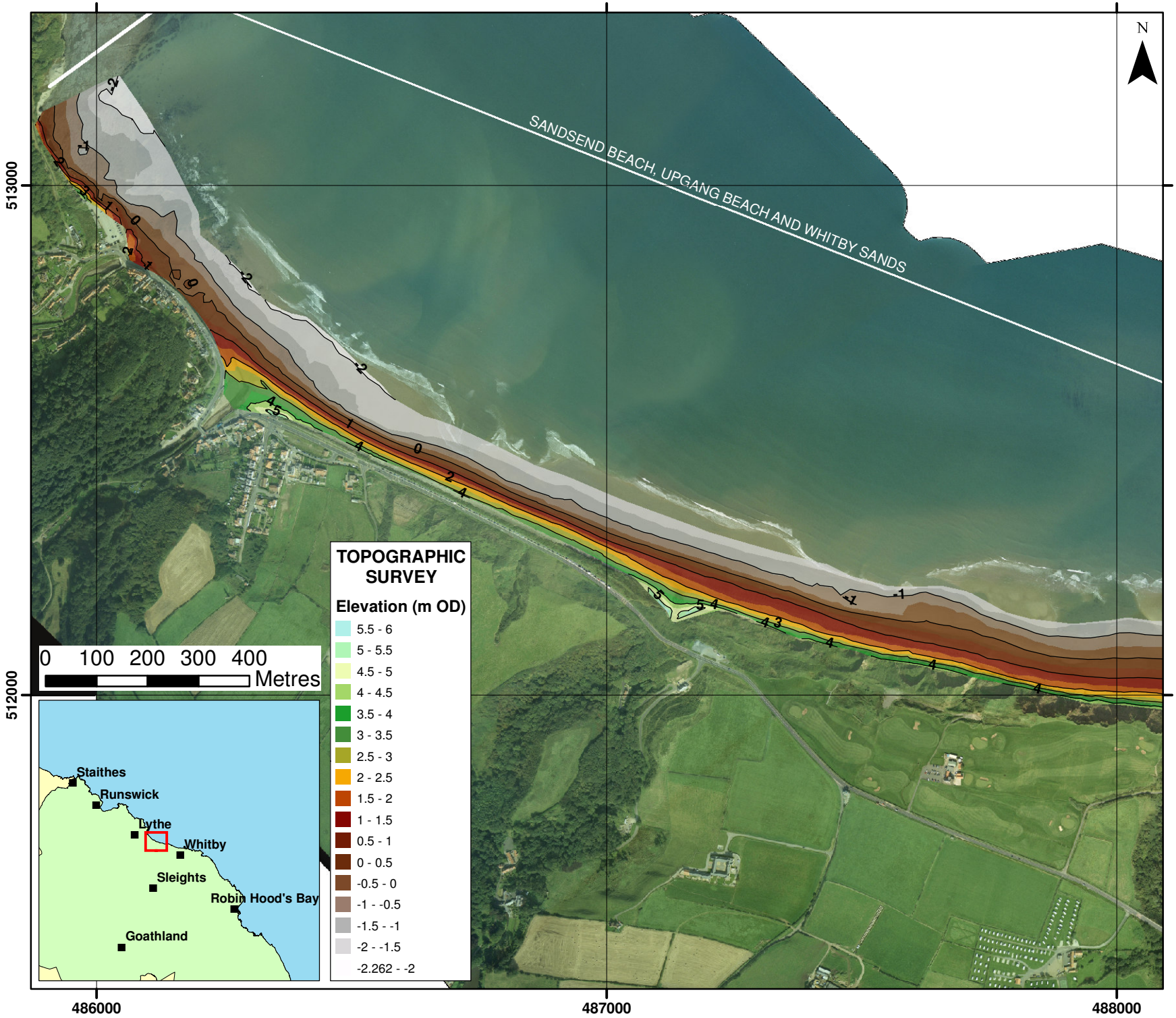

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3a Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

Drawn by:	ES	Date:	15/01/2010
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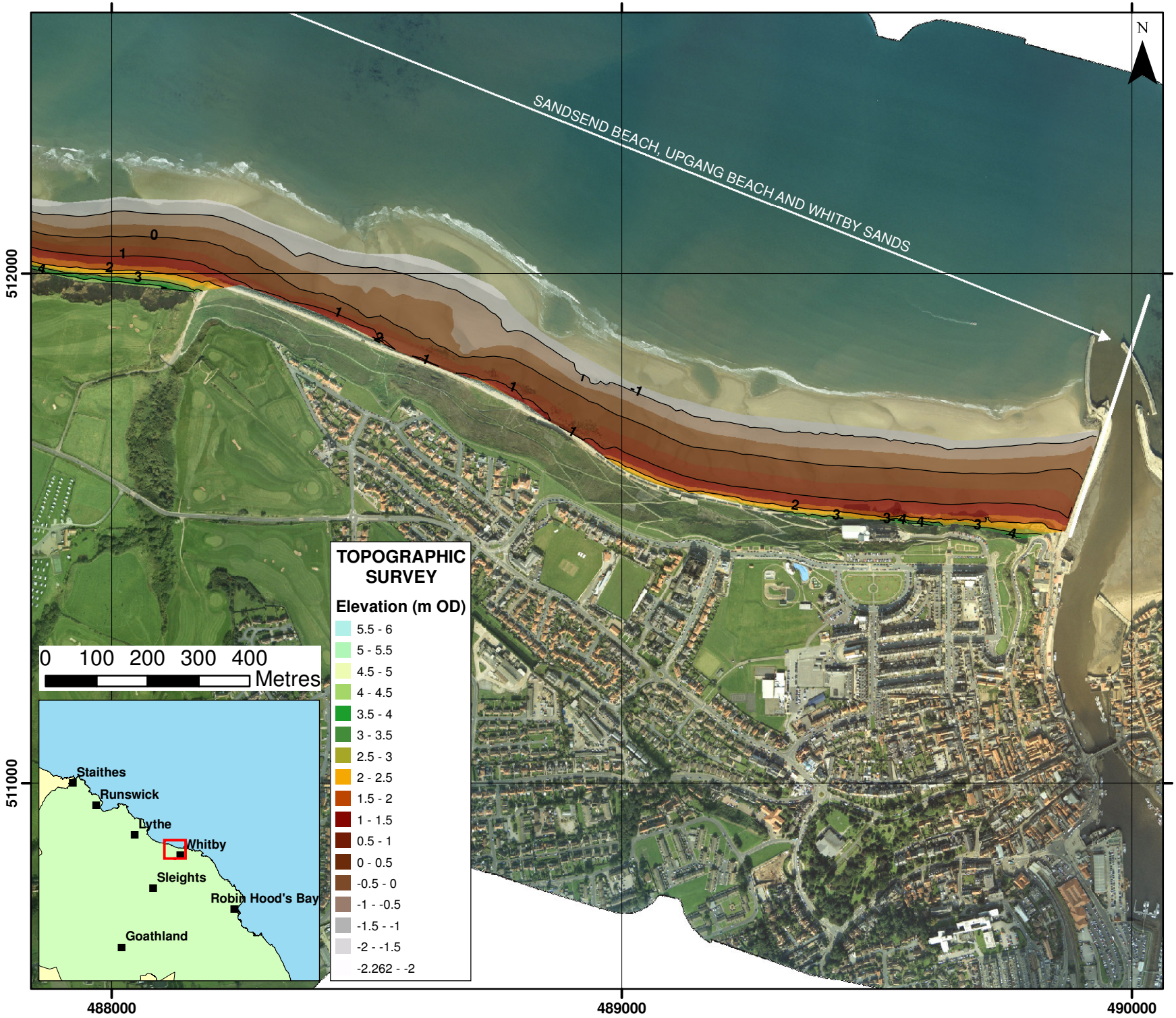

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3b Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

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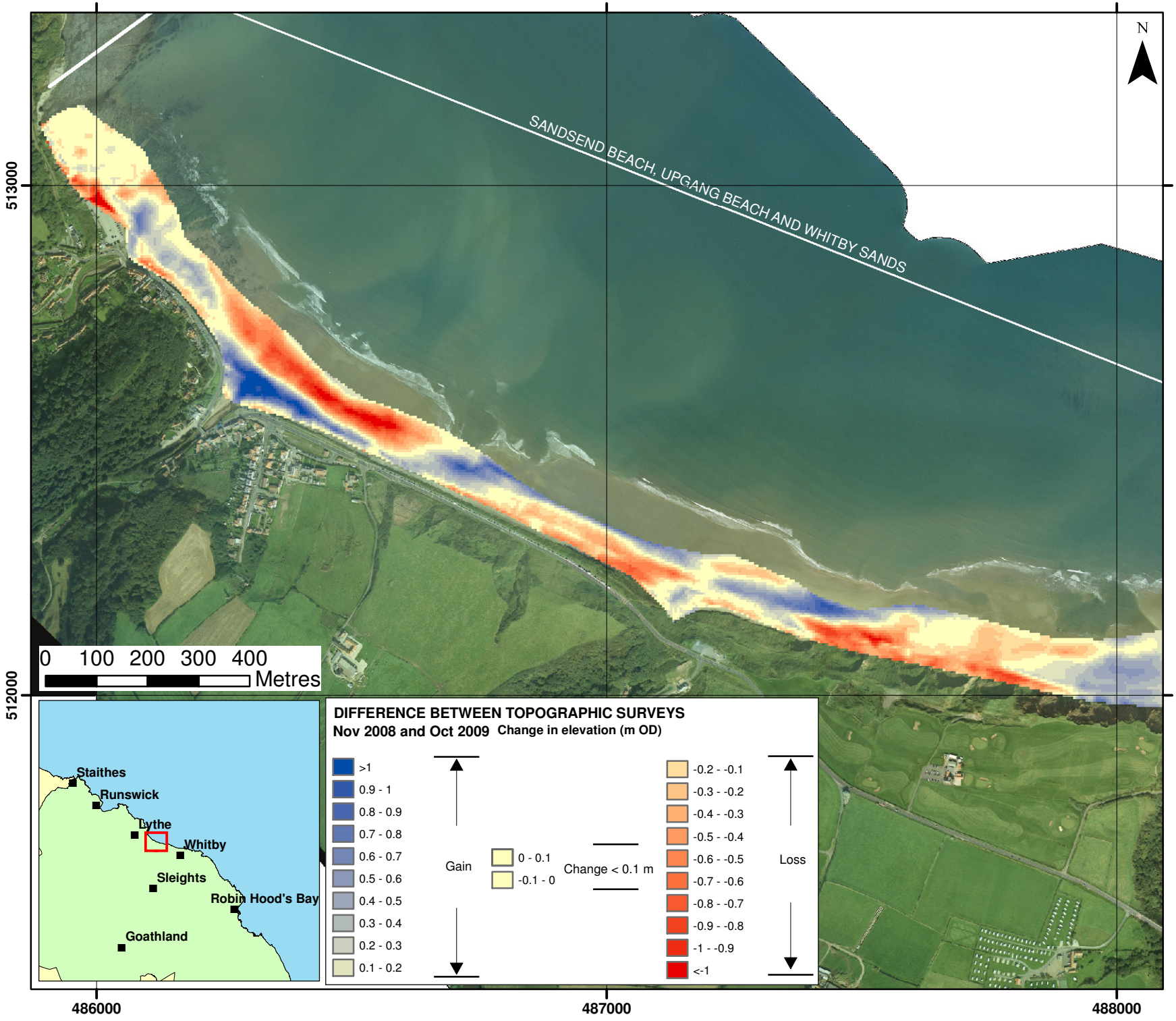

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4a Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

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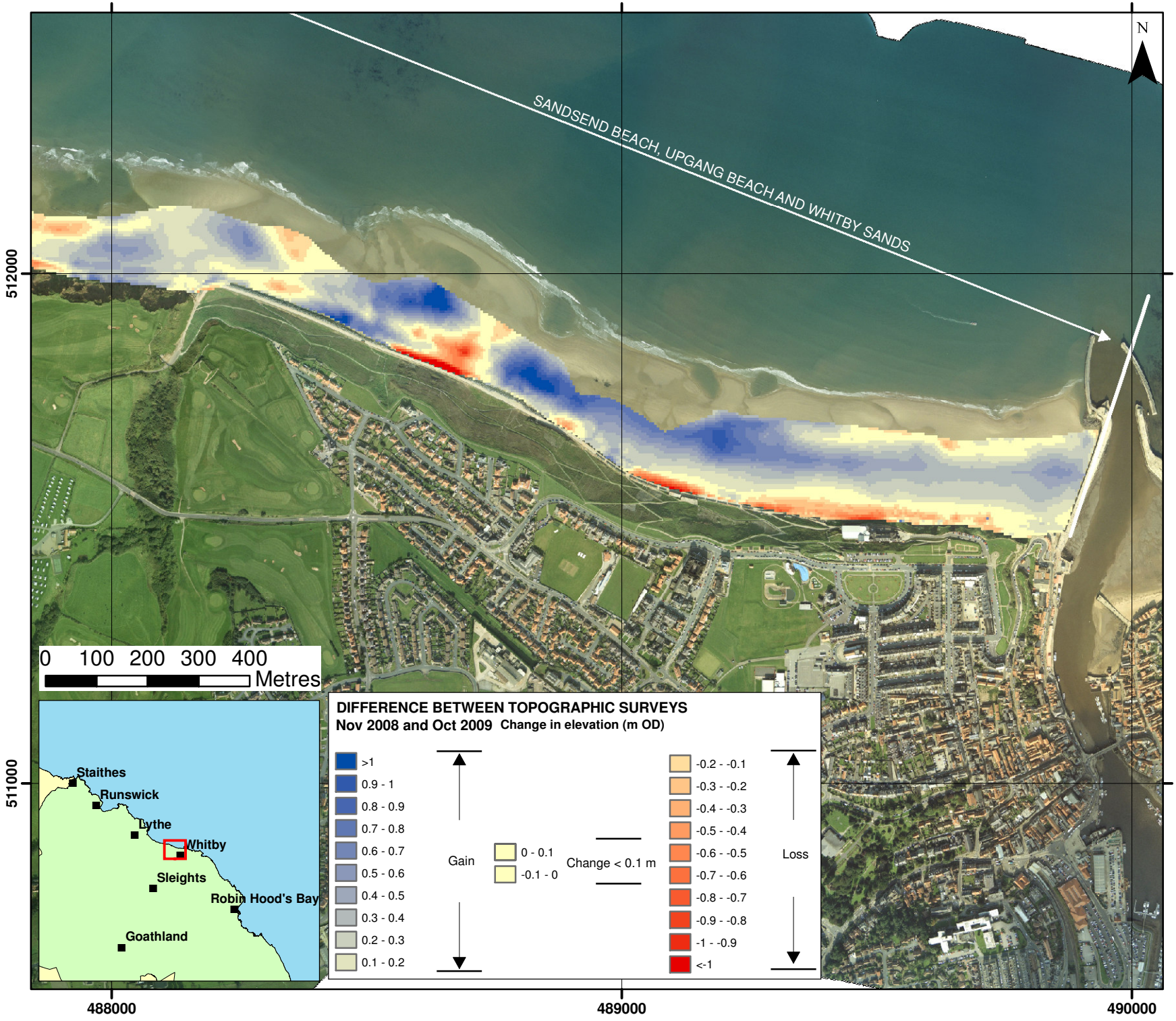

