ROYAL HASKONING

Halcrow

Cell 1 Regional Coastal Monitoring Programme
Update Report 2: 'Partial Measures' Survey 2010

Sunderland City Council

Sunderland City Council
Final Report

June 2010

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Authors	
Nick Cooper	Royal Haskoning
Tanja Cooper	Royal Haskoning

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

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

Glossary of Terms

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

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire.

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.

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	Mar-Apr 10	May10 (*)	-

(+) An Analytical Report was not produced in May 2009 for Sunderland City Council as part of the Cell 1 Regional Monitoring Programme because the survey data collection and reporting was coordinated under an existing 5-year local monitoring programme which Sunderland City Council had commissioned other consultants to undertake.

(*) The present report is **Update Report 2** and provides an analysis of the 2010 Partial Measures survey for Sunderland City Council's frontage. It is intended as a brief update of the key findings from this survey to maintain an understanding of ongoing changes.

1. Introduction

1.1 Study Area

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

- Whitburn Bay (also referred to as Sunderland North or 'SNN')
- Sunderland Harbour and Docks (also referred to as Sunderland Central or 'SNC')
- Hendon to Ryhope (also referred to as Sunderland South or 'SNS')

1.2 Methodology

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

- Full Measures survey annually each autumn/early winter comprising:
    - 58 no. beach profile lines
    - Topographic survey at Whitburn Bay
    - Topographic survey at Hendon to Ryhope

- Partial Measures survey annually each spring comprising:
    - 14 no. beach profile lines

- Cliff top survey bi-annually at:
    - Hendon to Ryhope

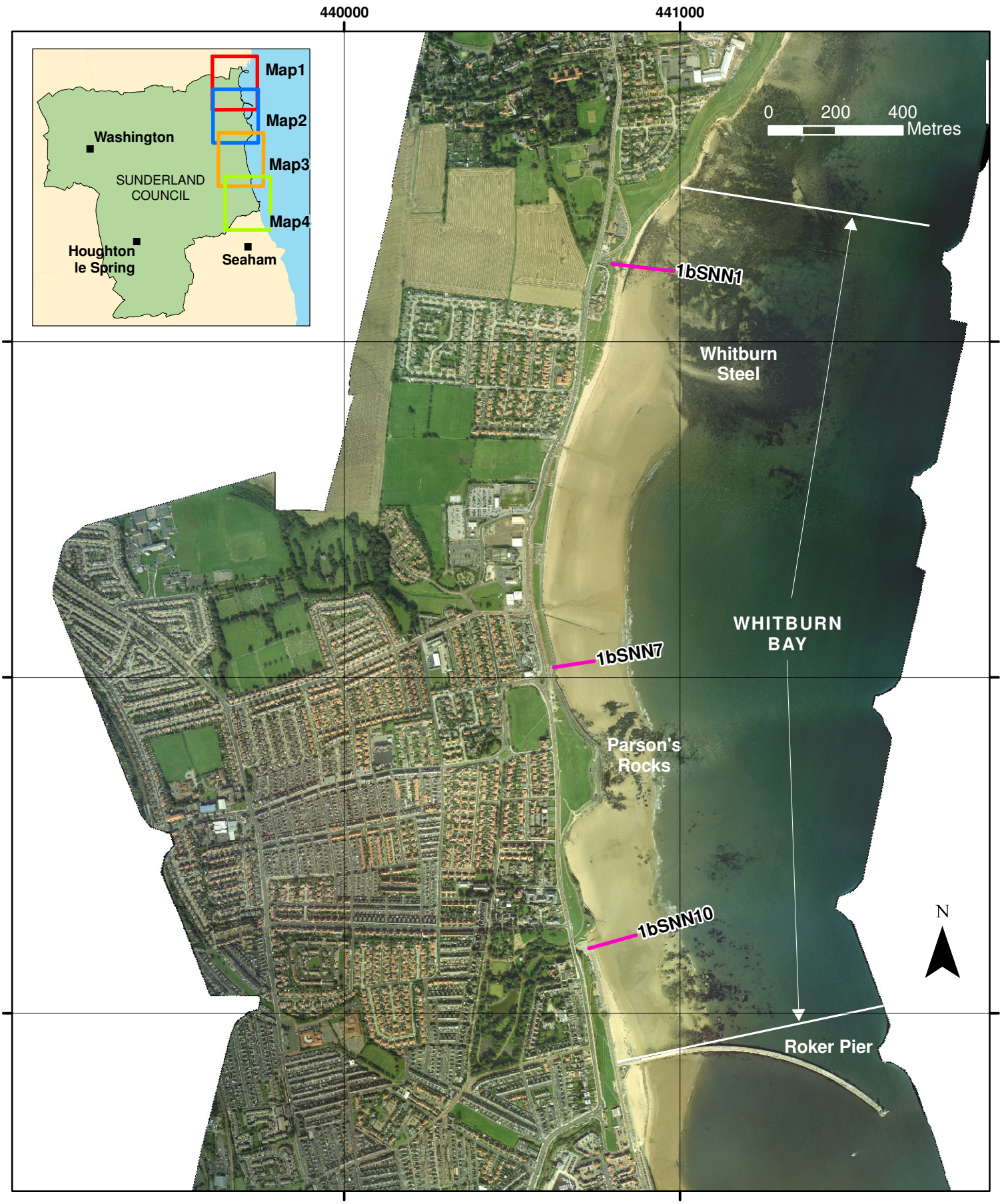
The location of these surveys is shown in Figure 1. They have also previously been provided on a digital file which can be opened in Google Earth showing the locations of the surveys.

The Partial Measures survey was undertaken along this frontage in March 2010, when weather conditions for the Sunderland North surveys were fine with calm winds and the sea state was flat, and the weather conditions for the Sunderland South surveys were dry and breezy and the sea state was calm.

The Update Report presents the following:

- 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.



TOPOGRAPHIC SURVEY LOCATIONS

- Bi-Annual Profile
- Cliff Top Survey @ 50m centres
- Cliff Top Survey @ 100m centres
- Cliff Top Survey @ 300m centres

(Indicative Survey Extents shown)

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

Figure 1 - Map 1 Sunderland Council Frontage

Update Report 2
'Partial Measures' Survey 2010

Drawing Scale 1:15,000 at A4

ROYAL HASKONING

Royal Haskoning
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

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

Halcrow

Halcrow Group Ltd
Lyndon House
62 Hagley Road
Edgbaston
Birmingham
B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44 (0)121 456 1569
www.halcrow.com

Drawn by:	TC	Date: 17/05/2010
Checked by:	MD	Date: 24/05/2010
Approved by:	NC	Date: 24/05/2010

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TOPOGRAPHIC SURVEY LOCATIONS

- Bi-Annual Profile
- Cliff Top Survey @ 50m centres
- Cliff Top Survey @ 100m centres
- Cliff Top Survey @ 300m centres

(Indicative Survey Extents shown)

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Figure 1 - Map 2 Sunderland Council Frontage

Update Report 2
'Partial Measures' Survey 2010

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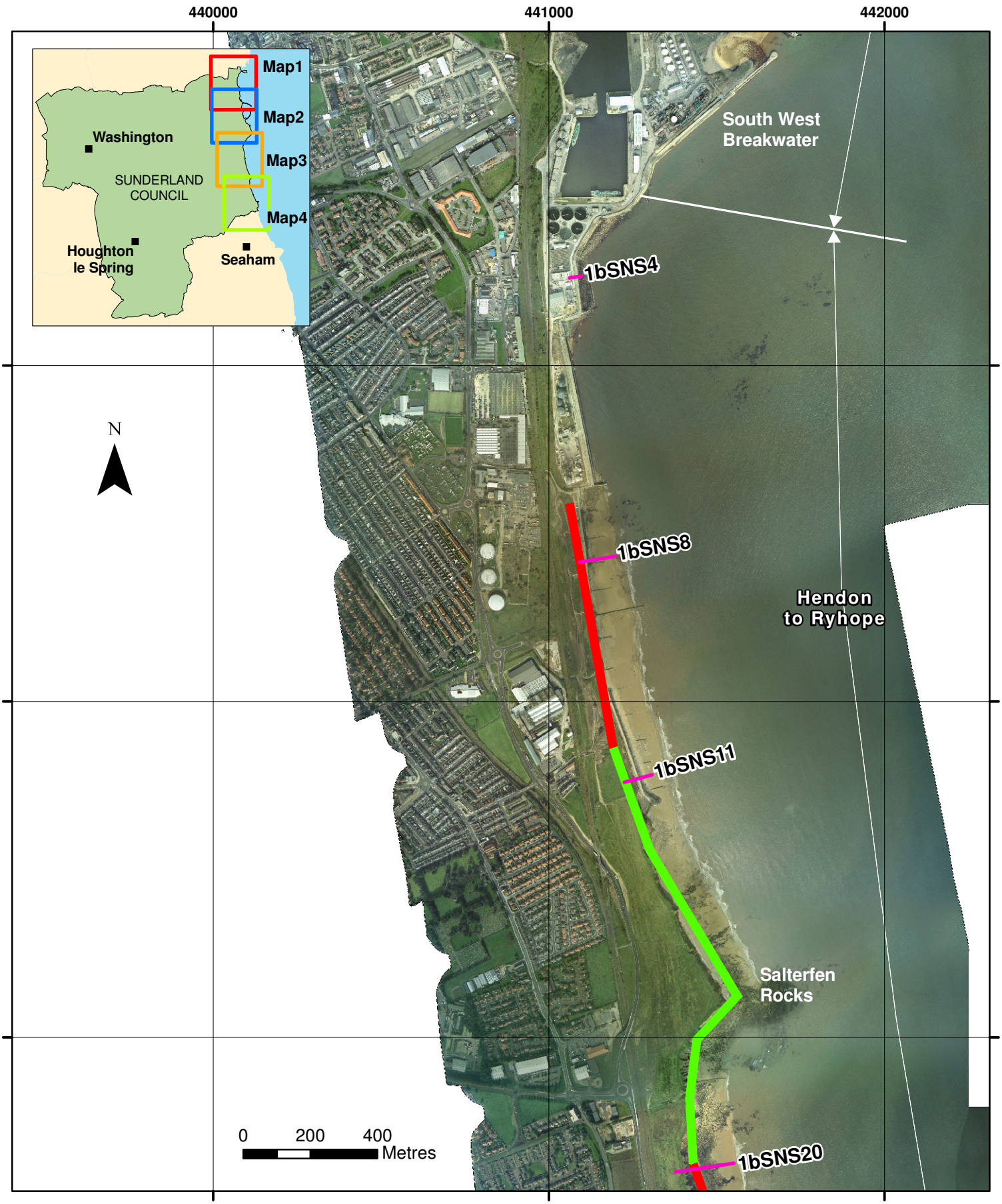

TOPOGRAPHIC SURVEY LOCATIONS

- Bi-Annual Profile
- Cliff Top Survey @ 50m centres
- Cliff Top Survey @ 100m centres
- Cliff Top Survey @ 300m centres

(Indicative Survey Extents shown)

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Figure 1 - Map 3 Sunderland Council Frontage

Update Report 2
'Partial Measures' Survey 2010

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ROYAL HASKONING

Royal Haskoning
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

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

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Lyndon House
62 Hagley Road
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Birmingham
B16 8PE

Tel: +44 (0)121 456 2345
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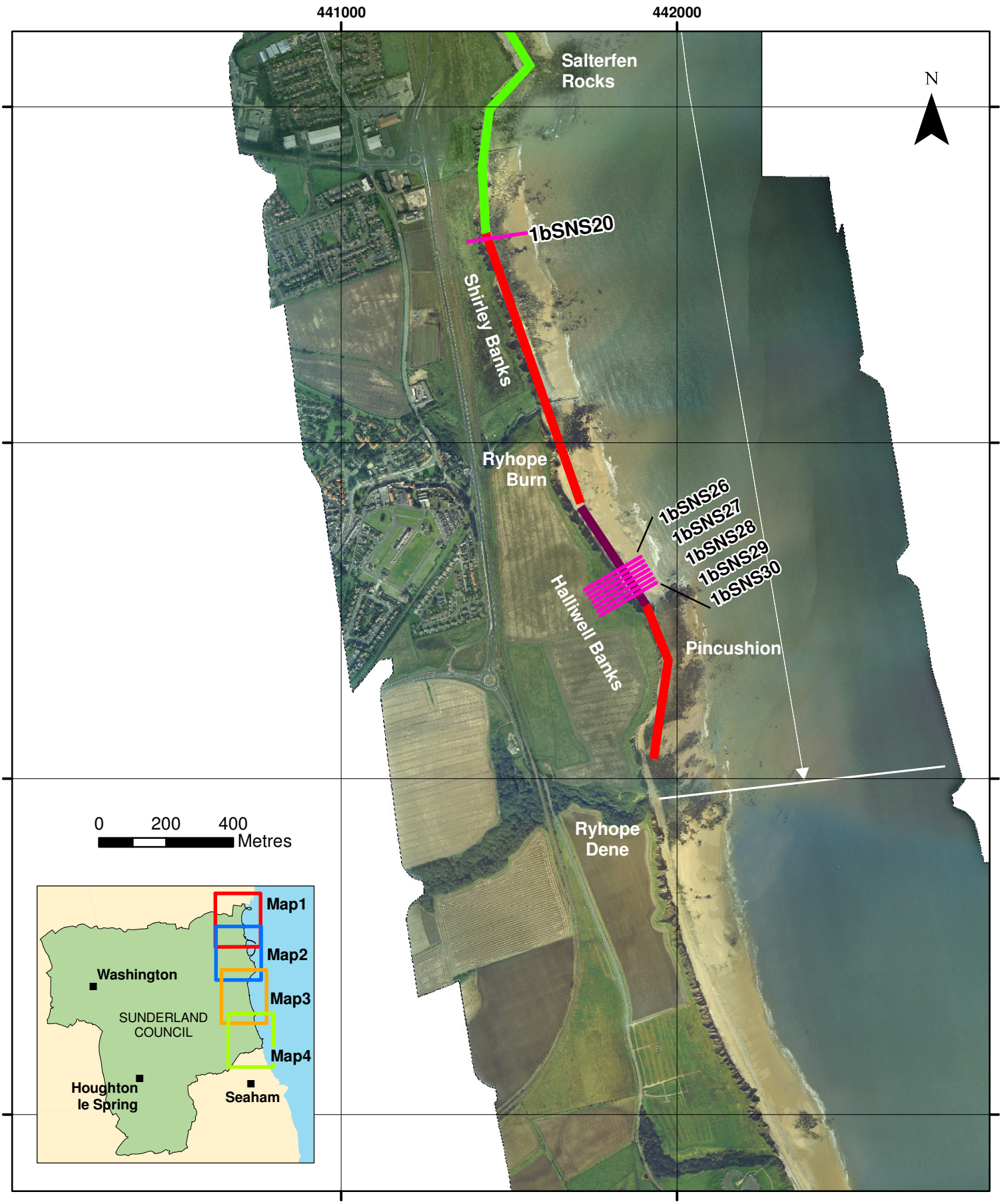