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4b Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

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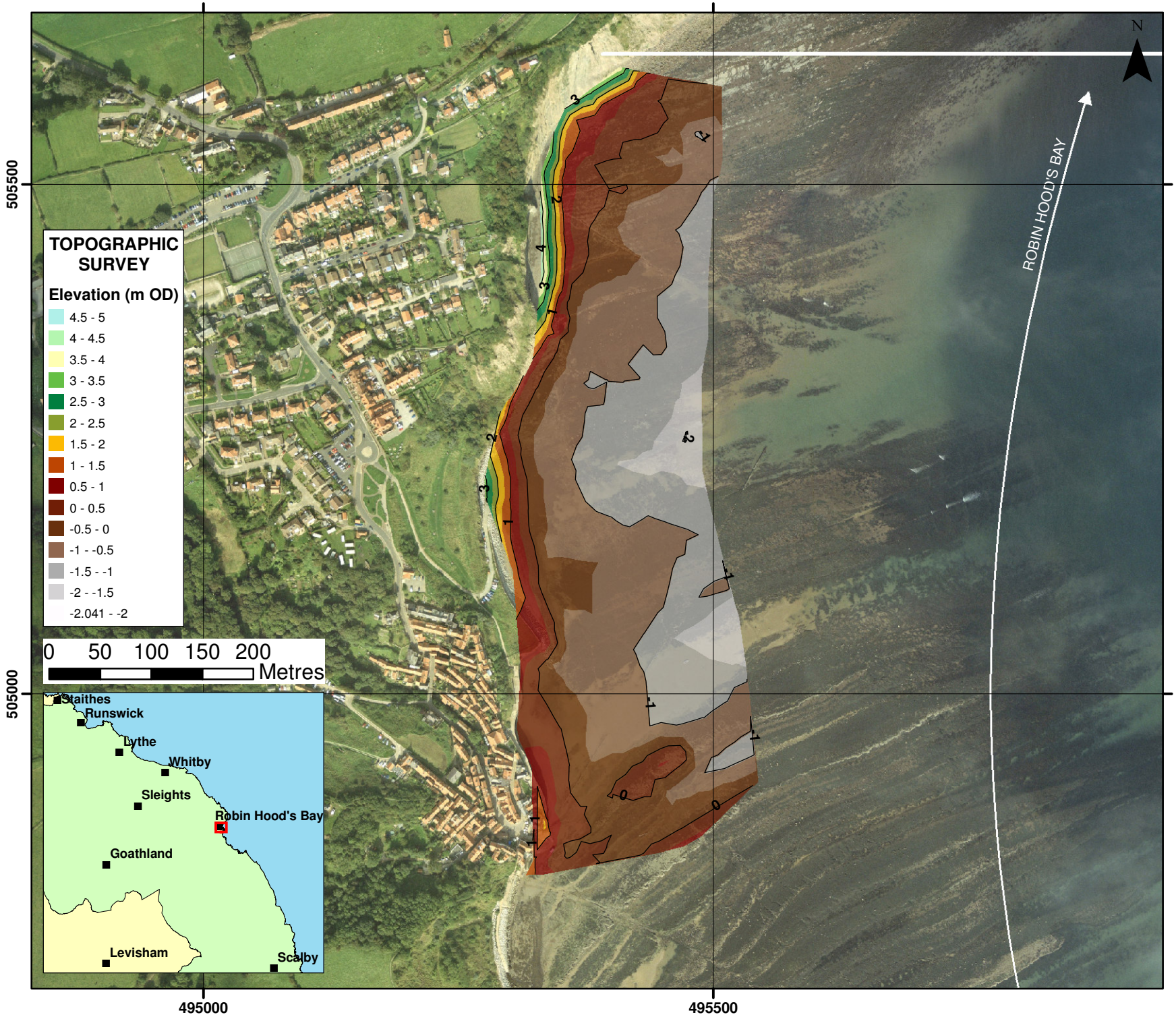

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 5 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:5,000 at A4

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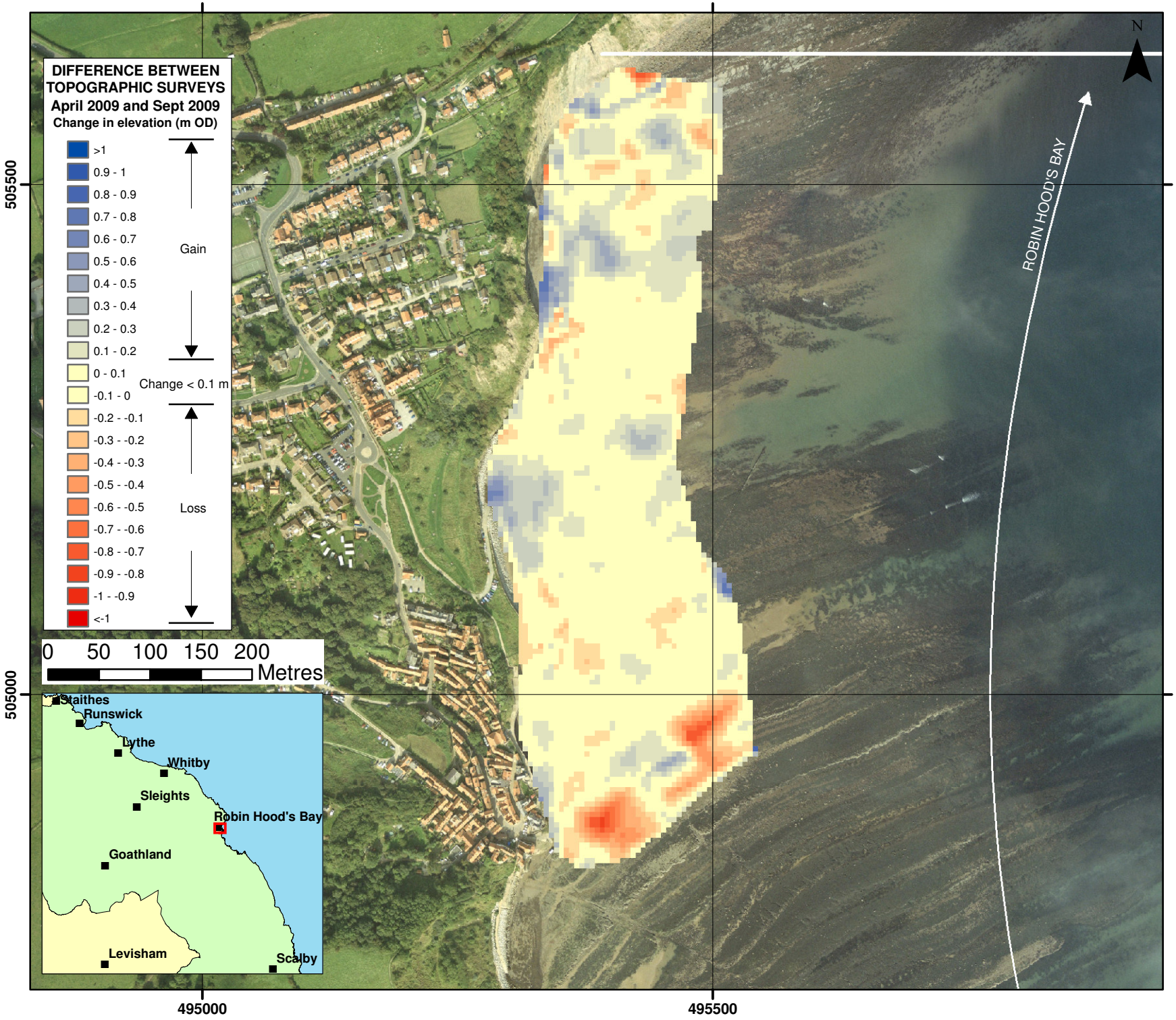

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 6 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:5,000 at A4

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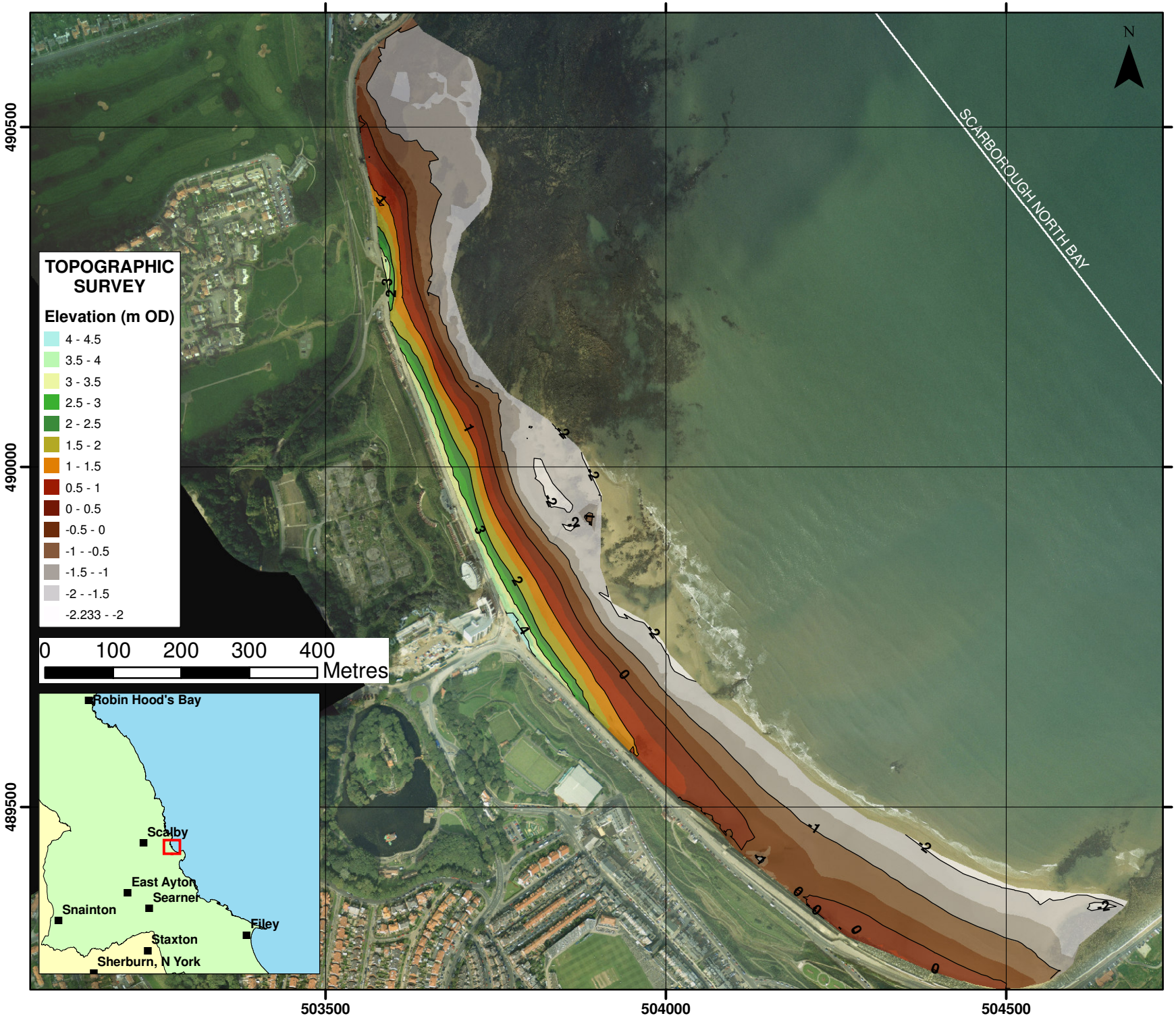

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 7 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:7,500 at A4

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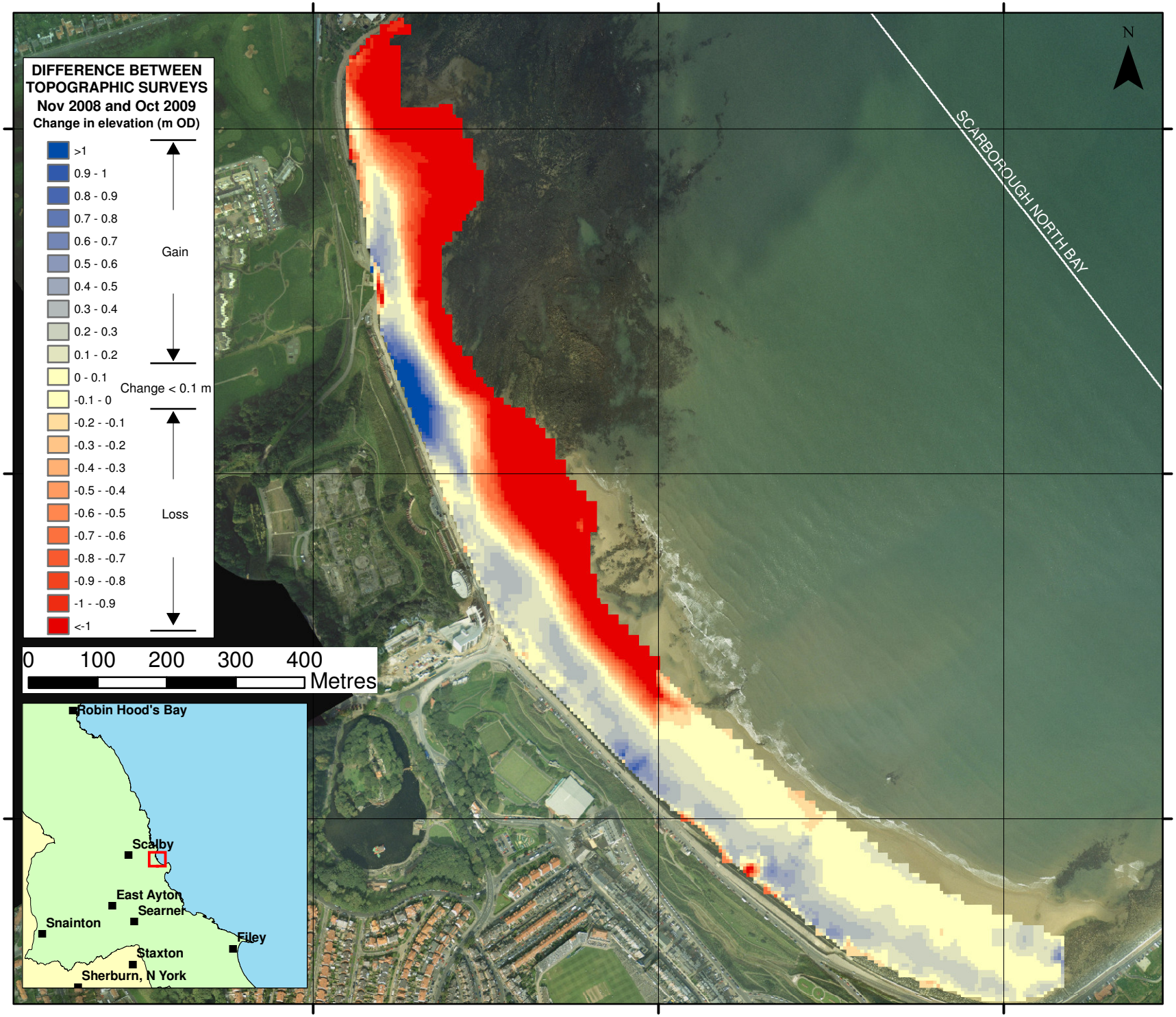

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 8 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:7,500 at A4

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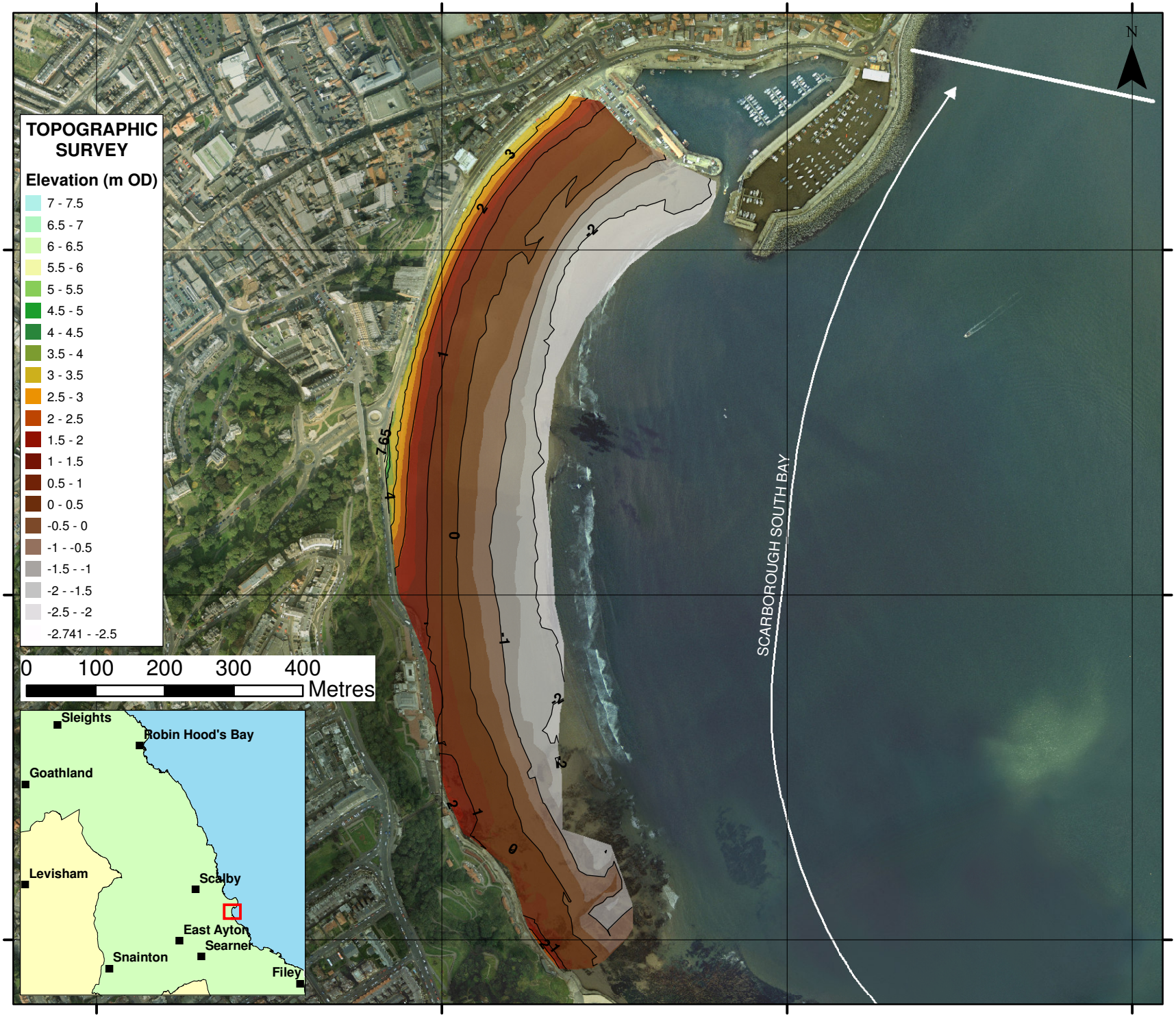

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 9 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:7,500 at A4

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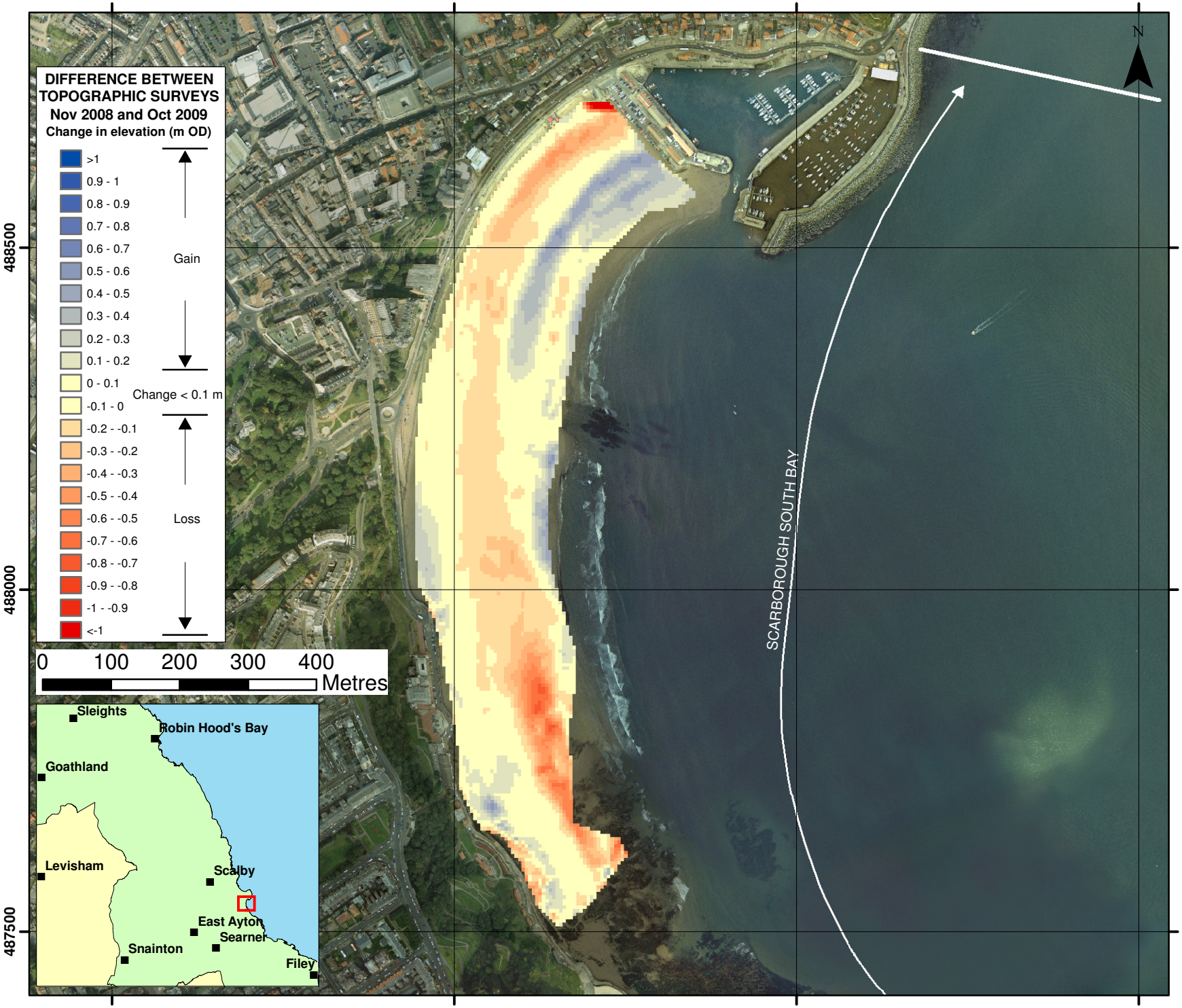

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 10 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:7,500 at A4

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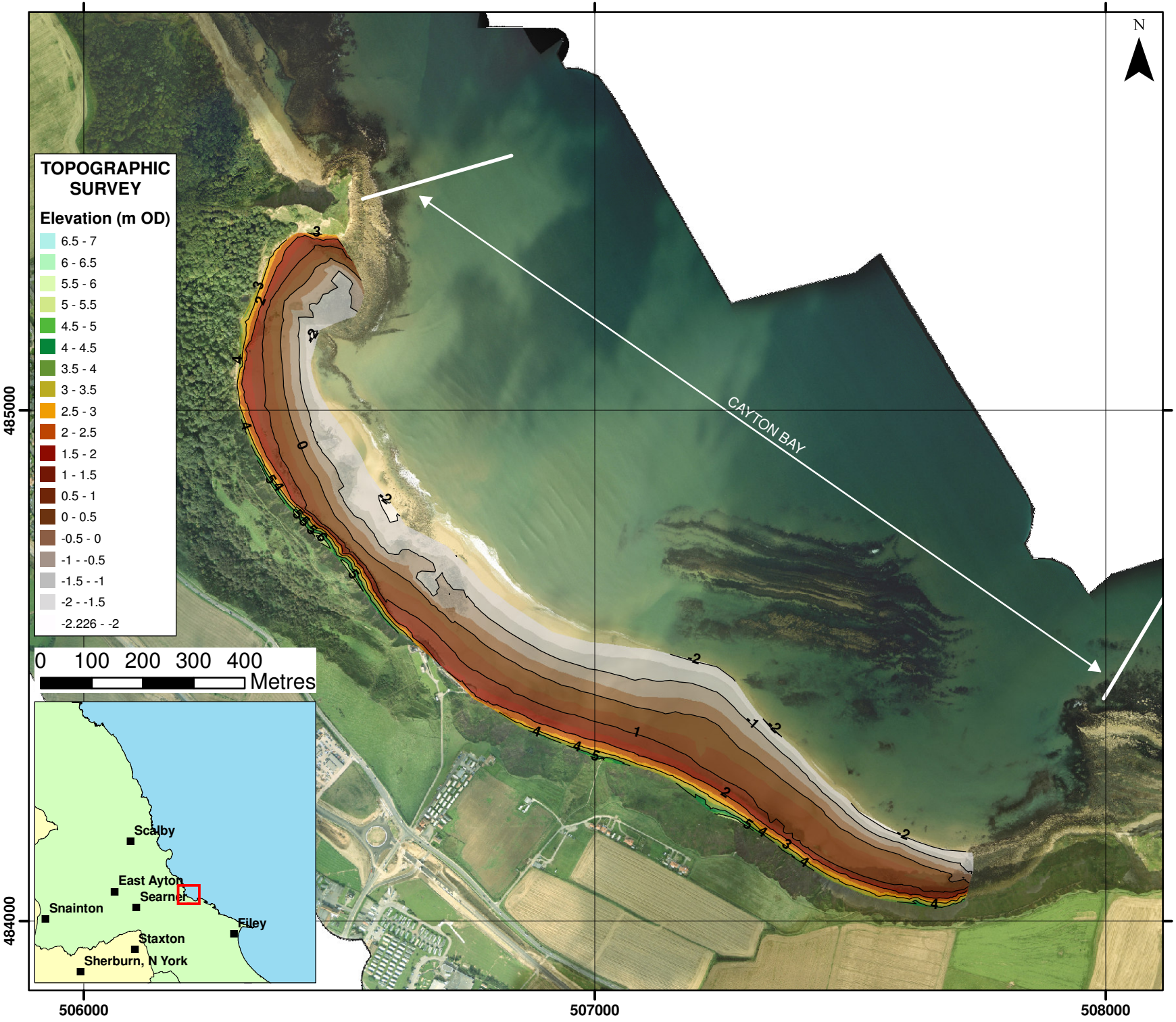

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 11 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