TOPOGRAPHIC SURVEY LOCATIONS

- Bi-Annual Profile
- Cliff Top Survey @ 50m centres
- Cliff Top Survey @ 100m centres
- Cliff Top Survey @ 300m centres

(Indicative Survey Extents shown)

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

Figure 1 - Map 4 Sunderland Council Frontage

Update Report 2
'Partial Measures' Survey 2010

Drawing Scale 1:15,000 at A4

ROYAL HASKONING
Royal Haskoning
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE
Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
www.royalhaskoning.com

Halcrow
Halcrow Group Ltd
Lyndon House
62 Hagley Road
Edgbaston
Birmingham
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Tel: +44 (0)121 456 2345
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2. Analysis of Survey Data

2.1 Whitburn Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
03-2010	**Beach Profiles:** Whitburn Bay is covered by three beach profile lines during the Partial Measures survey (Appendix A). SNN1 is just to the south of Sunderland City Council's northerly boundary of jurisdiction. The profile form shows general consistency in the area of scrub by the boat yard. Along the beach, levels did show change, with the upper gravel beach becoming eroded to low levels to a chainage of around 80m, but with the seaward profile remaining similar in form and level to that recorded in September 2009 to around a chainage of 180m. Seaward of here, rock outcrops on the lower foreshore were exposed, with no sand coverage. SNN7 is at Seaburn, just to the north of Parson's Rock. The profile extends across the crest of the sea wall, which is at an elevation of 5.6mODN, and down the vertical face to the toe. At the toe, sand had been eroded from the upper foreshore to a chainage of around 45m, with a water-filled trough evident running roughly parallel to the toe of the wall. Seaward of a chainage of 45m the foreshore levels were relatively high. SNN10 is located approximately mid-way between Parson's Rock and Roker Pier. It extends across the beach access slope and fronting sea wall before dropping to beach level. The profile then extends across the sandy foreshore down to low water. The survey in March 2010 shows the profile to adopt a similar form to that observed in September 2009, but the levels were universally lower by around 0.5m along the majority of its length. The only exception was directly at the toe of the wall, where levels dropped but only marginally.	North of Parson's Rock, the two profiles exhibited similar tendencies, with upper beach erosion and mid and lower beach accretion, suggesting a degree of profile flattening in response to the stormier wave climate over the winter of 2009/2010. South of Parson's Rock, profile SNN10 is different in that it tends to experience a net change (in between the two most recent surveys this has been one of lowering) across its length, rather than a redistribution of sediment from upper to lower (or *vice versa*) sections of the profile. This *may* be associated with discharge through Northumbrian Water's stormwater overflow and across the beach. This issue will be considered further in summer 2010 during the 2-yearly walk-over inspections.

2.2 Hendon to Ryhope

Survey Date	Description of Changes Since Last Survey	Interpretation
03-2010	**Beach Profiles:** Hendon to Ryhope is covered by twelve beach profile lines during the Partial Measures survey (Appendix A). Seven of these are closely spaced and located at Halliwell Banks to specifically monitor erosion rates along the cliffs fronting the former landfill area. SNS4 crosses the concrete boundary wall of the Hendon Sewage Treatment Works, which has an elevation in excess of 7.0mODN, and extends a further 5m across the concrete deck to the edge of the near vertical wall face. The profile then crosses the fronting rock revetment until it intercepts water. There is very little foreshore exposed along the frontage as the profile soon extends into deeper water, but the short length of foreshore that is present at the toe of the revetment did exhibit accretion between September 2009 and March 2010. SNS8 and SNS11 both start at the coastal slope/cliff backing the Hendon Sea Wall and extend across the wall and fronting rock armour before reaching sand levels and then extending down to low water. SNS8 experienced lowering of the beach profile between the toe of the revetment and a chainage of around 55m. The lower foreshore, seaward of a chainage of 55m, experienced accretion by around 0.4m. SNS11 experienced accretion between September 2009 and March 2010 along the upper section of the narrow foreshore zone that extends seawards from the toe of the rock revetment. SNS20 is located at Shirley Banks. The profile extends across the cliff top, which is at an elevation in excess of 25mODN, and drops over 21m in height down the steeply-sloping cliff face to the toe. The profile then extends across the foreshore down to low water, with some rock outcrops captured towards the landward end. Whilst there was no significant change in position of the cliff top along this profile, the toe of the cliff did experience cut-back of some 2.5m at the toe of the cliff. This has resulted in a steeper cliff profile which will lead to subsequent cliff failures and recession of the cliff top position. Profiles SNS26 to SNS32 are all located at close spacings at Halliwell Banks. Each profile exhibits a broadly similar form, with a gentle downward slope across the first 50m or so of cliff top followed by a slightly steeper upward slope to around 10m or so from the cliff edge. The profile then has a near-horizontal or very gently downward sloping form to the very cliff edge, which generally is around 26.8mODN, although slightly lower in elevation at SNS31 and SNS32. There is then a drop of around 22-24m down the steep cliff face to the upper foreshore. Each profile then extends a short distance across the gravelly foreshore to low water.	The accretion along the short length of foreshore at profile SNS4 is likely to be due to sediment mobilised and transported during storms over the winter of 2009/2010 becoming deposited in the lee of the harbour structures and remaining on the foreshore due to the relative shelter that the structures provide to this frontage. There appears to have been no consistent trend in profile response along the southern end of the Hendon Seawall, although some of the material liberated from SNS8 may have become deposited along SNS11. The profiles measured along the undefended cliffs of Shirley Banks and Halliwell Banks have generally experienced erosion at the toe of the cliffs, resulting in undercutting. This has resulted in a steeper cliff profile which in many cases has triggered a cliff failure and recession of the cliff top position and in other cases may lead to a subsequent failure following similar mechanisms.

Survey Date	Description of Changes Since Last Survey	Interpretation
	All profiles show signs of change since the September 2009 surveys, either at the toe of the cliff, the top of the cliff or both. Along profiles SNS26, SNS27 and SNS28, the cliff top position has eroded by around 1m, probably triggered by erosion at the cliff toe. Along profiles SNS29, SNS30, SNS31 and SNS32 the foreshore and toe of the cliffs have suffered some erosion, although the cliff top position has either not changed or only experienced minor change.	
03-2010	**Cliff Top Survey:** Thirty-five ground control points have been established along the cliff top between Hendon and Ryhope (Figure B1). **Note**: the numbering of control points is <u>not</u> intended to correlate with that of the beach profile lines and reference should be made to Figure B1 for locations of control points. Measurements are taken from each ground control point along a fixed bearing to the edge of the cliff top. These cliff top surveys are undertaken bi-annually and are intended to inform on erosion rates of the sea cliffs extending from the defended industrial areas at Hendon southwards along the undefended cliffs to Ryhope Dene. Points 1 to 3 have been affected by cliff landscaping works that were undertaken in 2009. All three cliff top positions recorded in March 2010 are somewhat landward of those recorded in September 2009 and these now represent a new 'baseline' against which future surveys will be compared now that the earthworks are complete. Points 4 to 23 are located along the undefended sea cliffs extending from the end of the Hendon Seawall south to Ryhope Burn (sometimes known as Ryhope Beach Road), which separates Shirley Banks from Halliwell Banks. Here, the changes recorded to date have been within the bands of accuracy of the surveying technique, so no net trends have been identified. Points 24 to 32, which extend along Halliwell Banks to Ryhope Dene, have generally experienced changes greater than the accuracy of the surveying technique and therefore must be considered as true records of recession. In some cases, such as at points 25, 27, 28 and 31, the recession has been of the order of metres since the first survey in March 2009.	Recession rates along the undefended cliffs appear greatest to date along Halliwell Banks (which fronts the former land fill) and immediately south of Pincushion. The surveyors have recorded undercutting of the cliff toe, leading to conditions that have triggered cliff failures or are likely to do so under future conditions. At the most extreme (point 27), the cliff top has eroded 4.6m between March 2009 and March 2010, giving rise to concern about the integrity of the rock barrier which retains the waste within the land fill.

3. Problems Encountered and Uncertainty in Analysis

Cliff Top Surveys

Surveying any cliff top is difficult due to the Health and Safety risks posed to surveyors, especially during adverse weather, and the 'apparent' changes that can arise due to surveyors interpreting different points as the cliff edge on successive surveys (Plate 1). This has previously been identified as affecting most of the cliff top surveys.

Plate 1 – Cliff Top Surveying

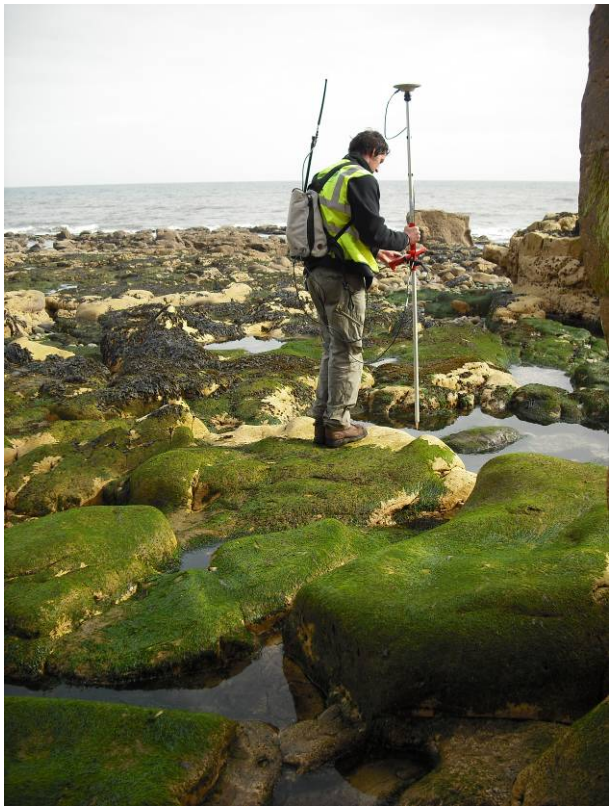
In addition to surveyor interpretation, cliffs along this frontage have a characteristic tendency to heave seawards prior to a toppling failure, leading to apparent discrepancies in the data.

It is also known that along cliff top monitoring points 1 – 3 the cliff top was re-landscaped in late 2009 behind the coastal defences, giving rise to the apparent massive increase in distance to the cliff edge recorded in the September 2009 survey.

Rock Foreshores

Surveys of foreshore areas that are covered by inter-tidal rock outcrops present some problems to our surveyors (Plate 2). It is logistically difficult for staff to access across the foreshore but more importantly it is very difficult to ensure that identical rock features are re-surveyed on each occasion. Due to the fragmented, creviced and 'rocky' nature of the foreshore it is extremely likely that different features will be recorded on successive surveys due to this. We would expect that the rock foreshore would not experience significant down-weathering over short timescales and therefore any apparent changes between successive surveys are likely to be due to surveying different features rather than erosion.

Plate 2 - Survey of Rock Foreshore



Notwithstanding this, the rock foreshore areas may periodically be covered with a thin veneer of beach sand, which due to its mobility, can be absent on subsequent surveys. Such changes are identified through inspection of the photographs that are taken by the surveyors along each transect line and analysis of the sediment coding that is included in the raw data file, depicting areas of 'sand' or 'rock'.