Drawn by:	ES	Date: 15/01/2010
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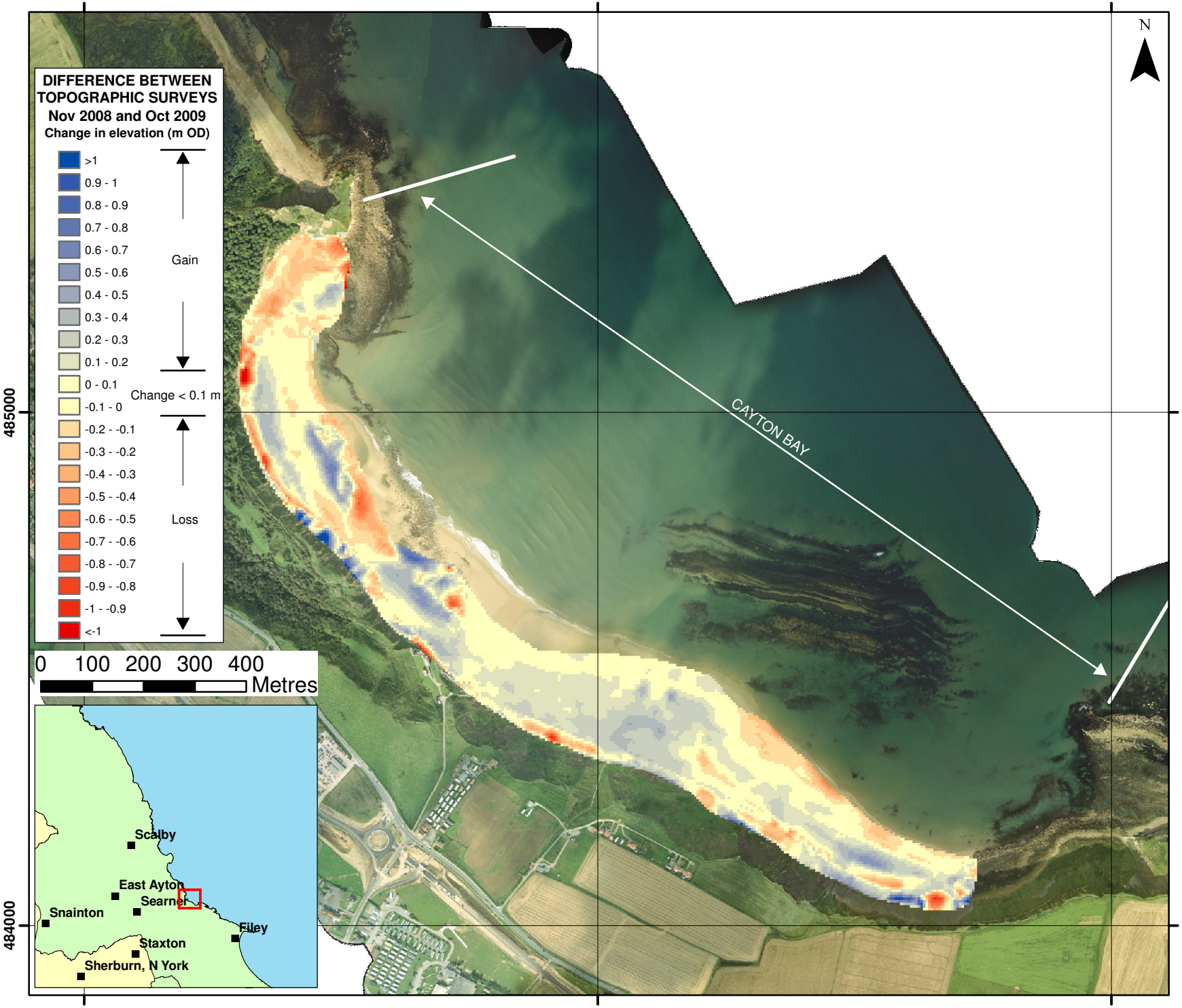

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 12 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

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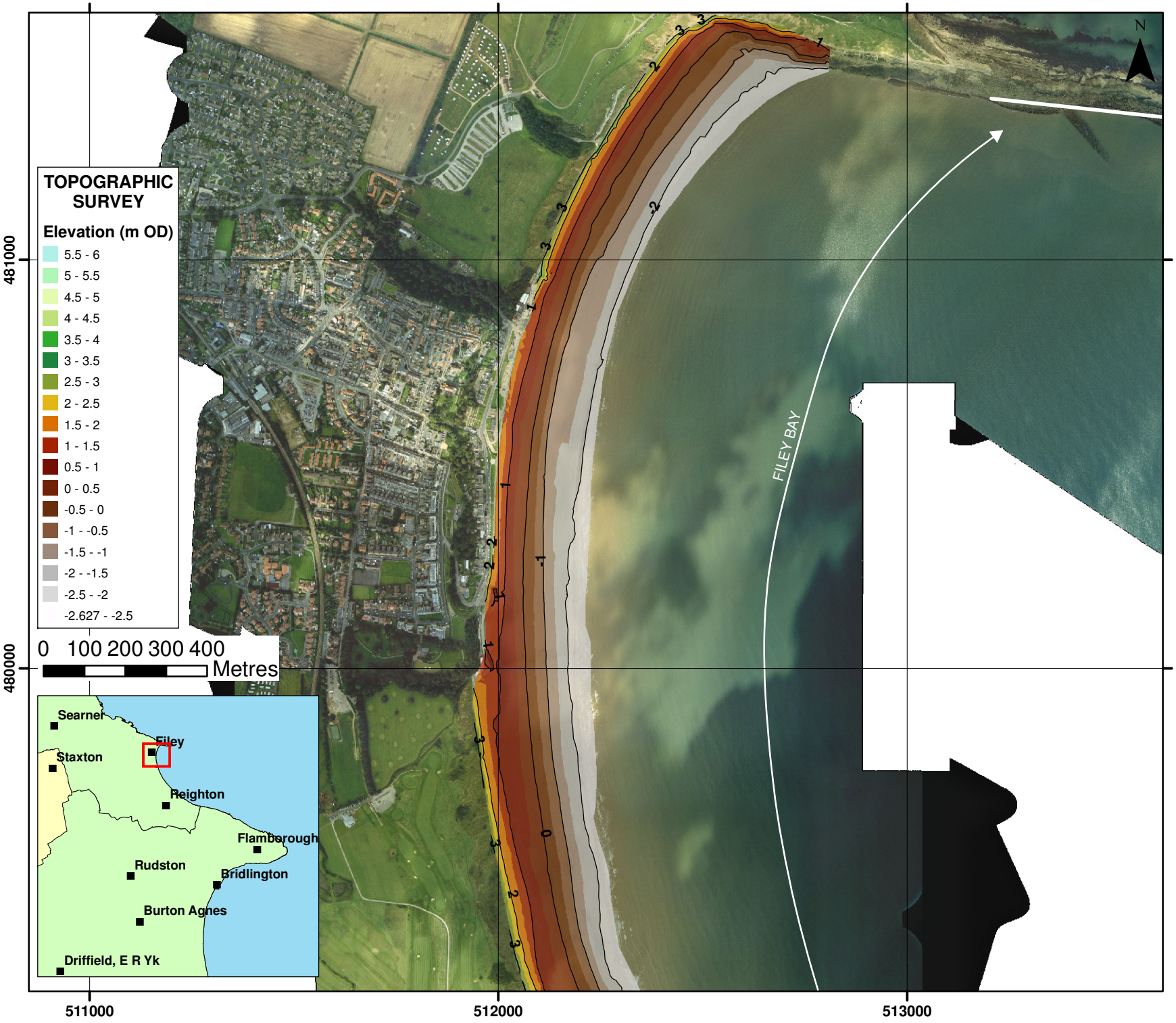

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 13a Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:12,500 at A4

Drawn by:	ES	Date:	15/01/2010
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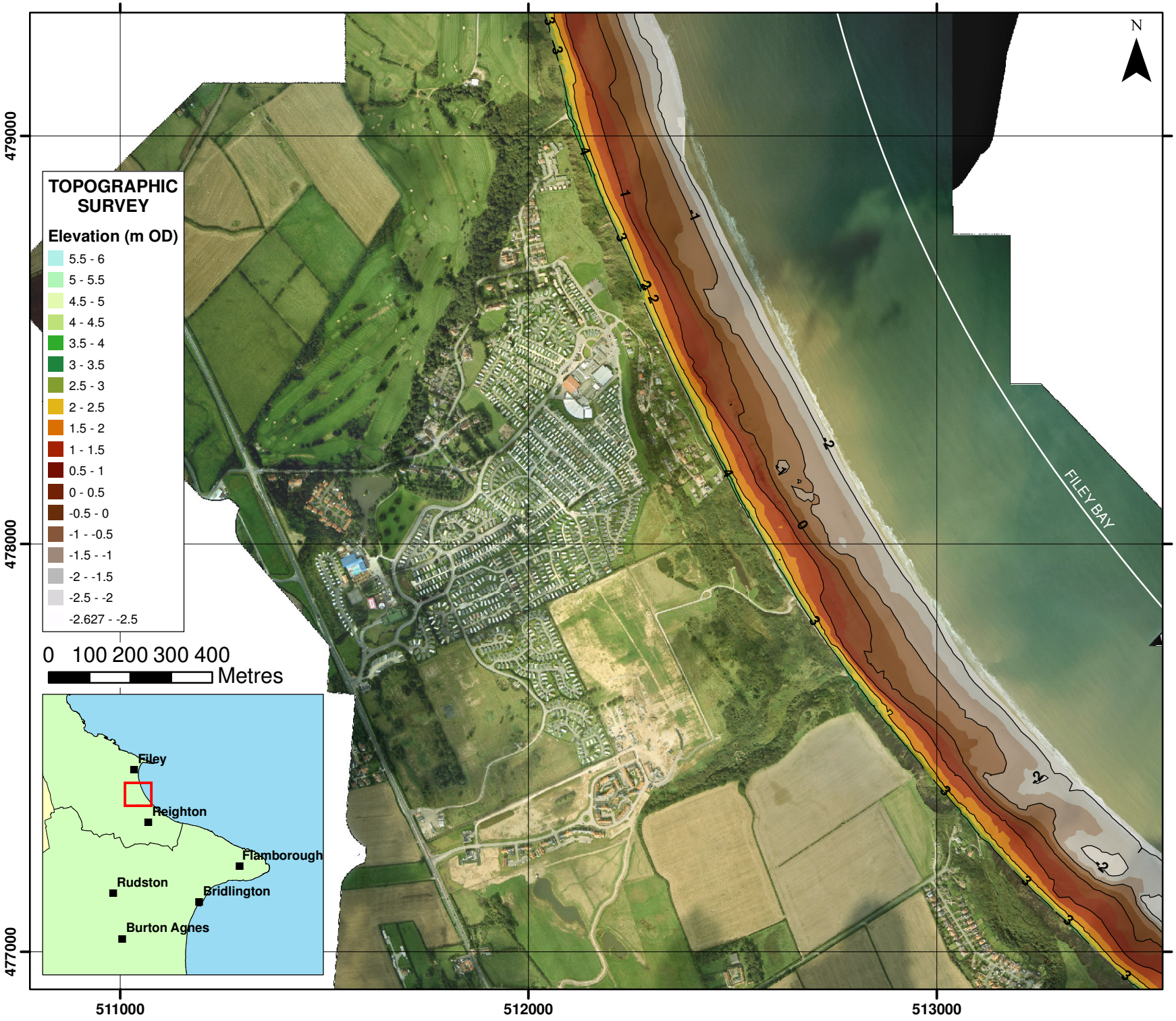

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 13b Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:12,500 at A4

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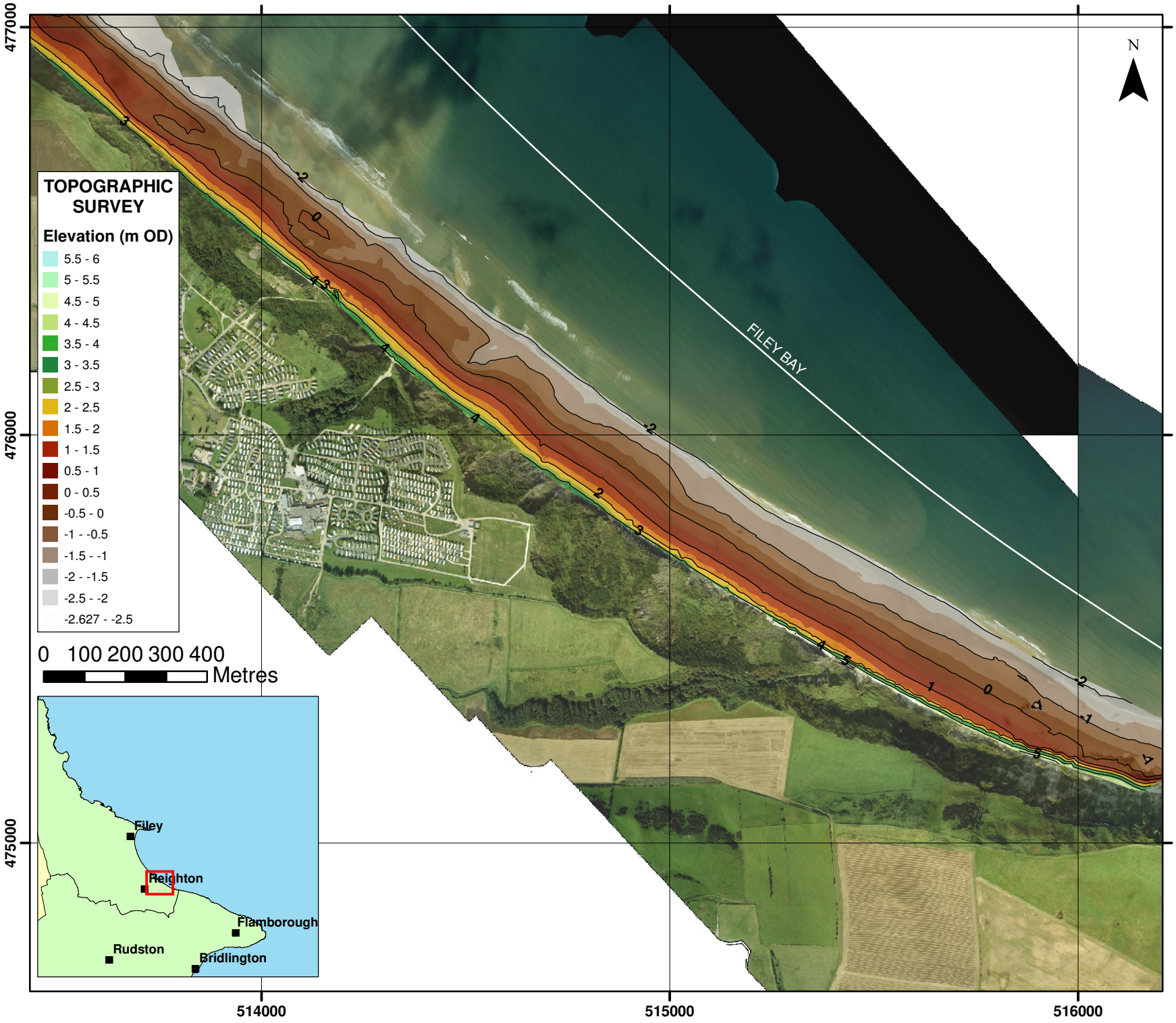