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

Following the cliff top surveys undertaken in March 2010 during this Partial Measures campaign, it is recommended that these surveys are retained in the programme. It should be recognised, however, that a long-term record will yield the most accurate results.

The surveyors have now added a further 3 ground control points (now named 28A, 28B and 28C) between points 28 and 29 to extend the cliff top surveys further south towards Pincushion.

5. Conclusions and Areas of Concern

- The sections of undefended cliff appear to be eroding quite rapidly, especially along Halliwell Banks, with several metres of cliff top recession recorded between March 2009 and March 2010.

- The mechanism for failure is initiated by undercutting at the base of the cliffs (Plate 3) by wave action. This has occurred on a quite widespread basis across the frontage during the winter of 2009/2010 because the weather conditions were severe, coinciding with a prolonged period of easterlies and high sea states.

Plate 3 – Cliff Undercutting

- Once such conditions have been created at the base of the cliffs, cliff failures can more readily be triggered by waves, rainfall, freeze-thaw cycles or additional loading (such as heavy snow during the winter of 2009/2010).

- Such failures generally take the form of material falling from the cliff face with the debris becoming deposited on the foreshore at the toe of the cliff (Plate 4). Here, the debris will provide some protection until it is removed by marine action and the process starts again.

Plate 4 – Debris at the Cliff Toe

- Such processes lead to landward recession of the cliffs. This is of most concern at Halliwell Banks where annual recession rates are now commonly of the order of several metres along the cliffs fronting the former land fill area and at one point (Control Point 25) has reached 5.2m between March 2009 and March 2010.

Appendices

Appendix A

Beach Profiles

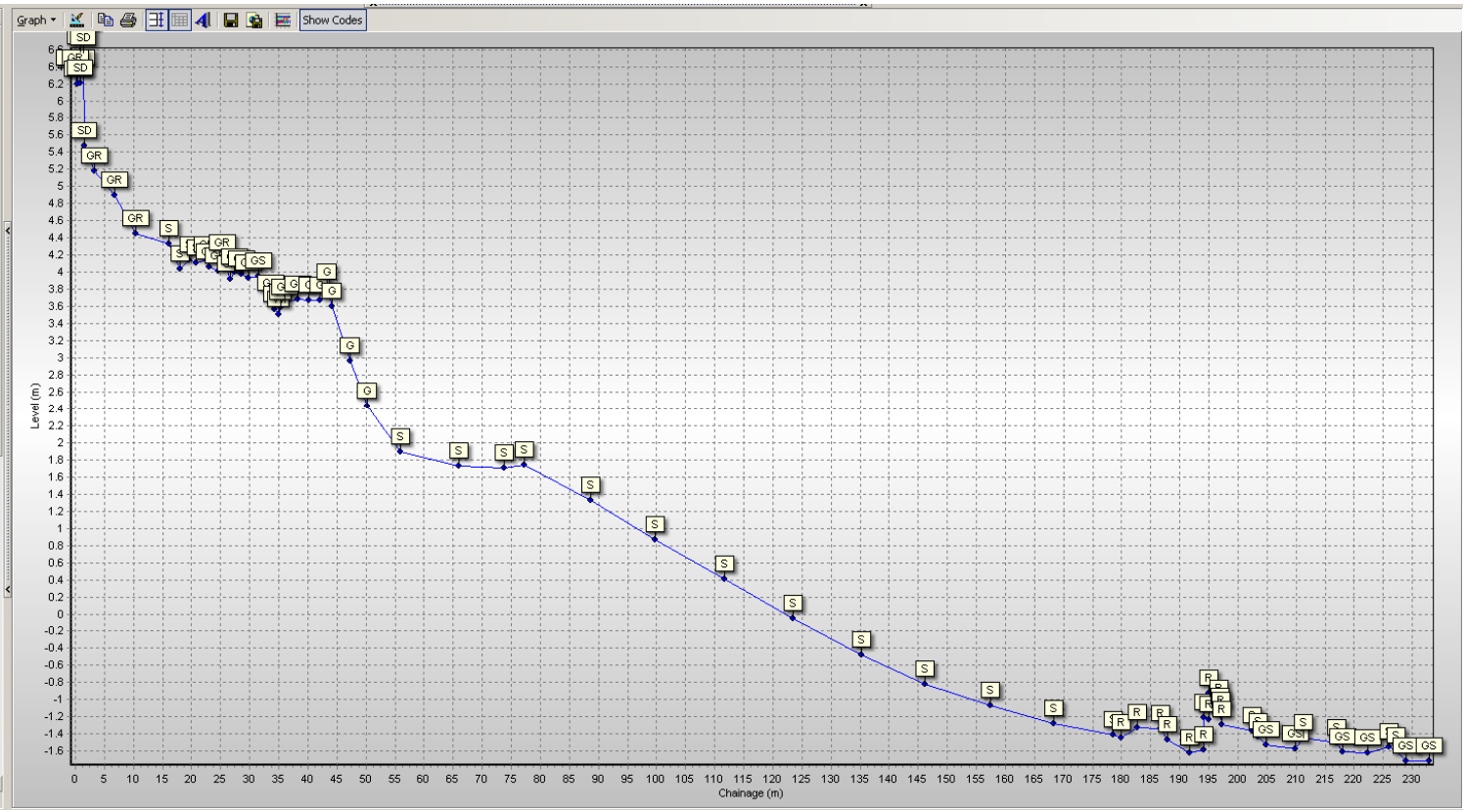
The following sediment feature codes are used on some profile plots:

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

Sunderland North

1bSNN1 - 18/03/2010

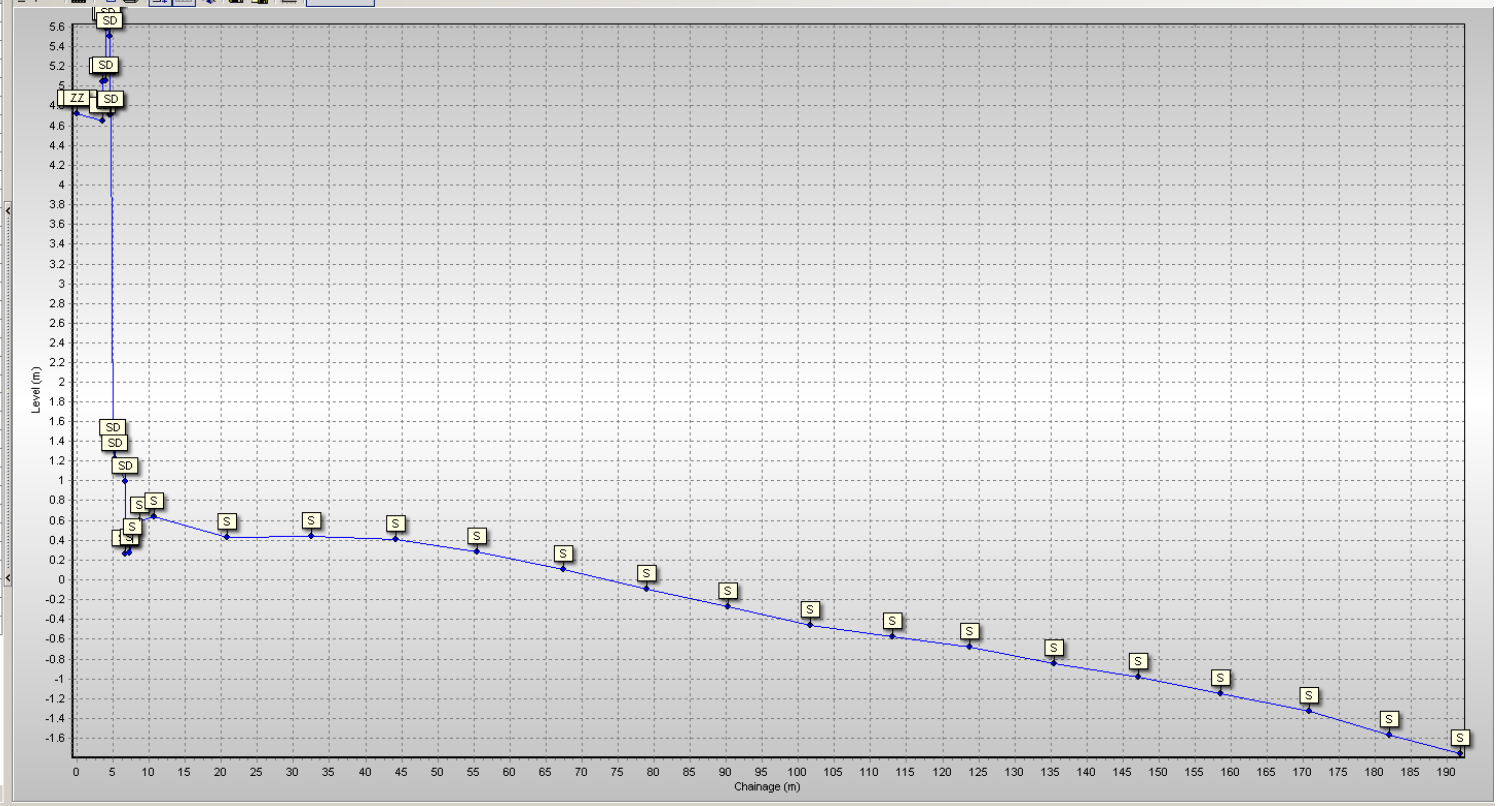
Chainage	Level	Code
0.000	6.326	
0.014	6.326	GR
0.394	6.196	GR
0.843	6.211	SD
0.874	6.572	SD
1.470	6.562	SD
1.555	5.476	SD
3.286	5.185	GR
6.725	4.902	GR
10.401	4.447	GR
16.047	4.336	S
18.080	4.038	S
19.600	4.141	S
20.702	4.111	S
22.767	4.138	GR
23.075	4.061	GR
24.514	4.015	GR
25.309	4.163	GR
26.662	3.924	GR
27.376	4.002	GR
28.638	3.983	GS
29.823	3.936	GS
31.522	3.956	GS
33.657	3.700	GS
34.338	3.568	W
34.933	3.508	W
35.349	3.588	W
35.932	3.649	GS
38.269	3.680	GS
40.242	3.678	G
42.070	3.673	G
43.281	3.824	G
44.146	3.603	G
47.298	2.970	G
50.257	2.435	G
56.015	1.894	S
66.053	1.731	S
73.746	1.705	S
77.182	1.735	S
88.635	1.325	S
99.828	0.870	S
111.630	0.408	S



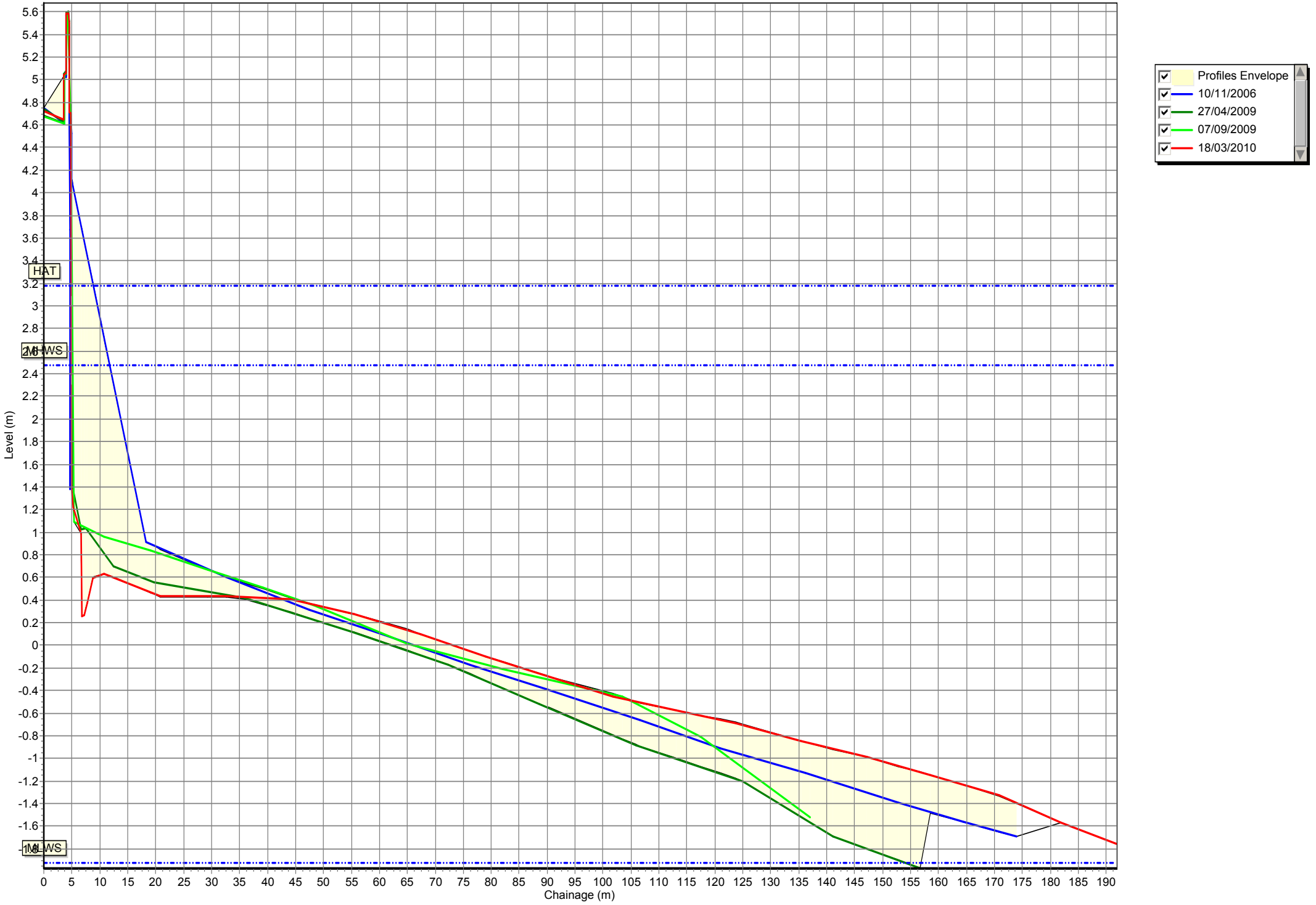
Beach Profiles: 1bSNN1

1bSNN7 - 18/03/2010

Chainage	Level	Code
0.000	4.724	
0.008	4.724	ZZ
3.556	4.647	SD
3.595	5.042	SD
4.004	5.058	SD
4.017	5.587	SD
4.344	5.585	SD
4.517	5.503	SD
4.532	4.714	SD
4.751	4.706	SD
4.996	1.383	SD
5.233	1.218	SD
6.657	0.990	SD
6.749	0.261	SD
7.208	0.270	S
7.755	0.377	S
8.733	0.598	S
10.697	0.633	S
20.796	0.432	S
32.557	0.434	S
44.186	0.410	S
55.523	0.277	S
67.386	0.101	S
79.047	-0.095	S
90.249	-0.277	S
101.725	-0.457	S
113.051	-0.578	S
123.724	-0.684	S
135.459	-0.848	S
147.192	-0.987	S
158.602	-1.151	S
170.887	-1.328	S
181.891	-1.571	S
191.797	-1.755	S

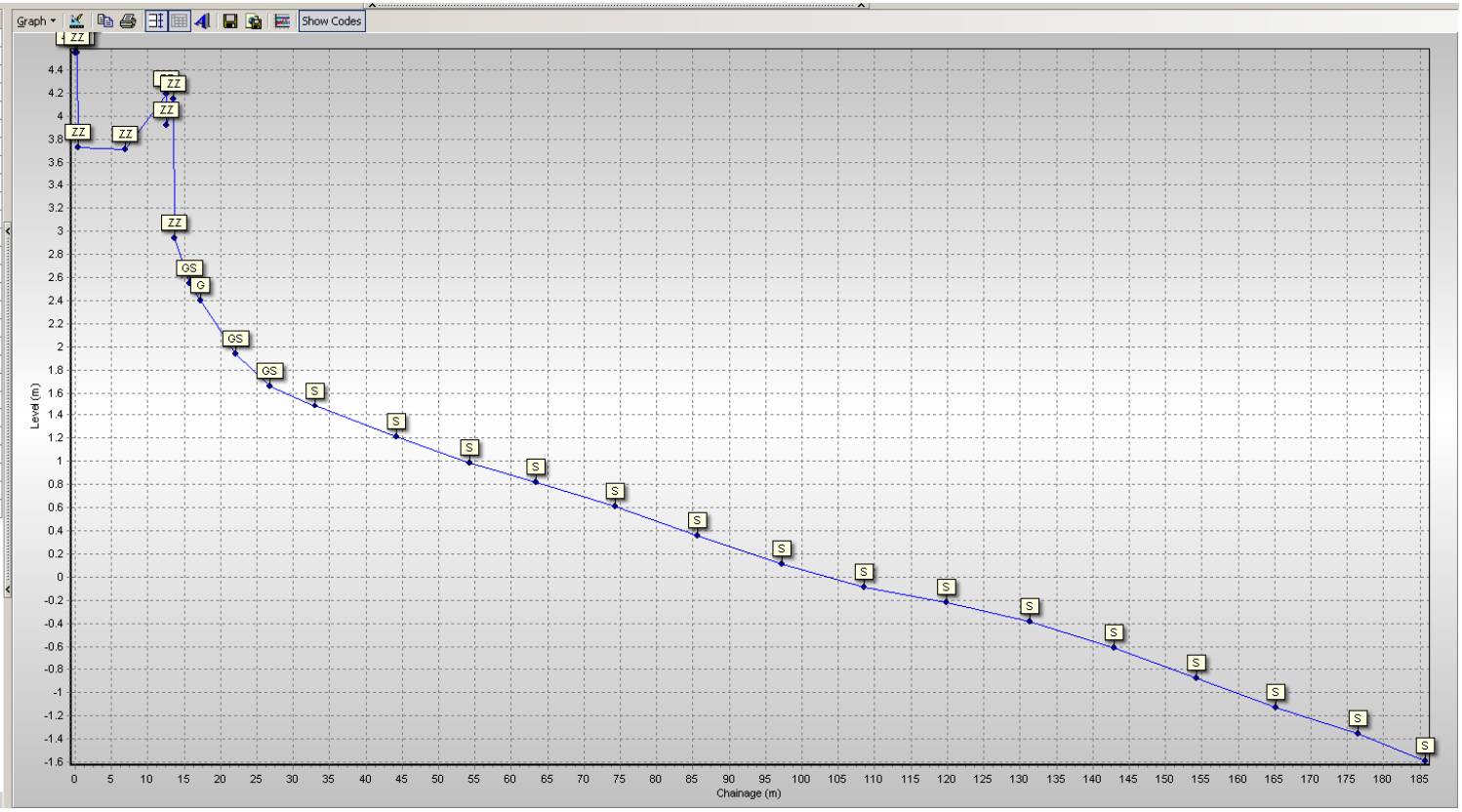


Beach Profiles: 1bSNN7

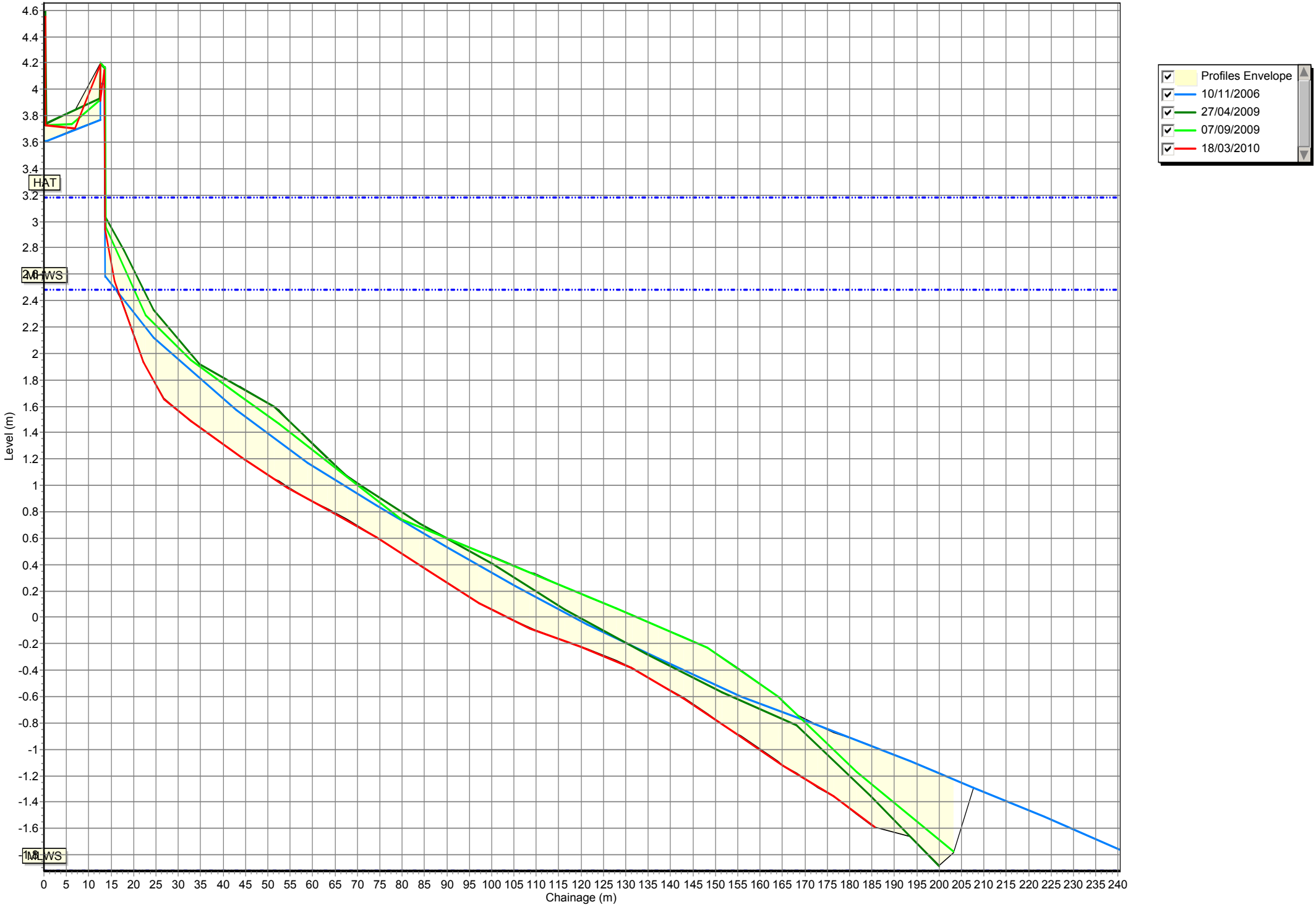


1bSNN10 - 18/03/2010

Chainage	Level	Code
0.000	4.548	
0.316	4.548	ZZ
0.436	3.726	ZZ
6.894	3.708	ZZ
12.511	4.191	ZZ
12.511	3.916	ZZ
13.535	4.145	ZZ
13.730	2.943	ZZ
15.707	2.545	GS
17.300	2.397	G
22.157	1.937	GS
26.855	1.656	GS
32.949	1.482	S
44.217	1.209	S
54.289	0.986	S
63.359	0.819	S
74.235	0.607	S
85.694	0.359	S
97.178	0.108	S
108.582	-0.085	S
119.922	-0.222	S
131.317	-0.383	S
142.959	-0.613	S
154.204	-0.872	S
165.176	-1.125	S
176.469	-1.359	S
185.753	-1.591	S