Topographic Contours at 1 metre interval

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 13c Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:12,500 at A4

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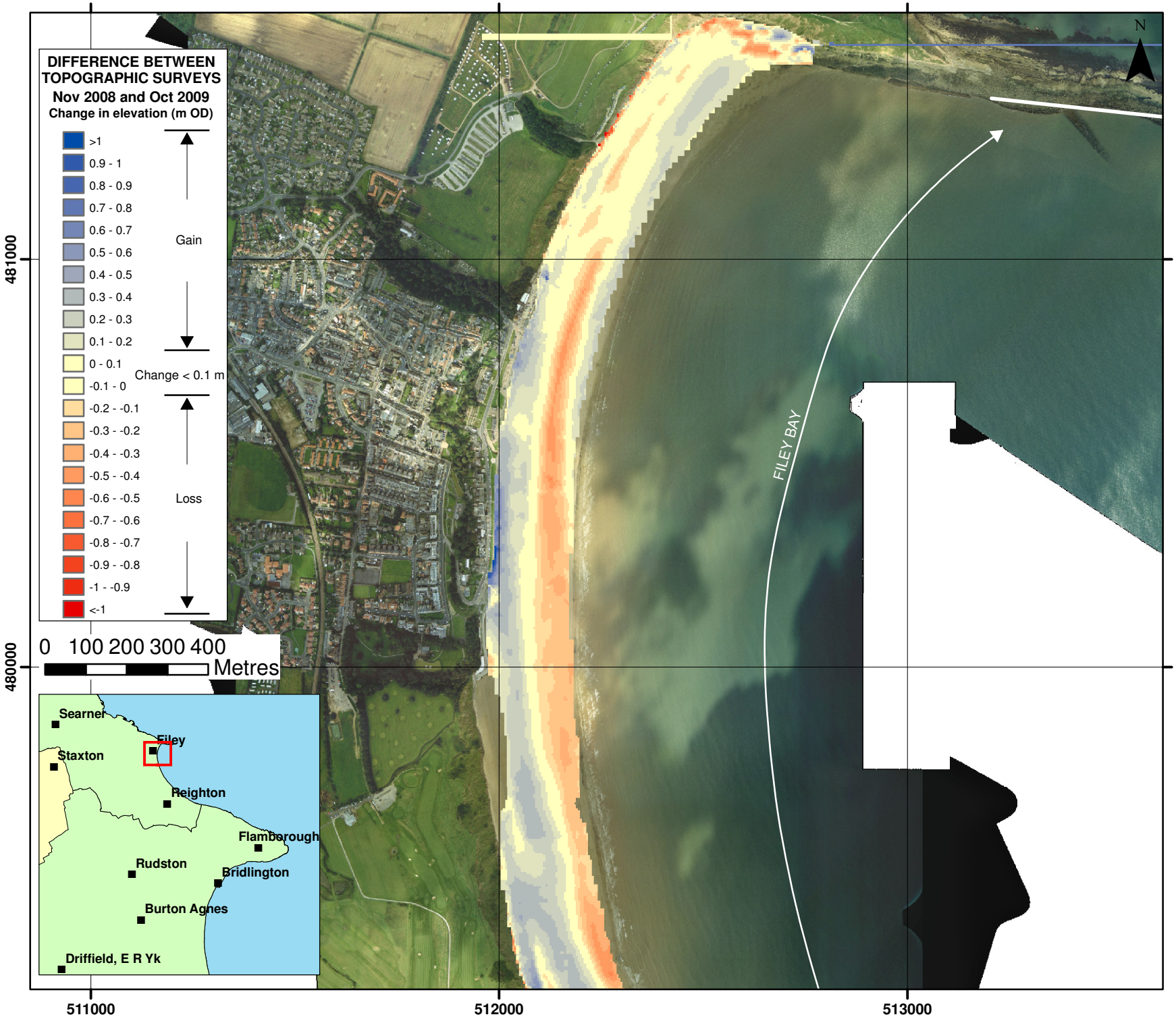

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 14a Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:12,500 at A4

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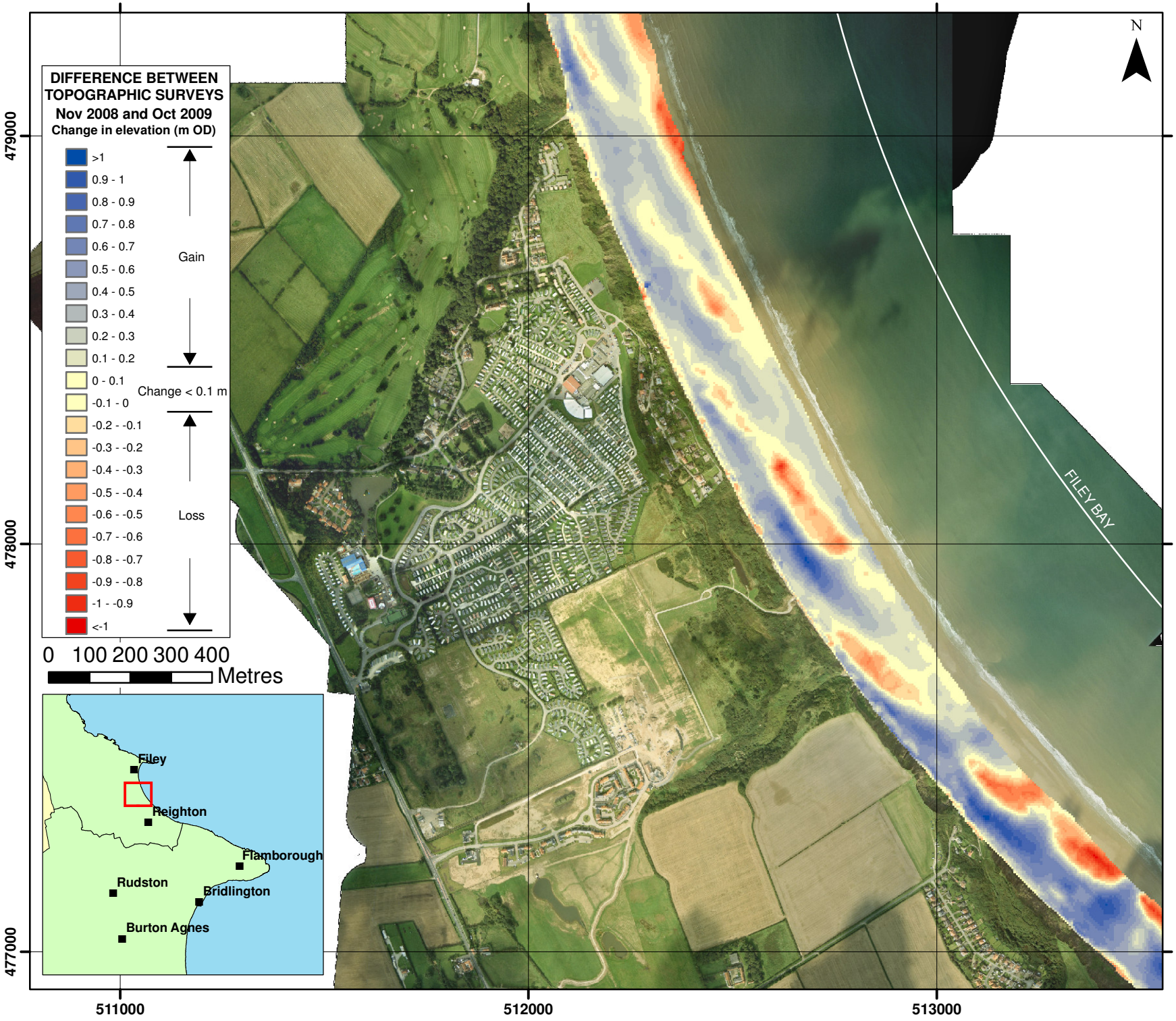

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 14b Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:12,500 at A4

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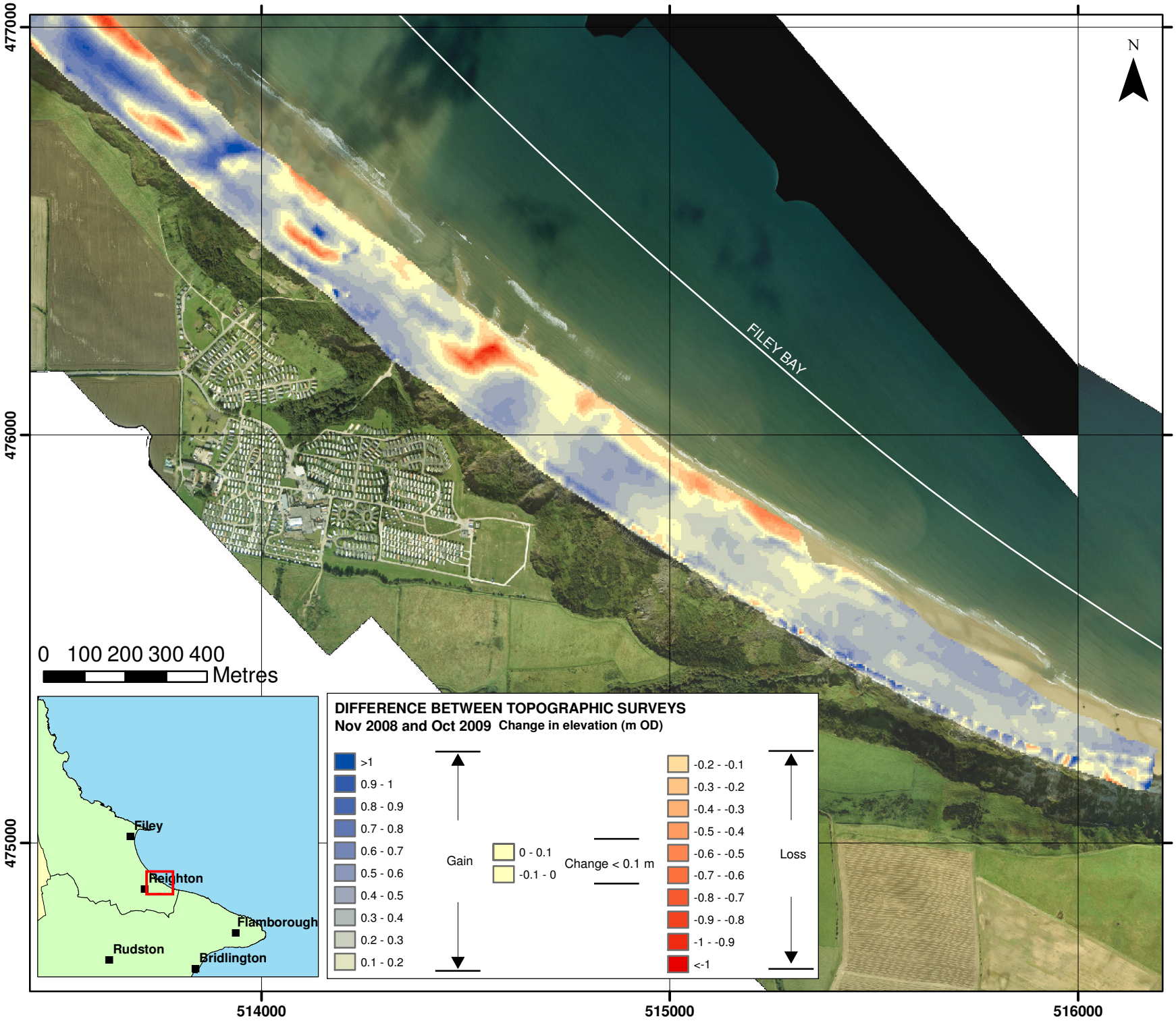

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 14c Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:12,500 at A4

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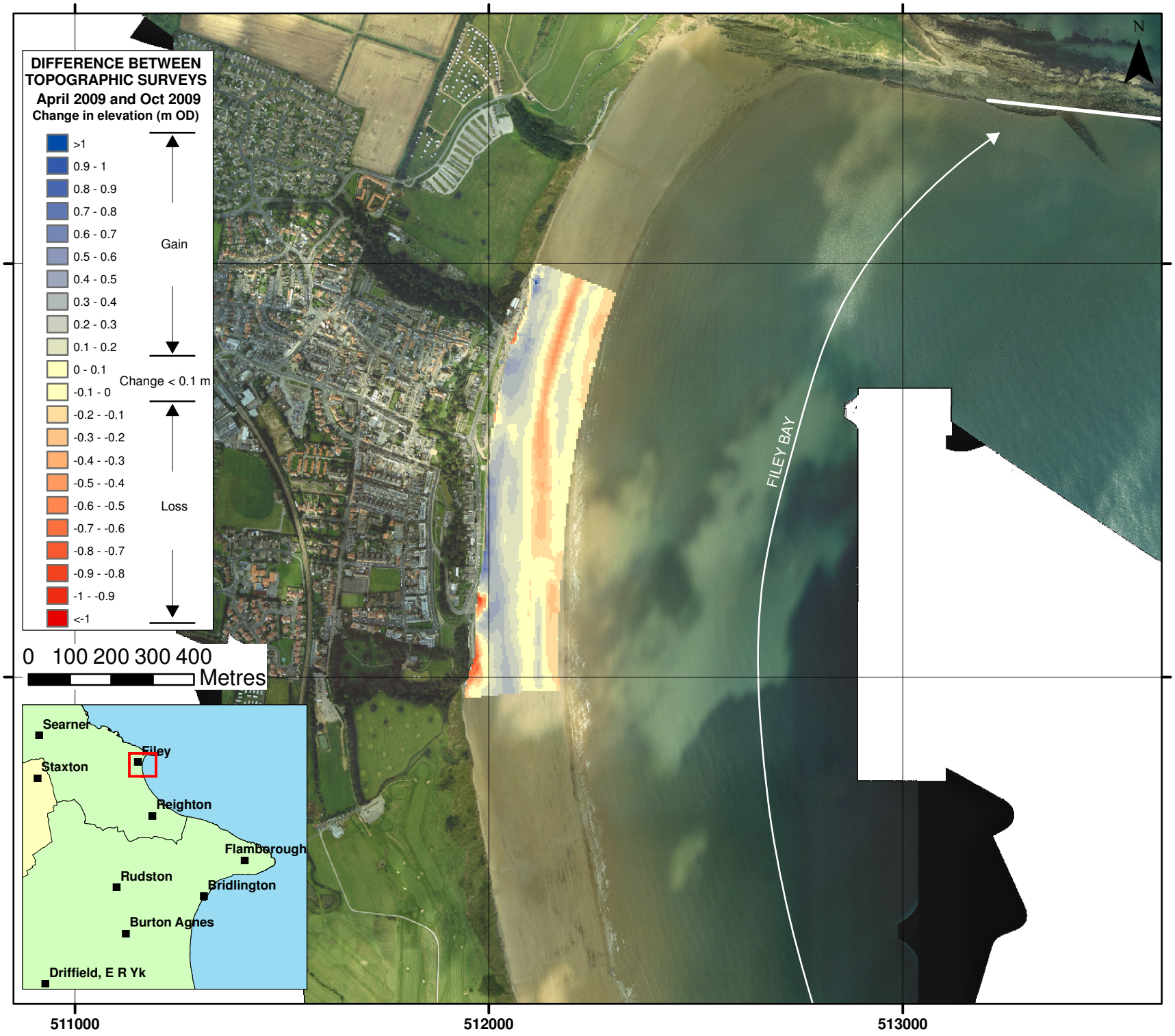

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 14d Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:12,500 at A4

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Appendix C

Scarborough South Bay January 2010 Beach Sand Removal

A COMPANY OF

ROYAL HASKONING

Note

HASKONING UK LTD.
COASTAL & RIVERS

To	:	Stewart Rowe
From	:	Tanja Cooper
Date	:	21 January 2010
Copy	:	
Our reference	:	/N/303434/Newc

Subject : Scarborough South Bay

Scarborough South Bay Beach Material Changes

The note includes 4 figures illustrating the changes in beach material along the Scarborough South Bay frontage between October 2009 and January 2010. The survey on the 5th October 2009 (Figure 1) was part of the Cell 1 Monitoring Programme, the survey on the 14th January 2010 (Figure 2) was undertaken on an adhoc basis to identify areas and volume of beach material removed from the South Bay frontage around the 14th January.

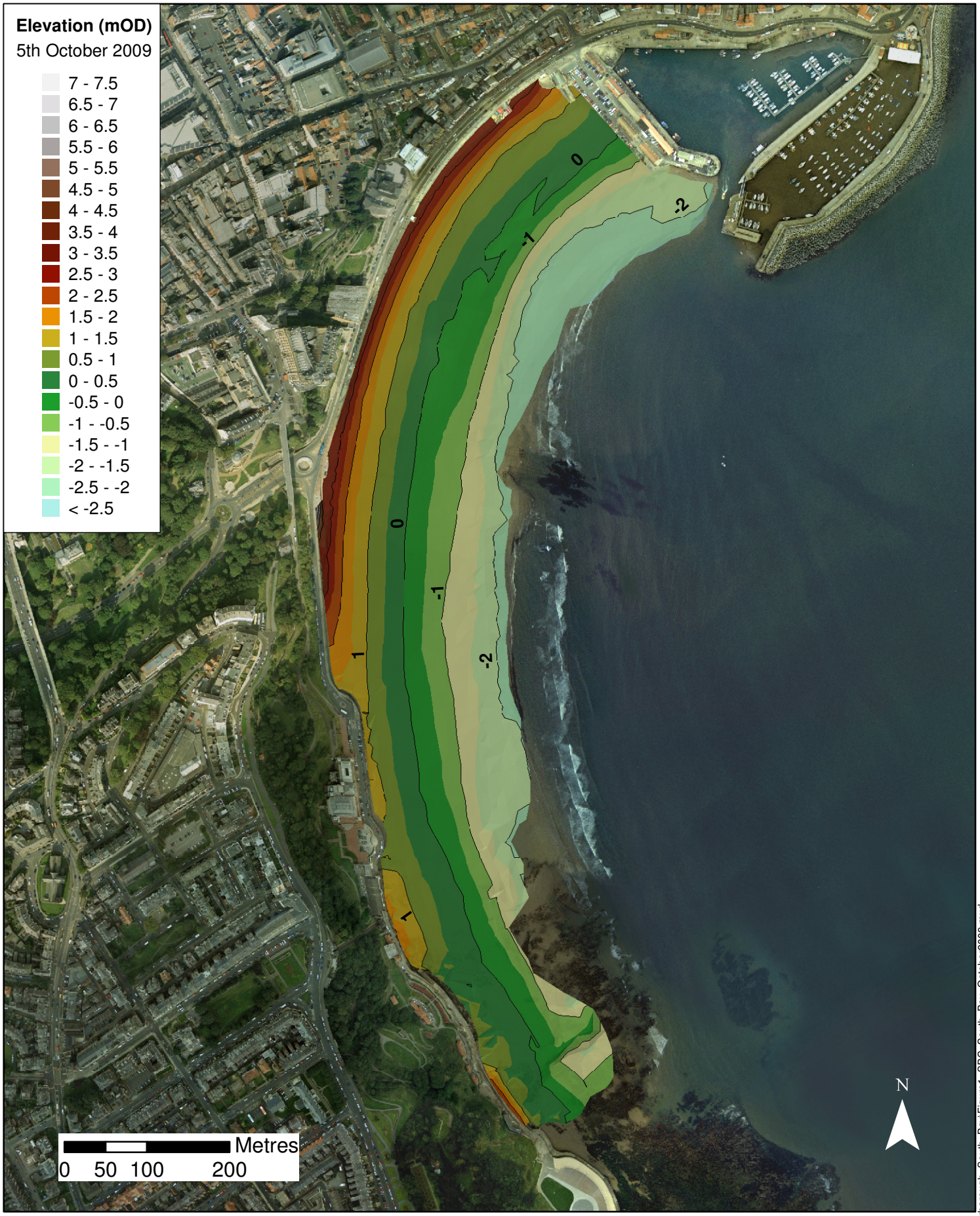
The extent of the January survey doesn't reach the same low beach levels as the October survey due to poor weather and the tide levels not being ideal.

Figure 3 shows the biggest changes to be located between St. Nicholas Cliff and South Cliff, in front of The Spa.

Figure 4 shows areas of net loss and gain along South Bay beach. The net volume loss for the total South Bay beach comes to 34,000 m^3.

It is difficult to say if this loss of material is only related to the removal or natural processes. It is most likely to be a combination of the two. The northerly section of the bay looks as if natural processes are responsible for the movement of material. Whilst the central and southerly parts of the bay indicate a more wide spread loss. The net loss area (blue area on Figure 4) in the central of the bay extends across the whole beach this suggests that most of the material has been taken from this part of the beach.

I would suggest that this note is incorporated into the Full Measures 2009 Report Halcrow is currently working on.



Key:

Title:
Topographic Survey (Oct 2009)

Project:
Scarborough South Bay

Client:
Scarborough Borough Council

Date:
January 2010

Scale on A4:
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Figure:
1

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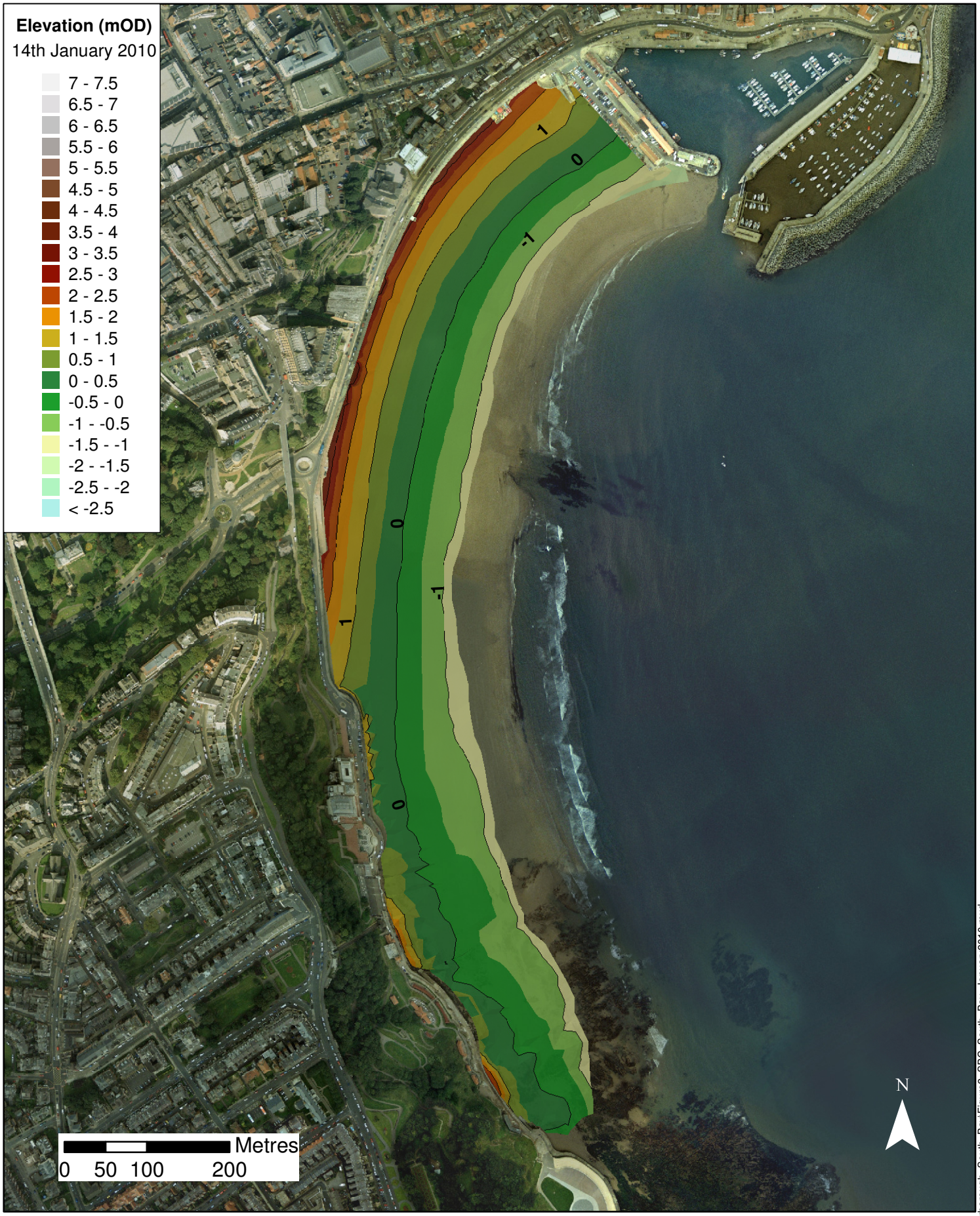

Key:

Title:
Topographic Survey (Jan 2010)

Project:
Scarborough South Bay

Client:
Scarborough Borough Council

Date:
January 2010

Scale on A4:
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Figure:
2

Drawn:
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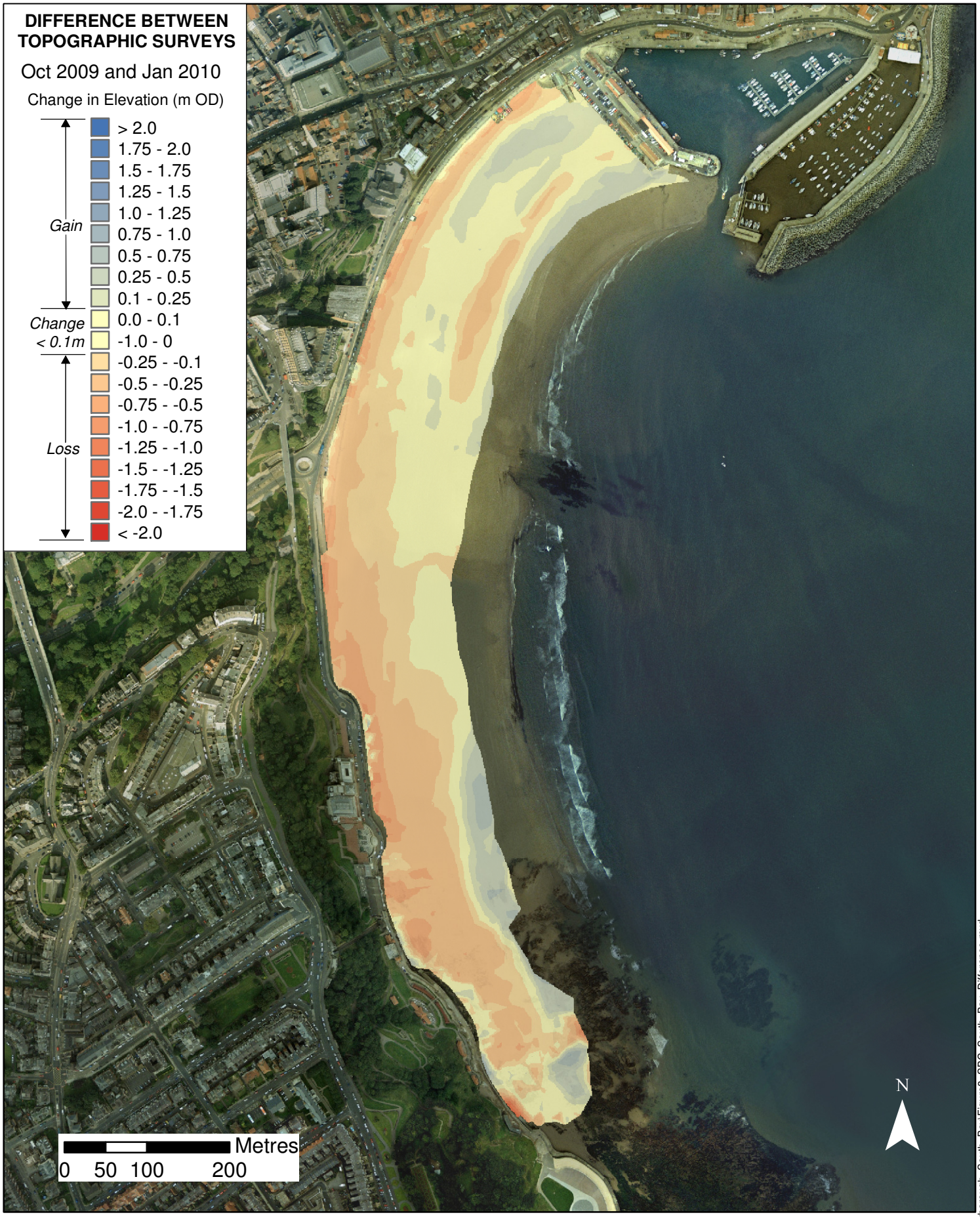