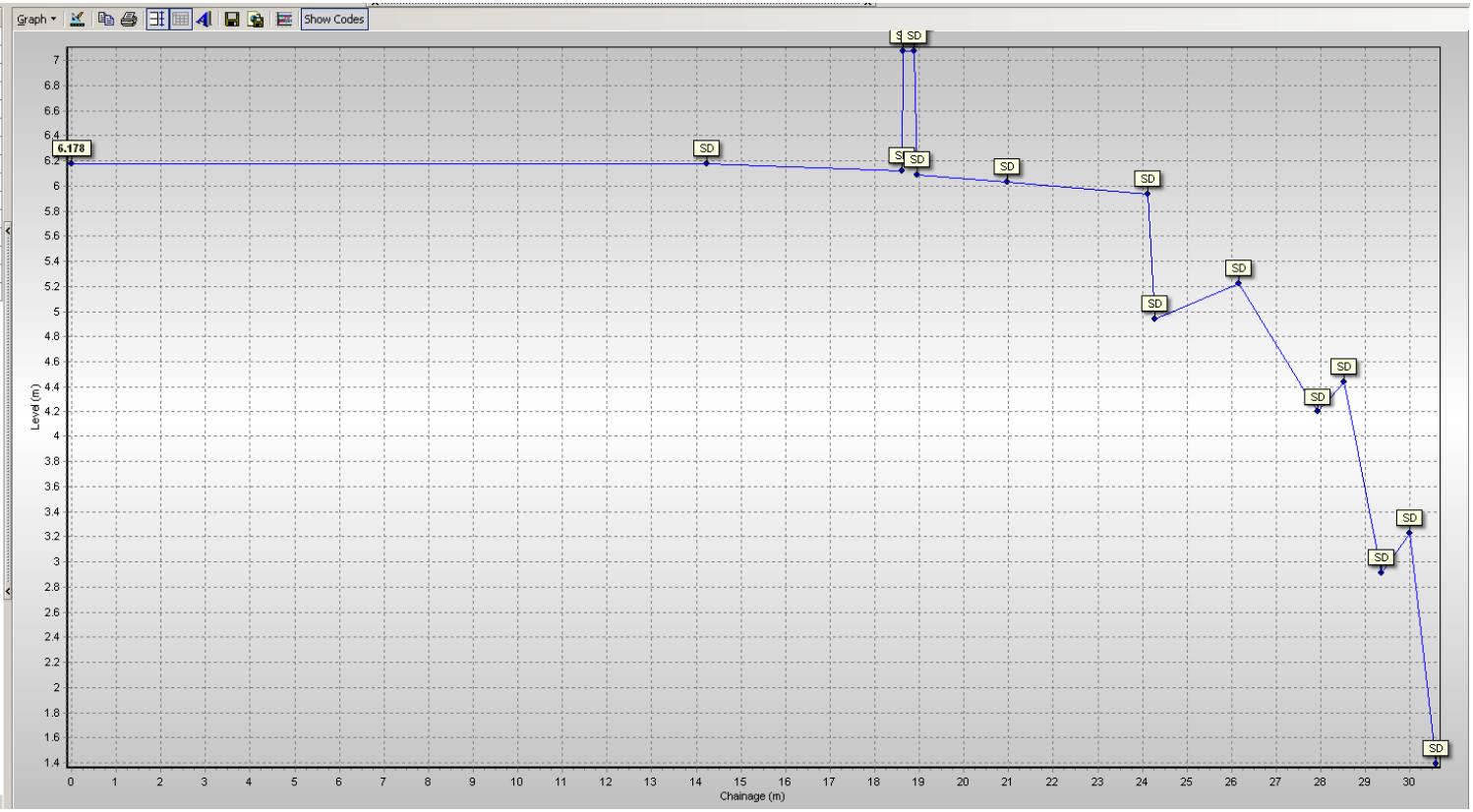
Beach Profiles: 1bSNN10



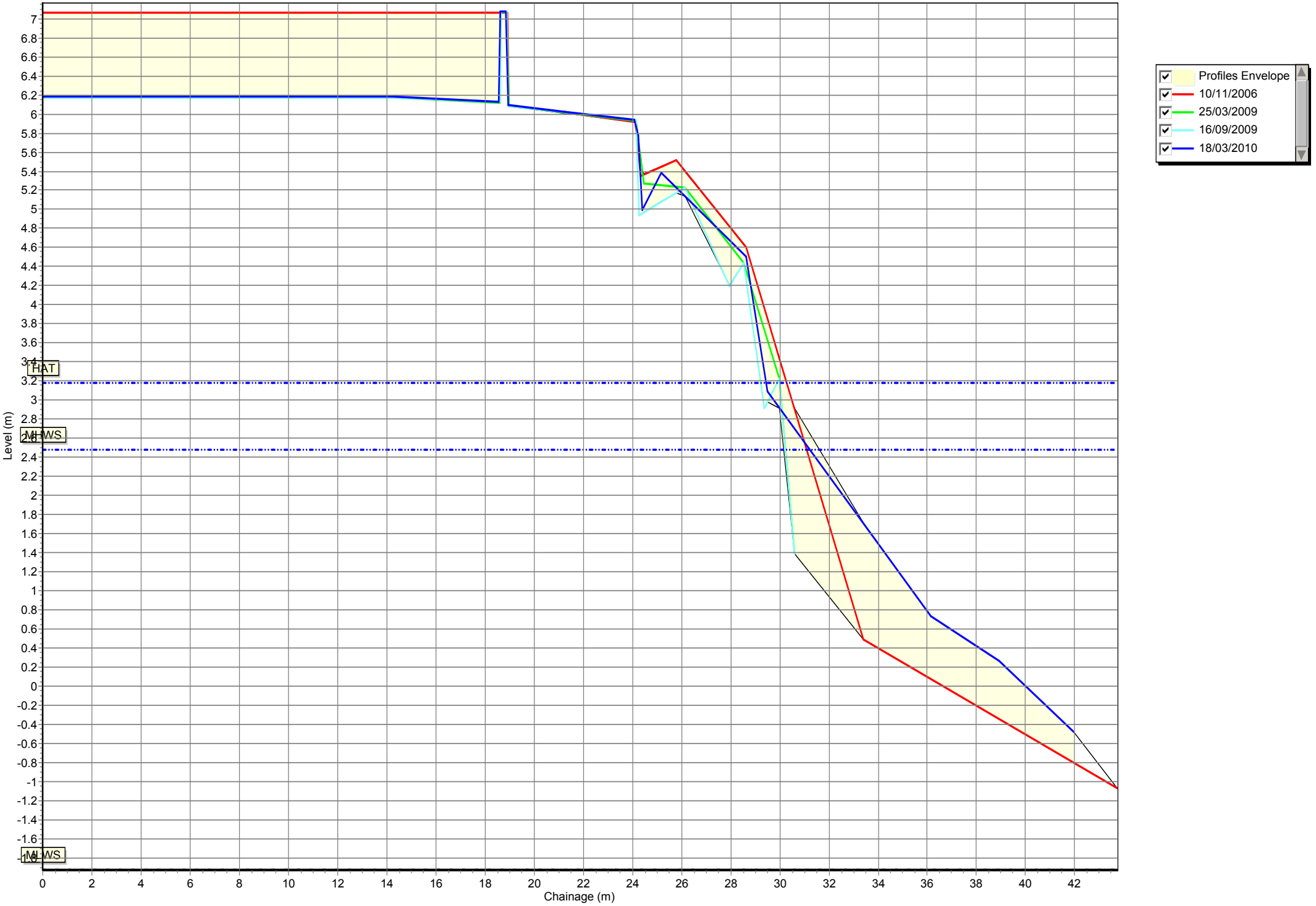
Sunderland South

1bSNS4 - 18/03/2010

Chainage	Level	Code
0.000	6.178	
14.242	6.178	SD
18.606	6.123	SD
18.639	7.073	SD
18.874	7.071	SD
18.945	6.089	SD
20.963	6.030	SD
24.126	5.936	SD
24.278	4.944	SD
26.154	5.226	SD
27.936	4.195	SD
28.527	4.443	SD
29.361	2.911	SD
29.990	3.231	SD
30.581	1.393	SD

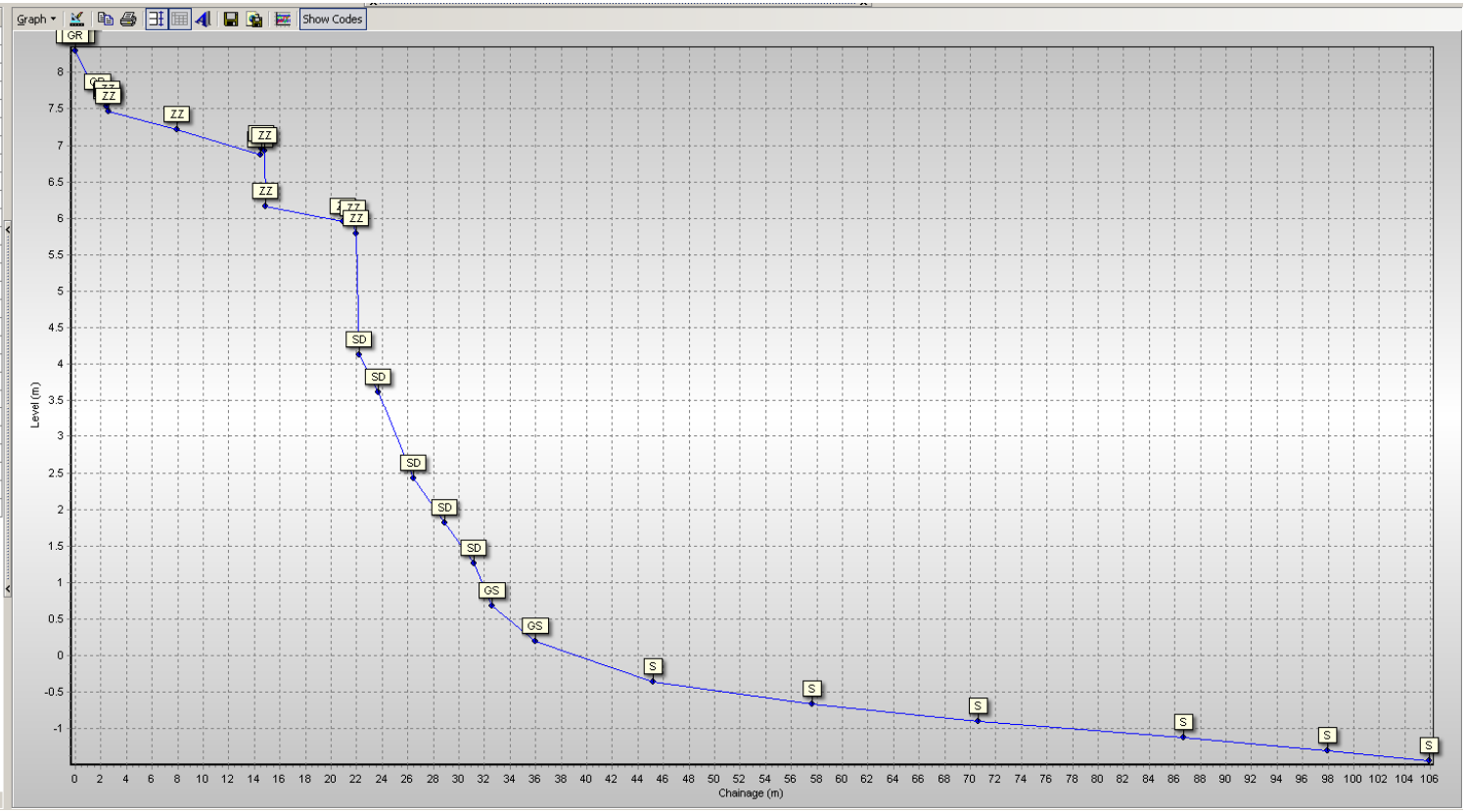


Beach Profiles: 1bSNS4

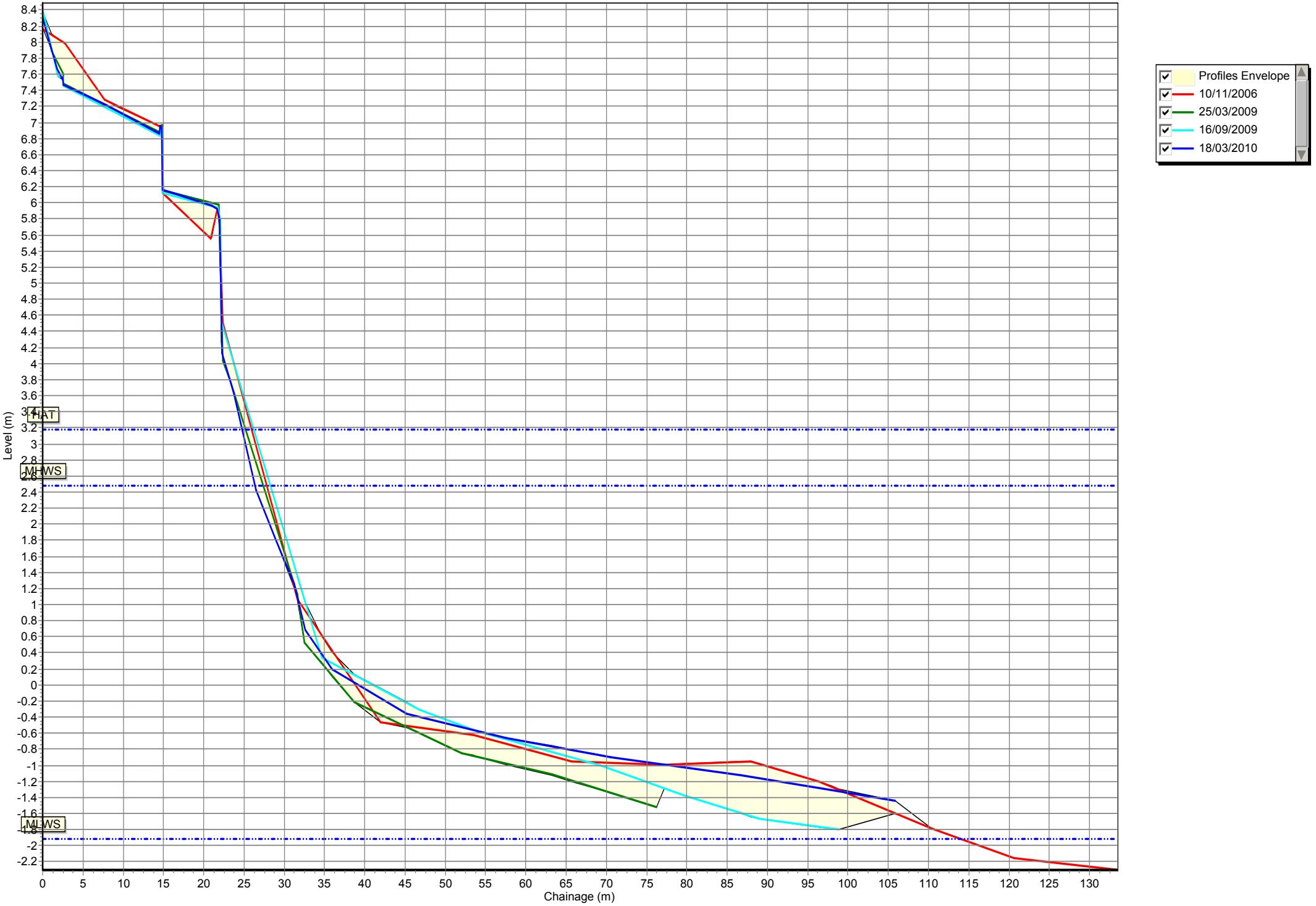


1bSNS8 - 18/03/2010

Chainage	Level	Code
0.000	8.296	
0.034	8.296	GR
1.741	7.663	GR
2.441	7.536	GR
2.494	7.565	ZZ
2.582	7.463	ZZ
7.927	7.212	ZZ
14.503	6.866	ZZ
14.554	6.949	ZZ
14.798	6.926	ZZ
14.891	6.160	ZZ
20.928	5.961	ZZ
21.701	5.930	ZZ
21.979	5.789	ZZ
22.211	4.131	SD
23.712	3.621	SD
26.453	2.425	SD
28.910	1.809	SD
31.175	1.259	SD
32.571	0.679	GS
35.992	0.189	GS
45.222	-0.361	S
57.648	-0.665	S
70.613	-0.904	S
86.724	-1.121	S
97.950	-1.305	S
105.904	-1.440	S

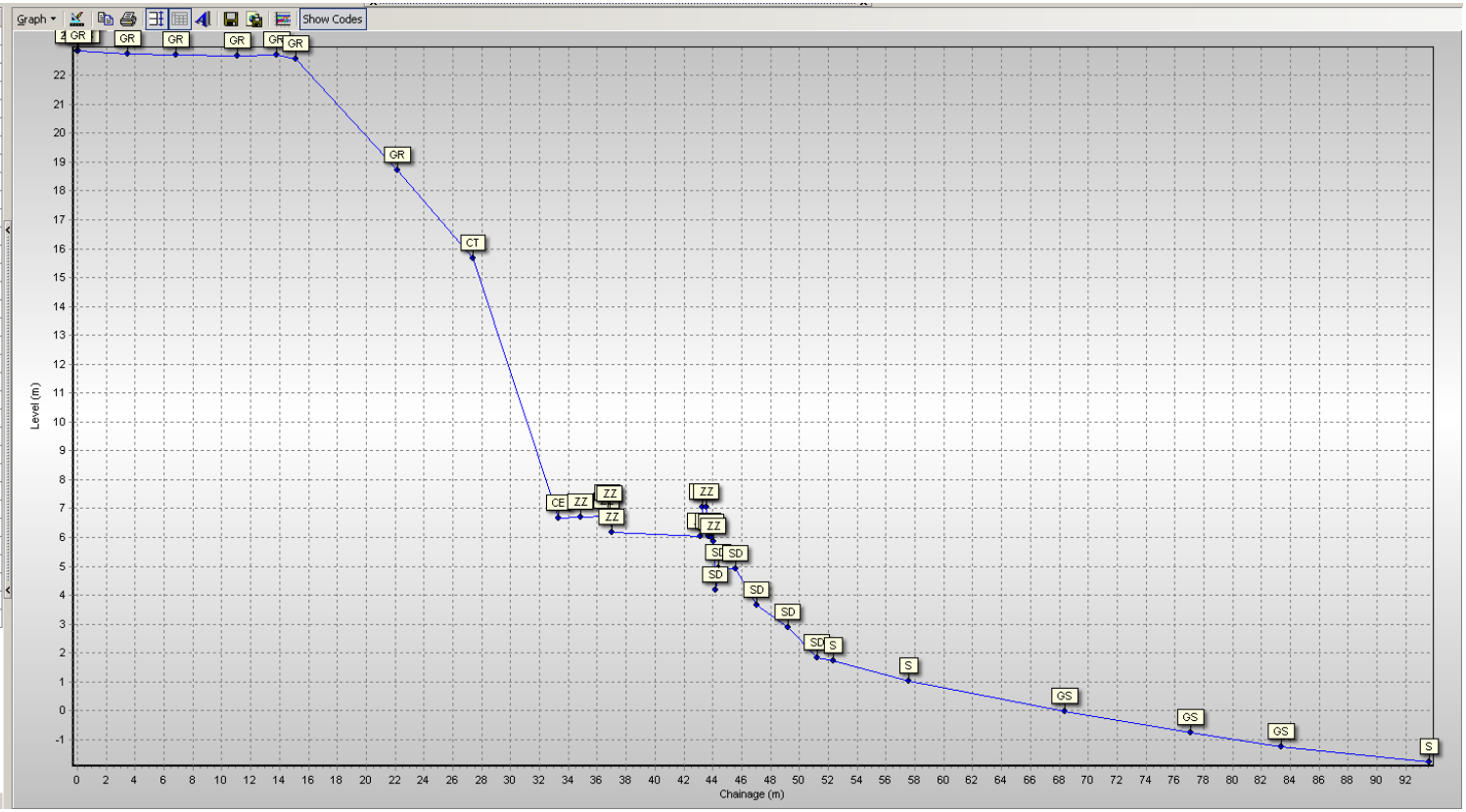


Beach Profiles: 1bSNS8

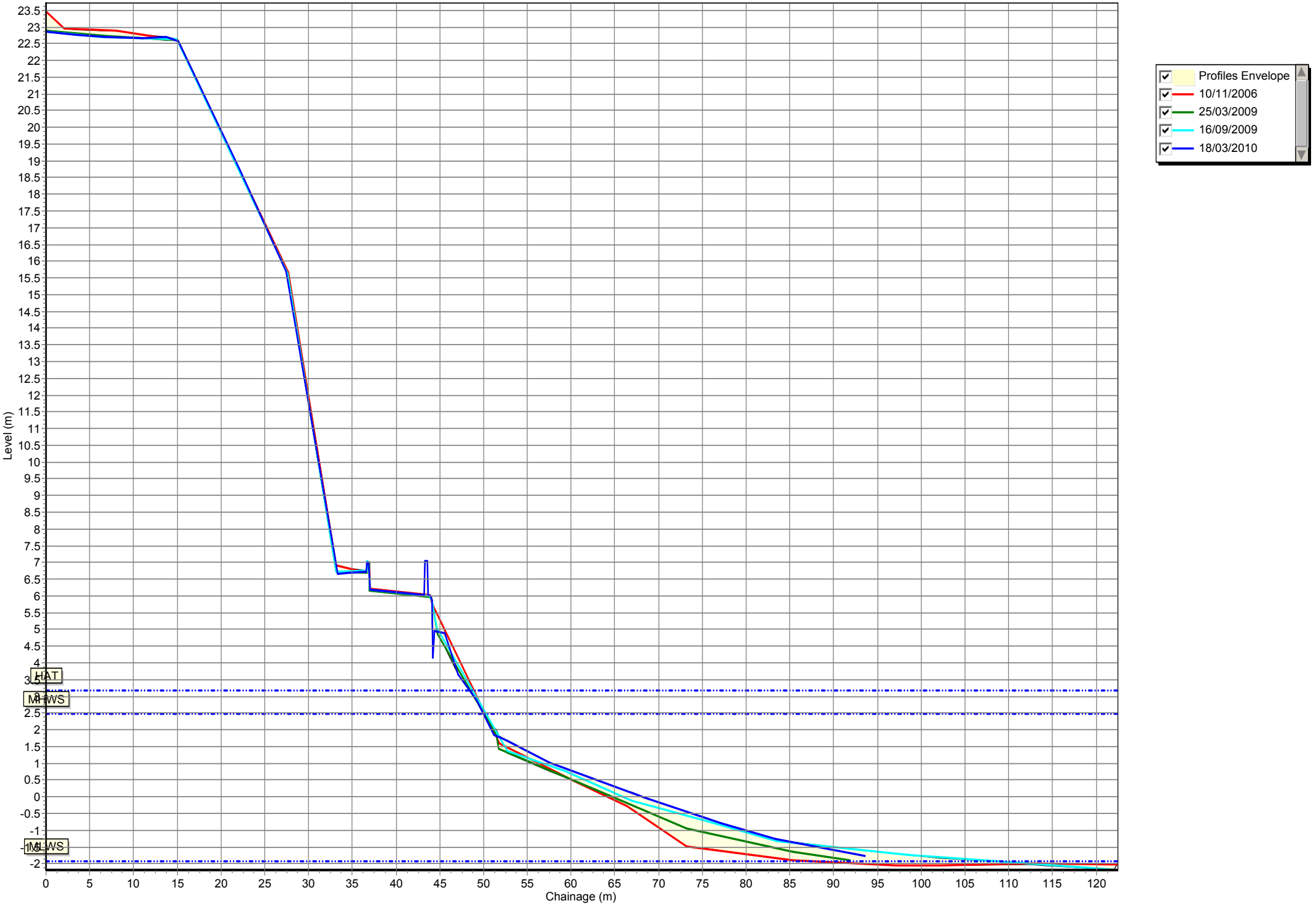


1bSNS11 - 18/03/2010

Chainage	Level	Code
0.000	22.848	
0.035	22.848	GR
3.458	22.759	GR
6.798	22.709	GR
11.050	22.672	GR
13.784	22.697	GR
15.099	22.568	GR
22.164	18.701	GR
27.426	15.685	CT
33.328	6.665	CE
34.828	6.693	ZZ
36.642	6.727	ZZ
36.711	7.022	ZZ
36.870	6.984	ZZ
37.021	6.187	ZZ
43.182	6.021	ZZ
43.281	7.036	ZZ
43.543	7.037	ZZ
43.676	6.030	ZZ
43.939	5.989	ZZ
44.087	5.859	ZZ
44.217	4.164	SD
44.409	4.942	SD
45.577	4.901	SD
47.068	3.645	SD
49.219	2.884	SD
51.224	1.848	SD
52.374	1.734	S
57.556	1.021	S
68.414	-0.010	GS
77.084	-0.773	GS
83.350	-1.260	GS
93.617	-1.775	S