Key:

Title:
Changes between Oct 2009 and Jan 2010 Topographic Surveys

Project:
Scarborough South Bay

Client:
Scarborough Borough Council

Date: January 2010

Scale on A4: 1:6,000

Figure: 3

Drawn: TC

Checked: NC

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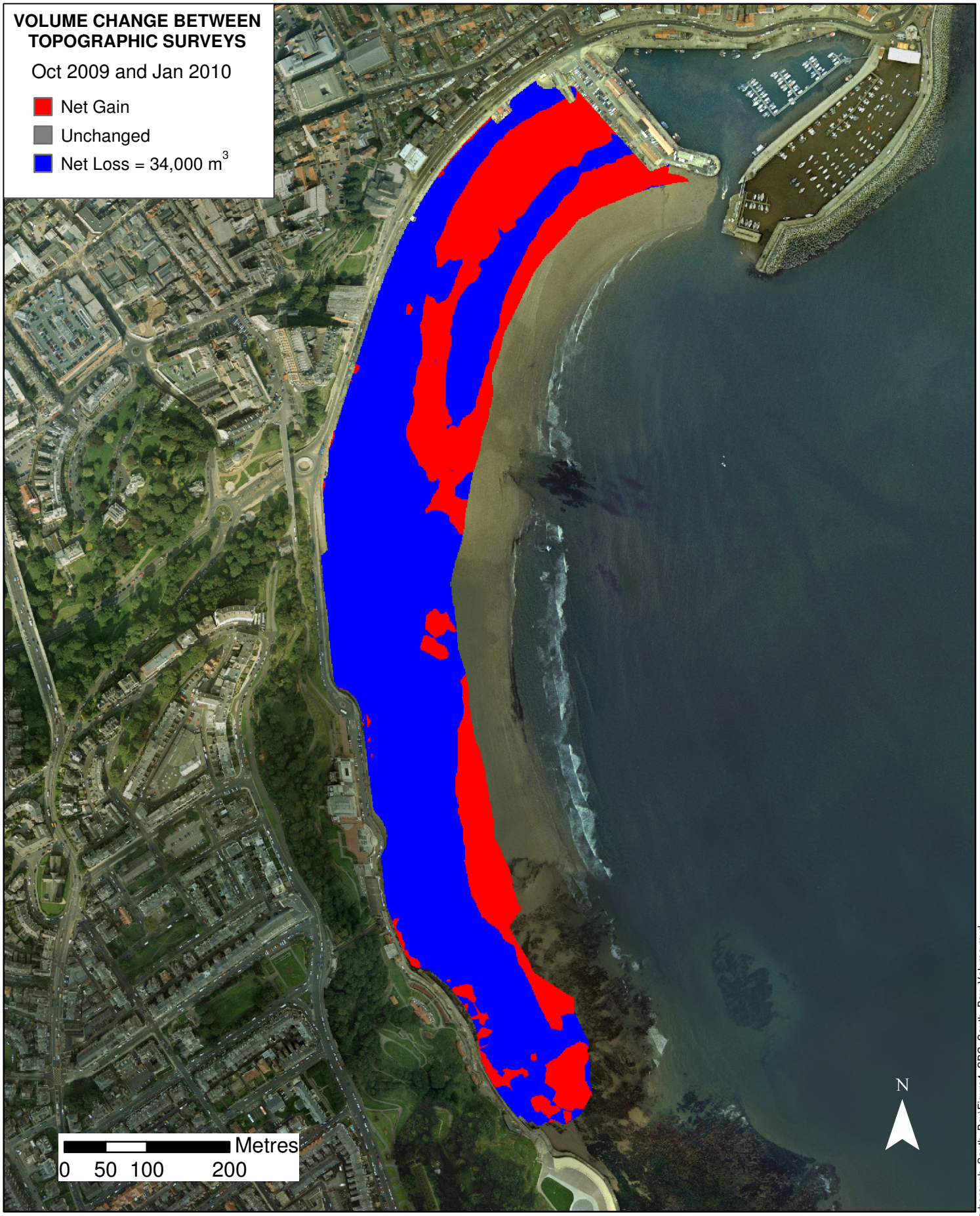

Key:

Title:
Volume Change between Oct 2009 and Jan 2010 Topographic Surveys

Project:
Scarborough South Bay

Client:
Scarborough Borough Council

Date:	Scale on A4:
January 2010	1:6,000

Figure:	Drawn:	Checked:
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ROYAL HASKONING

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Appendix D

Cliff Top Survey

Staithes

Twenty ground control points have been established at Staithes (Appendix D- Map 1). The maximum separation between any two points is nominally 100 m.

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 D1 provides baseline information about these ground control points and results from the September 2009 survey showing the position 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.

Table D1 – Cliff Top Surveys at Staithes

Ground Control Point Details					Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Level (mODN)	Bearing (º)	Baseline Survey (Nov 2008)	Previous Survey (April 2009)	Present Survey (Sept 2009)	Baseline (Nov 2008) to Present (Sept 2009)	Previous (April 2009) to Present (Sept 2009)	Baseline (Nov 2008) to Present (Sept 2009)
1	477228	518769	60.587	320	1.9	1.7	1.7	-0.2	0	-0.3
2	477334	518798	57.543	0	10.9	10.6	10.6	-0.3	0	-0.3
3	477487	518789	54.861	350	7.1	7.8	8.4	+1.3	+0.6	-
4	477594	518801	53.636	340	5.9	5.6	5.7	-0.2	+0.1	-0.3
5	477683	518911	48.371	350	8.4	7.8	8.5	+0.1	+0.7	-
6	477792	518867	47.422	30	8.6	8.5	8.5	-0.1	0	-0.1
7	477891	518828	44.602	60	7.7	7.6	7.7	0	+0.1	0
8	477959	518873	39.974	350	8.7	8.7	9.0	+0.3	+0.3	-
9	478088	518950	37.281	350	7.6	7.3	8.4	+0.8	+1.1	-
10	478191	519023	42.655	340	8.4	8.6	12.7	+4.3	+4.1	-
11	478237	519007	39.990	60	6.9	6.8	6.8	-0.2	0	-0.2
12	478213	518988	37.169	150	6.1	6.7	6.4	+0.3	-0.3	-
13	478501	518809	50.260	15	11.4	10.9	9.3	-2.1	-1.6	-2.5
14	478624	518807	55.345	20	7.5	7.0	7.6	+0.1	+0.6	-
15	478737	518858	56.017	60	6.1	6.8	6.1	0	-0.7	0
16	478823	518757	50.237	60	8.0	8.1	7.9	-0.1	-0.2	-0.1
17	478944	518671	46.764	30	9.3	9.5	9.0	-0.3	-0.5	-0.3
18	479052	518630	47.026	20	9.2	9.1	9.1	-0.1	0	-0.1
19	479147	518610	47.108	0	14.2	14.4	14.0	-0.3	-0.5	-0.3
20	479274	518618	44.243	20	11.4	11.2	11.5	+0.1	+0.3	-

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.

Cliff Top Survey

Cayton Bay

Eight ground control points have been established within Cayton Bay (Appendix D- Map 2). The maximum separation between any two points is nominally 300m.

The cliff top surveys at Cayton Bay 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 D2 provides baseline information about these ground control points and results from the October 2009 survey showing the position 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.

Table D2 – Cliff Top Surveys at Cayton Bay

Ground Control Point Details					Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Level (mODN)	Bearing (º)	Baseline Survey (Nov 2008)	Previous Survey (April 2009)	Present Survey (Oct 2009)	Baseline (Nov 2008) to Present (Oct 2009)	Previous (April 2009) to Present (Oct 2009)	Baseline (Nov 2008) to Present (Oct 2009)
1	506325	484850	32.079	50	4.0	3.7	3.5	-0.5	-0.2	-0.6
2	506459	484716	28.227	65	5.0	4.9	4.0	-1.0	-0.9	-1.1
3	506597	484539	28.204	65	5.0	5.1	6.4	+1.4	+1.3	-
4	506778	484345	38.944	21	9.0	9.2	8.8	-0.2	-0.3	-0.2
5	507019	484222	38.816	342	7.7	7.7	7.9	+0.2	+0.2	-
6	507242	484122	46.544	2	7.4	7.4	7.4	0	0	0
7	507518	484008	69.549	25	7.5	7.3	7.5	0	+0.2	0
8	507819	484006	80.135	1	5.5	5.6	5.4	-0.1	-0.2	-0.1

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.

Cliff Top Survey

Filey Bay

Twenty-three ground control points have been established within Filey Bay (Appendix D- Map 3a & 3b). The maximum separation between any two points is nominally 300 m.

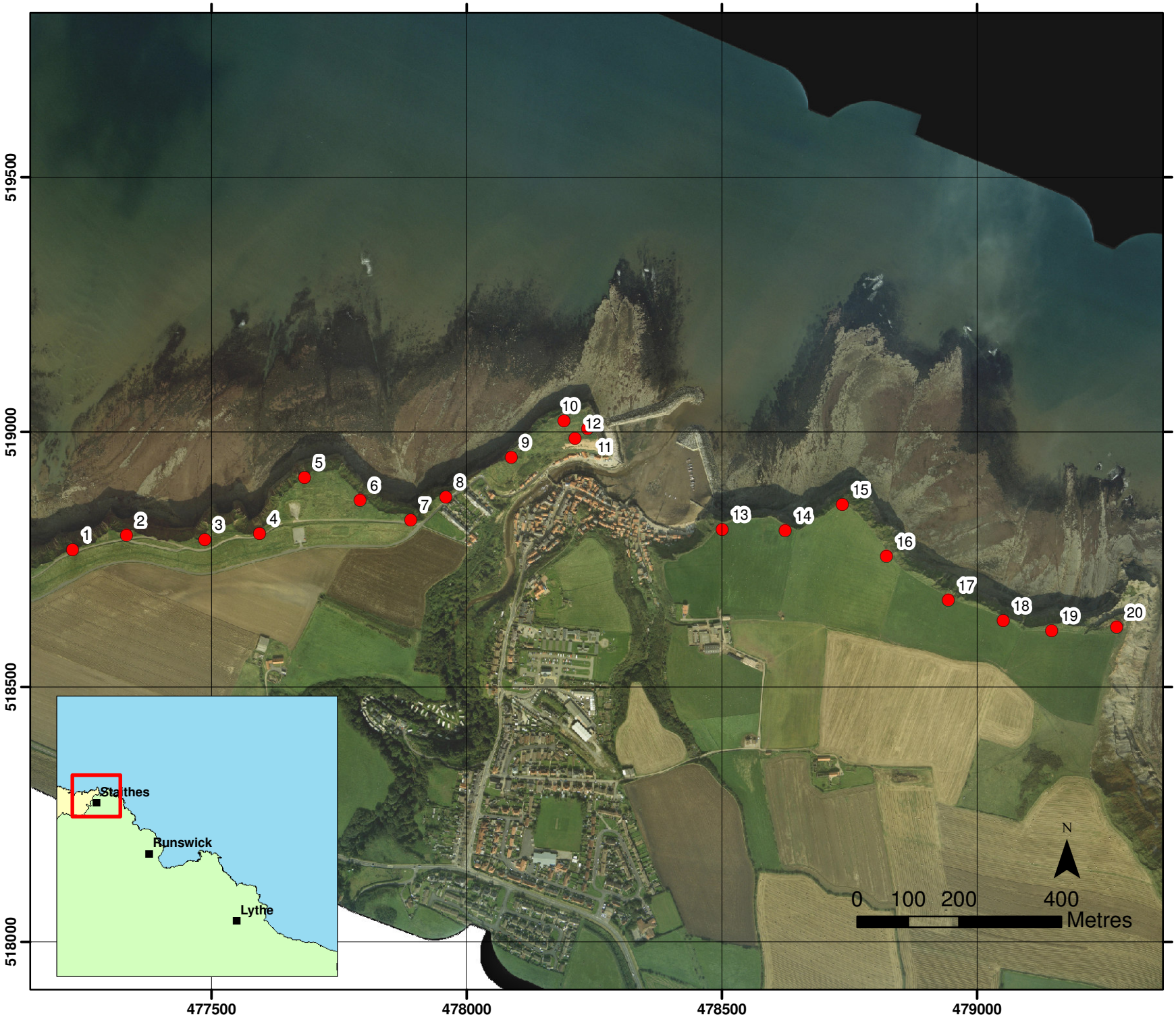
The cliff top surveys at Filey Bay are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table D3 provides baseline information about these ground control points and results from the October 2009 survey showing the position 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.