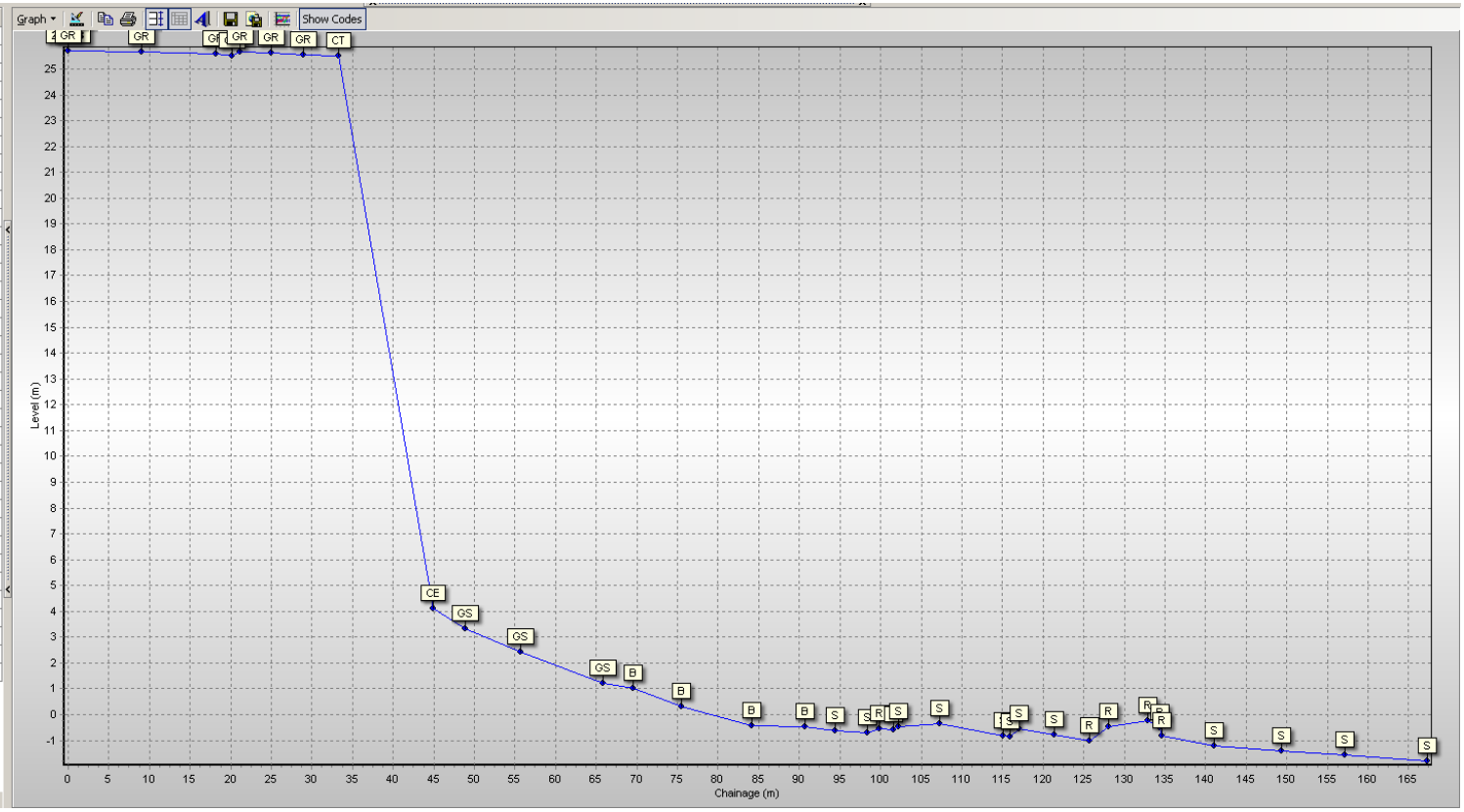


Beach Profiles: 1bSNS11

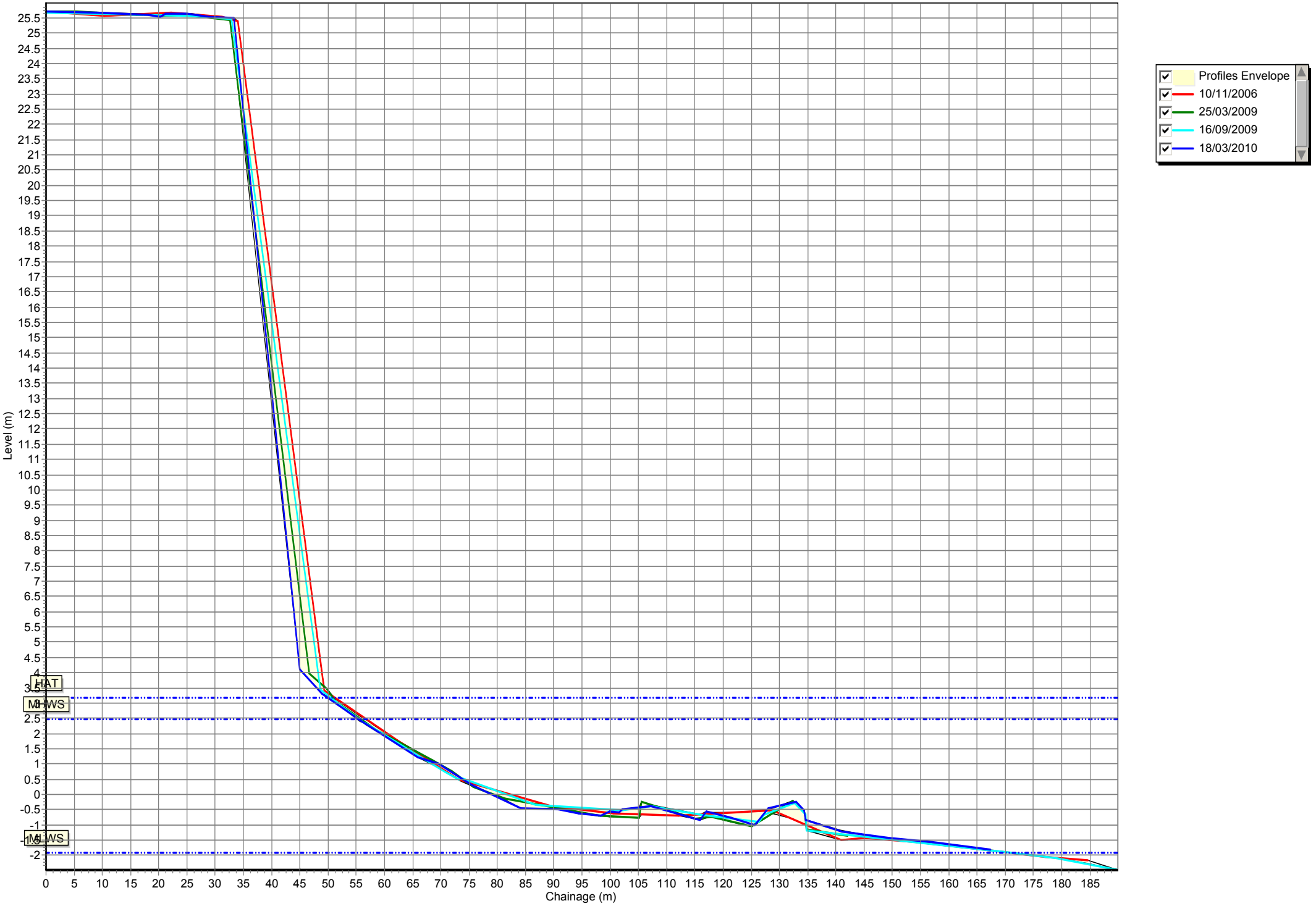


1bSNS20 - 18/03/2010

Chainage	Level	Code
0.000	25.703	
0.002	25.703	GR
9.022	25.661	GR
18.190	25.586	GR
20.215	25.516	GR
21.195	25.648	GR
24.976	25.635	GR
28.933	25.535	GR
33.314	25.489	CT
44.946	4.103	CE
48.891	3.320	GS
55.660	2.425	GS
65.890	1.231	GS
69.568	1.008	B
75.500	0.313	B
84.149	-0.440	B
90.708	-0.473	B
94.436	-0.625	S
98.329	-0.704	S
99.885	-0.548	R
101.583	-0.599	R
102.177	-0.480	S
107.266	-0.366	S
115.138	-0.811	S
115.947	-0.845	S
117.089	-0.564	S
121.374	-0.766	S
125.688	-1.018	R
128.058	-0.467	R
132.963	-0.247	R
134.360	-0.519	R
134.586	-0.824	R
141.128	-1.202	S
149.314	-1.425	S
157.107	-1.576	S
167.307	-1.799	S

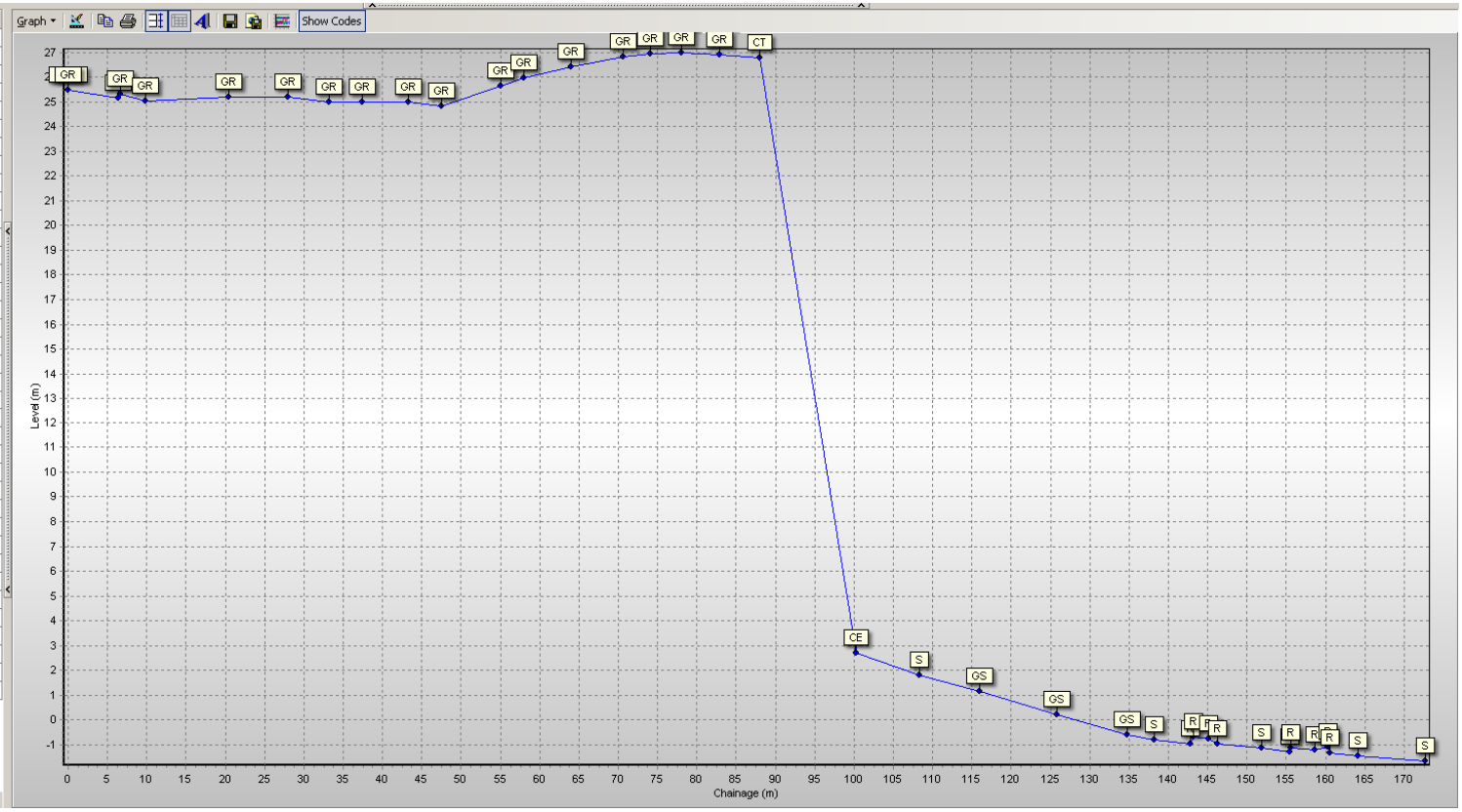


Beach Profiles: 1bSNS20

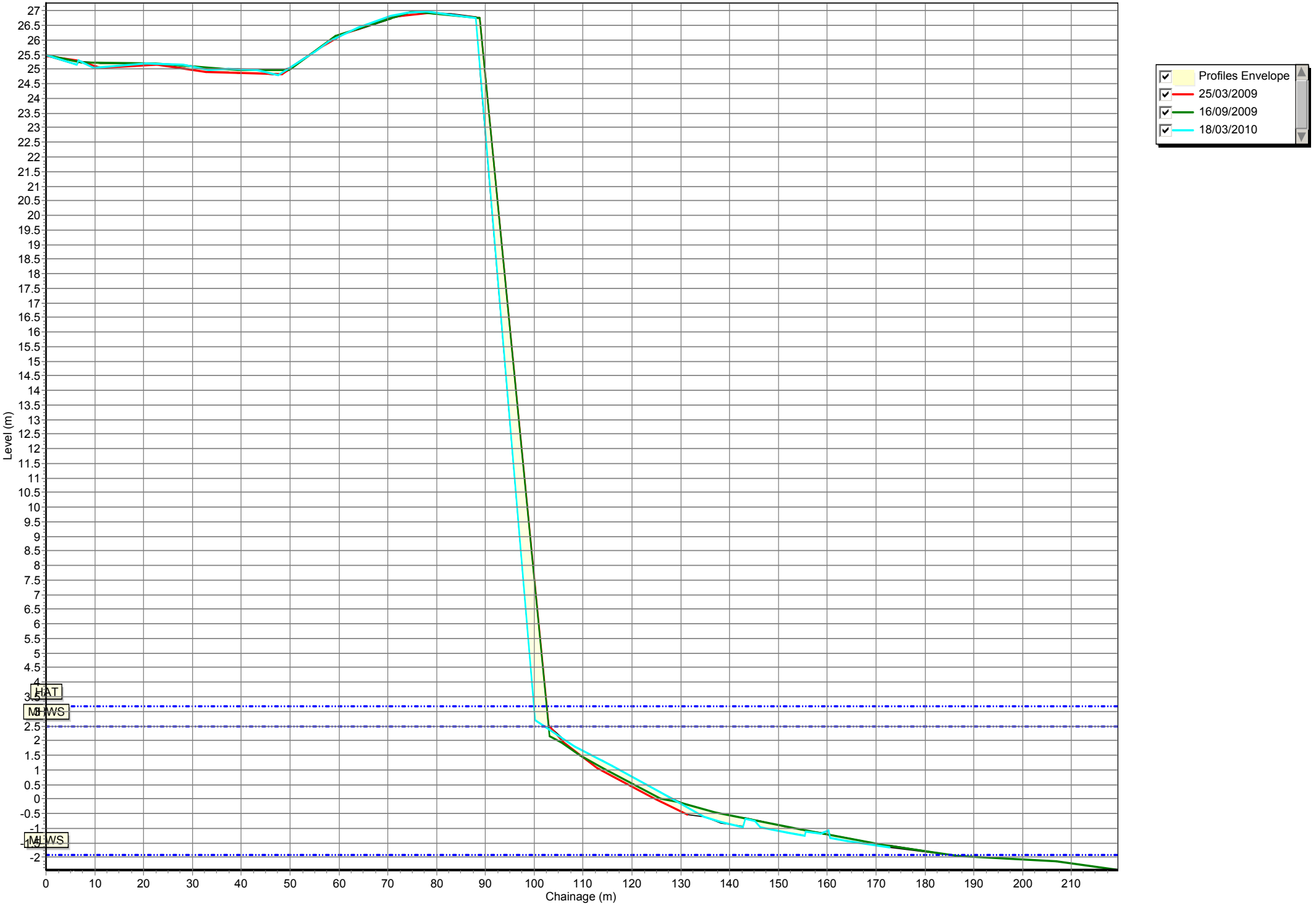


1bSNS26 - 18/03/2010

Chainage	Level	Code
0.000	25.480	
0.014	25.480	GR
6.398	25.161	GR
6.624	25.292	GR
9.785	25.045	GR
20.425	25.206	GR
28.036	25.179	GR
33.246	24.964	GR
37.398	25.003	GR
43.242	24.978	GR
47.516	24.810	GR
55.095	25.616	GR
57.952	25.975	GR
64.029	26.419	GR
70.657	26.825	GR
74.022	26.946	GR
78.013	26.980	GR
82.948	26.889	GR
88.002	26.757	CT
100.265	2.708	CE
108.339	1.797	S
115.931	1.144	GS
125.784	0.239	GS
134.720	-0.591	GS
138.245	-0.806	S
142.763	-0.953	R
143.149	-0.673	R
145.113	-0.758	R
146.257	-0.970	R
151.898	-1.140	S
155.466	-1.269	R
155.625	-1.117	R
158.623	-1.201	R
160.310	-1.096	R
160.576	-1.323	R
164.131	-1.439	S
172.696	-1.653	S