Table D3 – Cliff Top Surveys at Filey Bay

Ground Control Point Details					Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Level (mODN)	Bearing (º)	Baseline Survey (Nov 2008)	Previous Survey (April 2009)	Present Survey (Oct 2009)	Baseline (Nov 2008) to Present (Oct 2009)	Previous (April 2009) to Present (Oct 2009)	Baseline (Nov 2008) to Present (Oct 2009)
1	512445	481631	42.536	130	8.7	8.5	8.9	+0.2	+0.4	-
2	512307	481490	37.536	144	7.6	7.5	7.7	+0.1	+0.2	-
3	512154	481235	34.607	122	8.3	8.6	8.5	+0.2	-0.1	-
4	512029	480960	33.034	112	7.4	7.5	7.6	+0.2	+0.1	-
5	511895	479888	28.755	89	7.1	3.6	3.6	-3.5	0	-3.8
6	511908	479597	31.804	48	6.7	6.8	6.9	+0.1	0	-
7	511991	479310	29.201	69	6.7	6.7	7.0	+0.3	+0.3	-
8	512083	478981	27.177	66	10.2	10.3	10.3	+0.1	0	-
9	512121	478786	30.903	76	8.3	8.1	8.5	+0.2	+0.4	-
10	512226	478548	32.958	74	7.5	7.3	7.6	+0.1	+0.3	-
11	512471	478153	11.301	53	6.6	6.6	6.2	-0.4	-0.4	-0.4
12	512559	477902	20.254	66	7.7	7.6	7.7	0	+0.1	0
13	512698	477719	20.216	34	4.2	4.2	4.1	-0.1	-0.1	-0.1
14	512939	477401	31.736	66	8.0	7.3	7.9	-0.1	+0.6	-0.1
15	513157	477193	27.613	51	5.2	5.2	5.3	+0.1	+0.1	-
16	513299	477025	27.972	30	7.7	7.6	7.8	+0.1	+0.2	-
17	513508	476821	36.784	34	10.7	10.5	10.8	+0.1	+0.3	-
18	513721	476602	39.676	31	7.2	7.2	7.3	+0.1	+0.1	-
19	513917	476354	48.852	51	6.6	6.5	7.1	+0.5	+0.6	-
20	514175	476179	41.826	32	7.0	6.9	6.9	-0.2	-0.1	-0.2
21	514472	475966	43.232	66	7.6	7.5	7.7	+0.1	+0.2	-
22	514656	475729	56.553	101	8.1	8.2	8.1	0	-0.1	0
23	514889	475538	68.497	60	9.1	8.9	9.2	+0.1	+0.3	-

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



Ground Control Points

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix D - Map 1 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

Drawn by:	ES	Date: 25/01/2010
Checked by:	RJ	Date: 25/01/2010
Approved by:	RJ	Date: 25/01/2010

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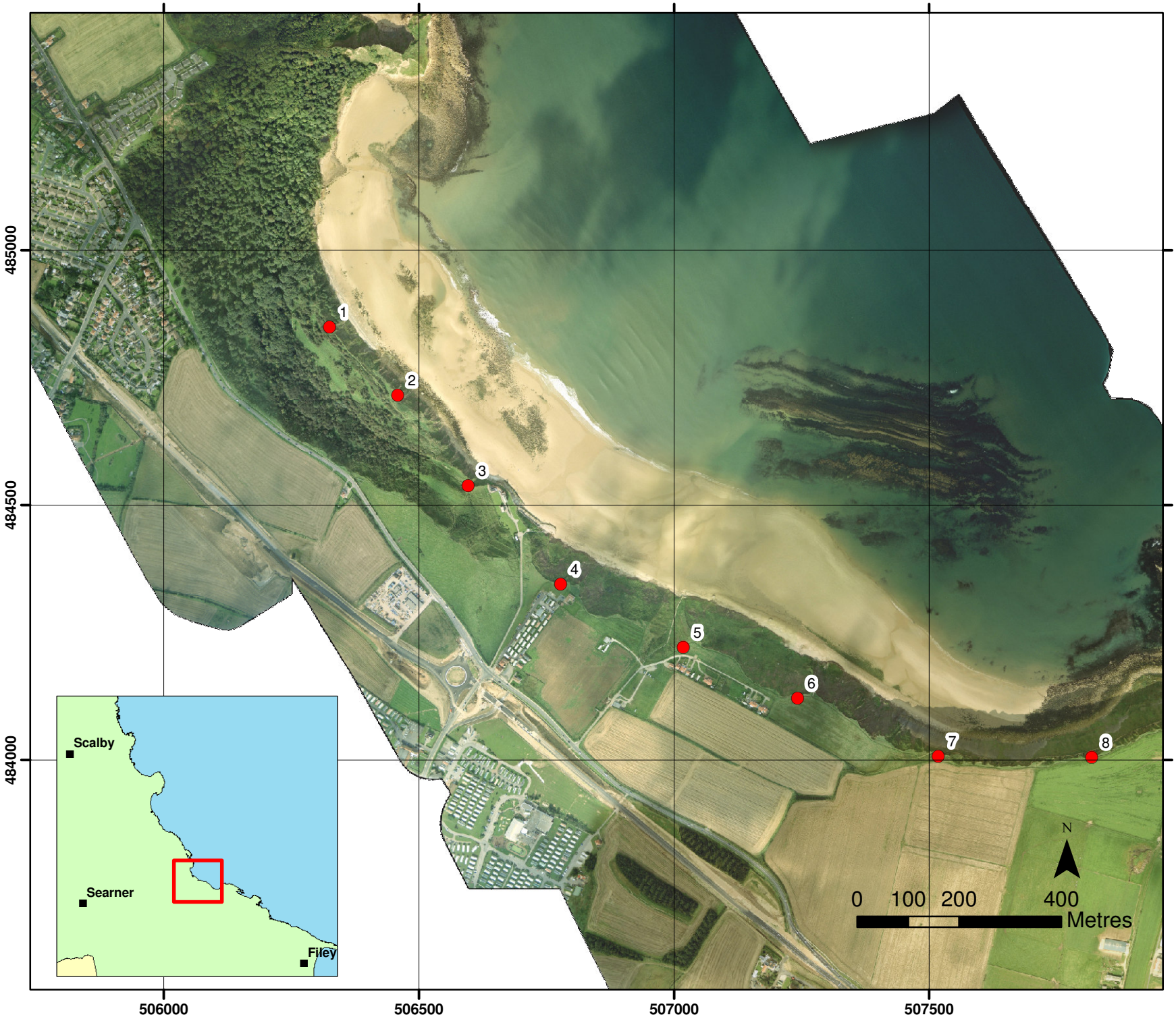

Ground Control Points

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix D - Map 2 Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:10,000 at A4

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Checked by:	RJ	Date: 25/01/2010
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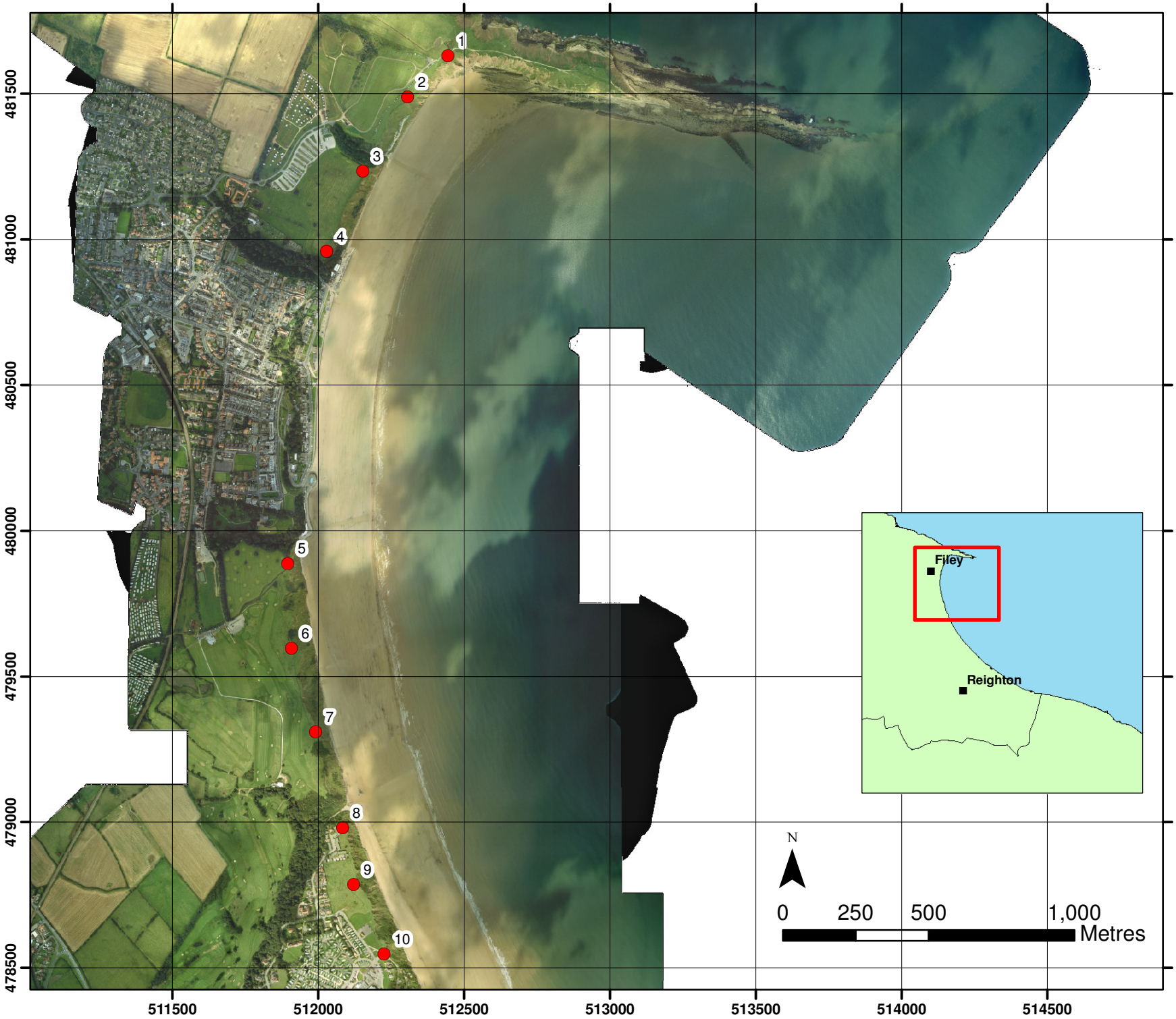

Ground Control Points

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix D - Map 3a Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:17,500 at A4

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Approved by:	RJ	Date:	25/01/2010

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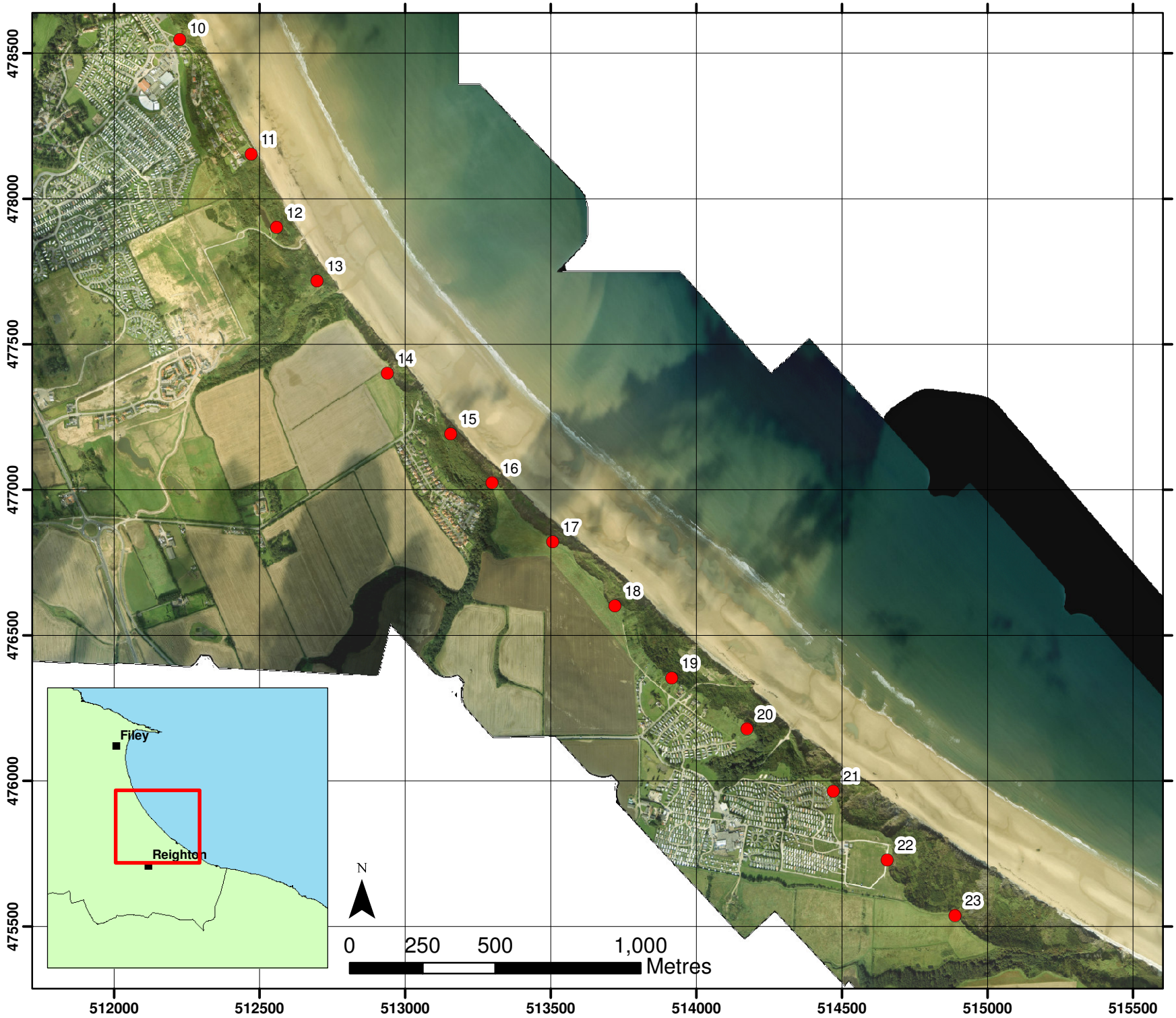

Ground Control Points

Client: Scarborough Borough Council

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix D - Map 3b Scarborough Borough Council Frontage

Analytical Report 2
'Full Measures' Survey 2009

Drawing Scale 1:17,500 at A4

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Approved by:	RJ	Date: 25/01/2010

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