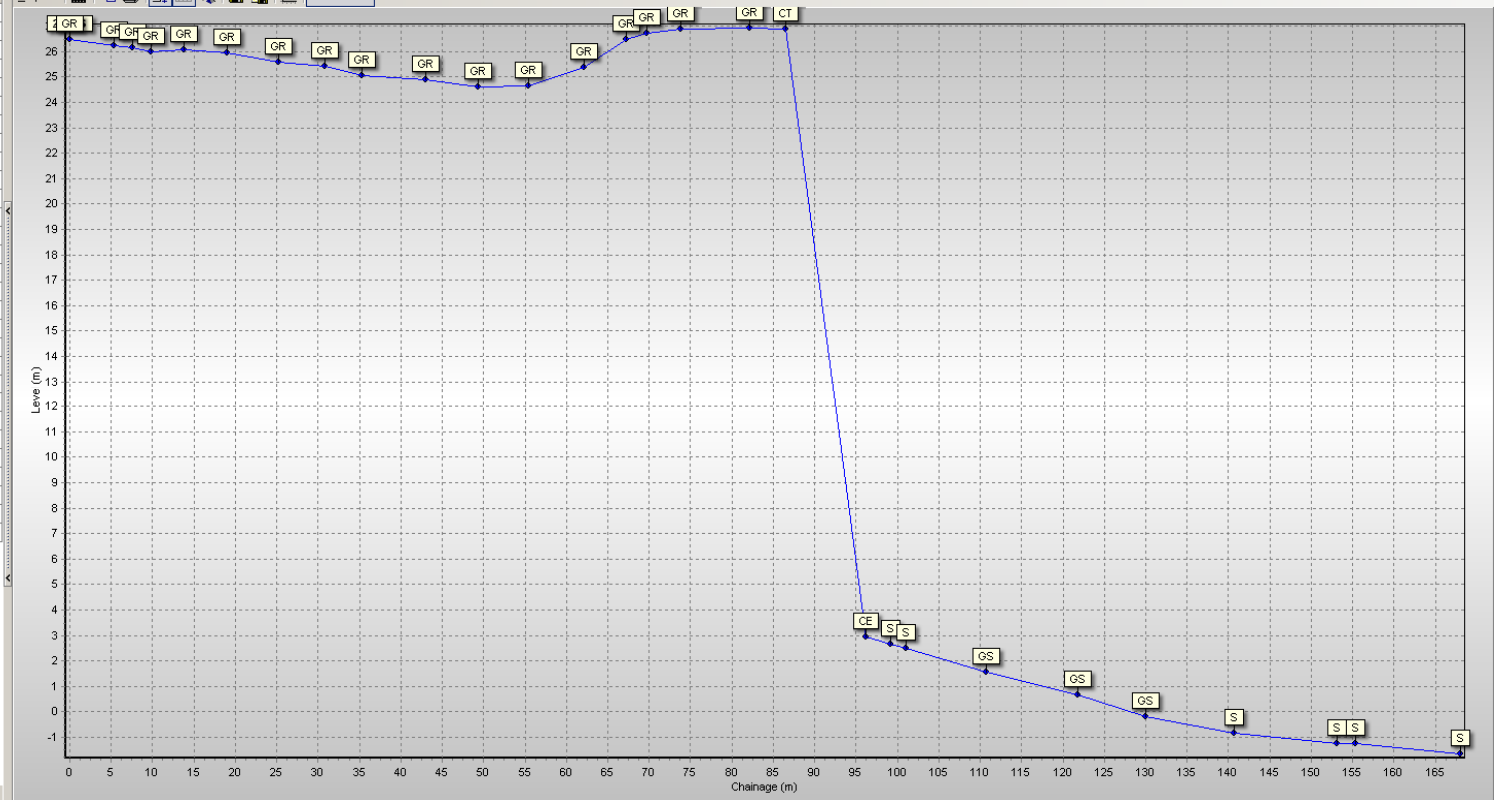


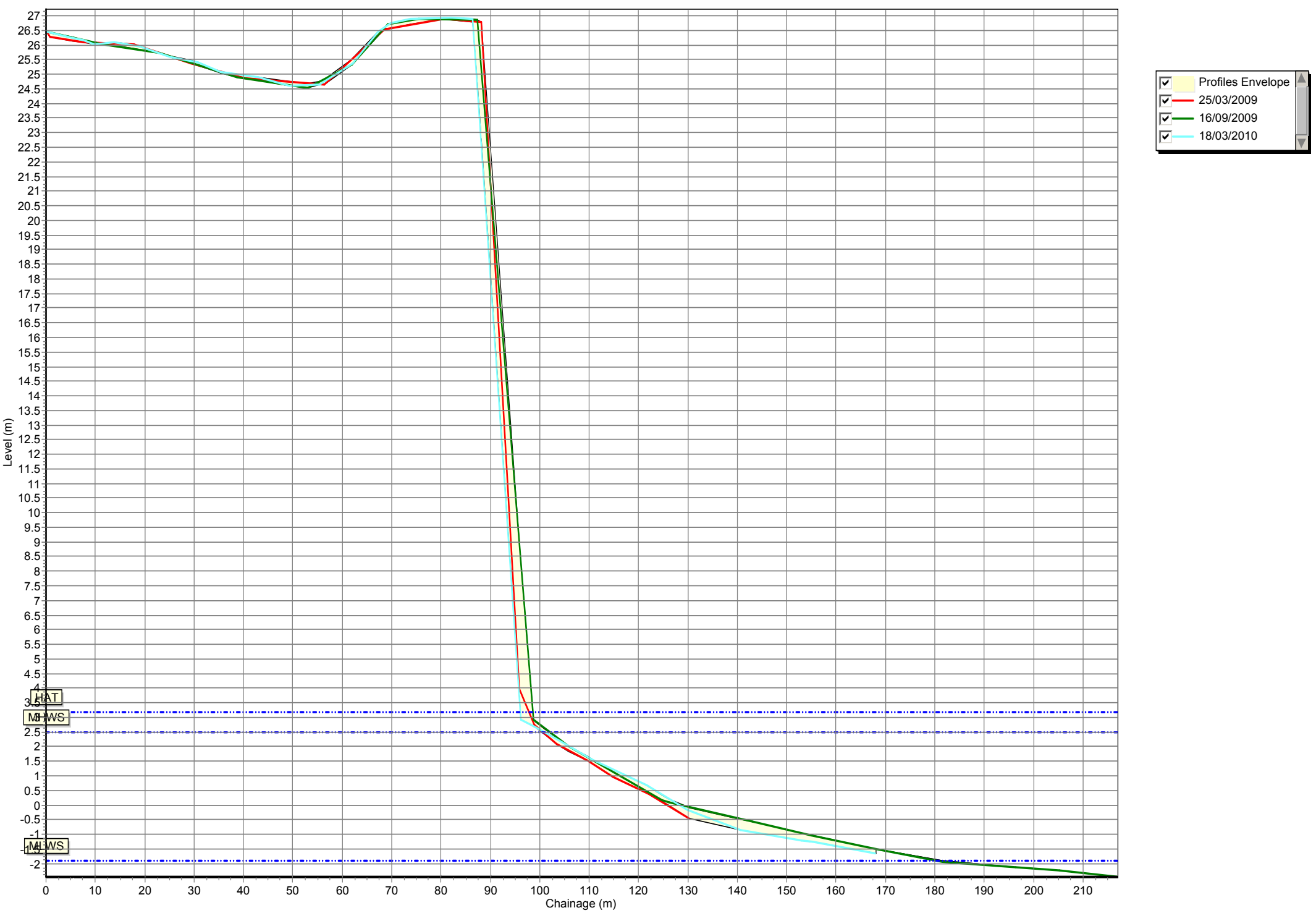
Beach Profiles: 1bSNS26



1bSNS27 - 18/03/2010

Chainage	Level	Code
0.000	26.466	
0.027	26.466	GR
5.296	26.244	GR
7.531	26.178	GR
9.795	26.015	GR
13.824	26.078	GR
18.995	25.965	GR
25.269	25.598	GR
30.875	25.418	GR
35.271	25.061	GR
42.981	24.896	GR
49.317	24.603	GR
55.452	24.637	GR
62.178	25.375	GR
67.237	26.474	GR
69.773	26.744	GR
73.841	26.878	GR
82.120	26.931	GR
86.458	26.884	CT
96.150	2.927	CE
99.150	2.665	S
101.050	2.499	S
110.750	1.560	GS
121.792	0.659	GS
129.956	-0.175	GS
140.706	-0.835	S
153.088	-1.232	S
155.324	-1.237	S
168.035	-1.655	S




Beach Profiles: 1bSNS27
Profiles Envelope
25/03/2009
16/09/2009
18/03/2010
Level (m)
Chainage (m)
HAT
MHWS
MLWS
27
26.5
26
25.5
25
24.5
24
23.5
23
22.5
22
21.5
21
20.5
20
19.5
19
18.5
18
17.5
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16.5
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15.5
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14.5
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13.5
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12.5
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11.5
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10.5
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9.5
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8.5
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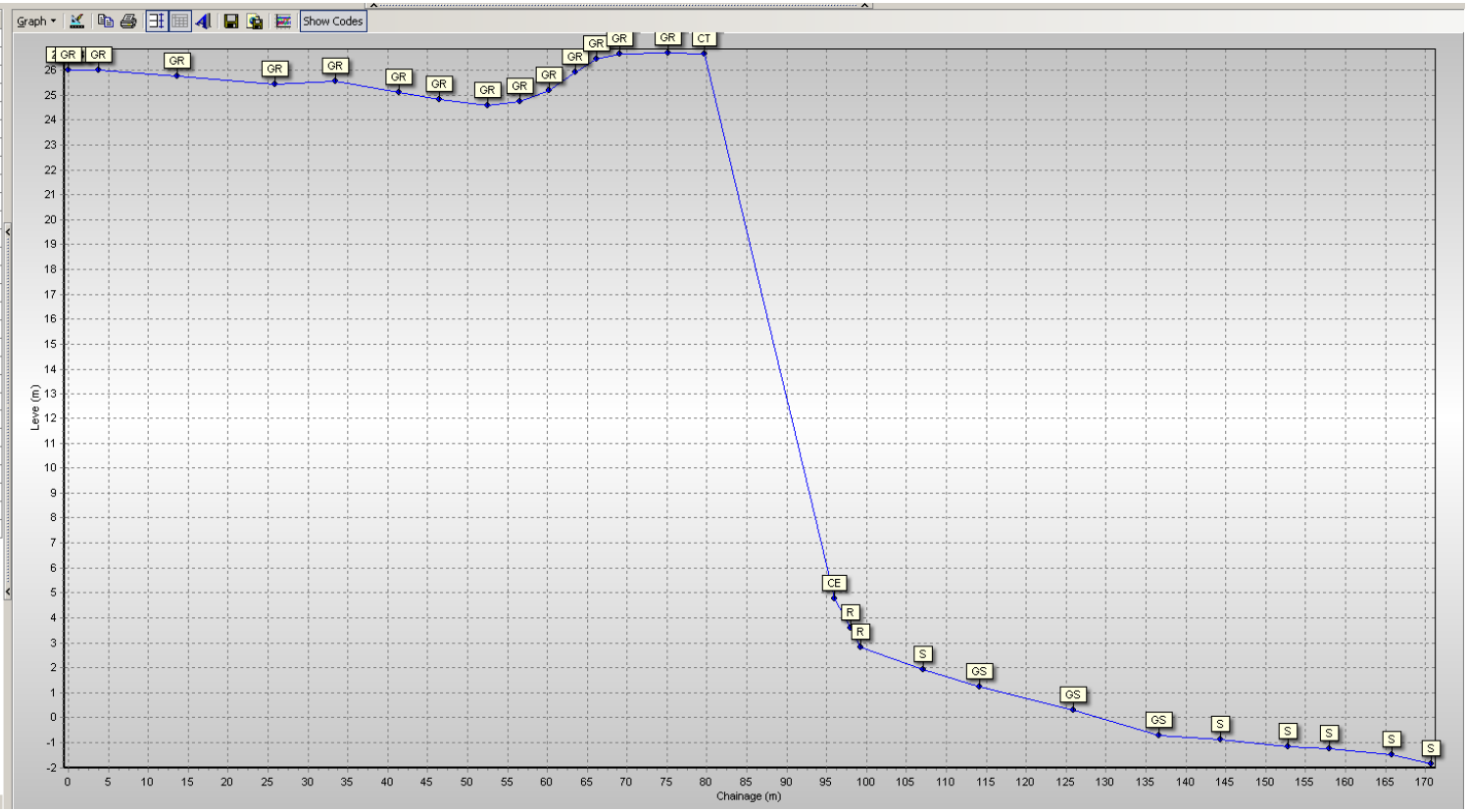
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

1bSNS28 - 18/03/2010

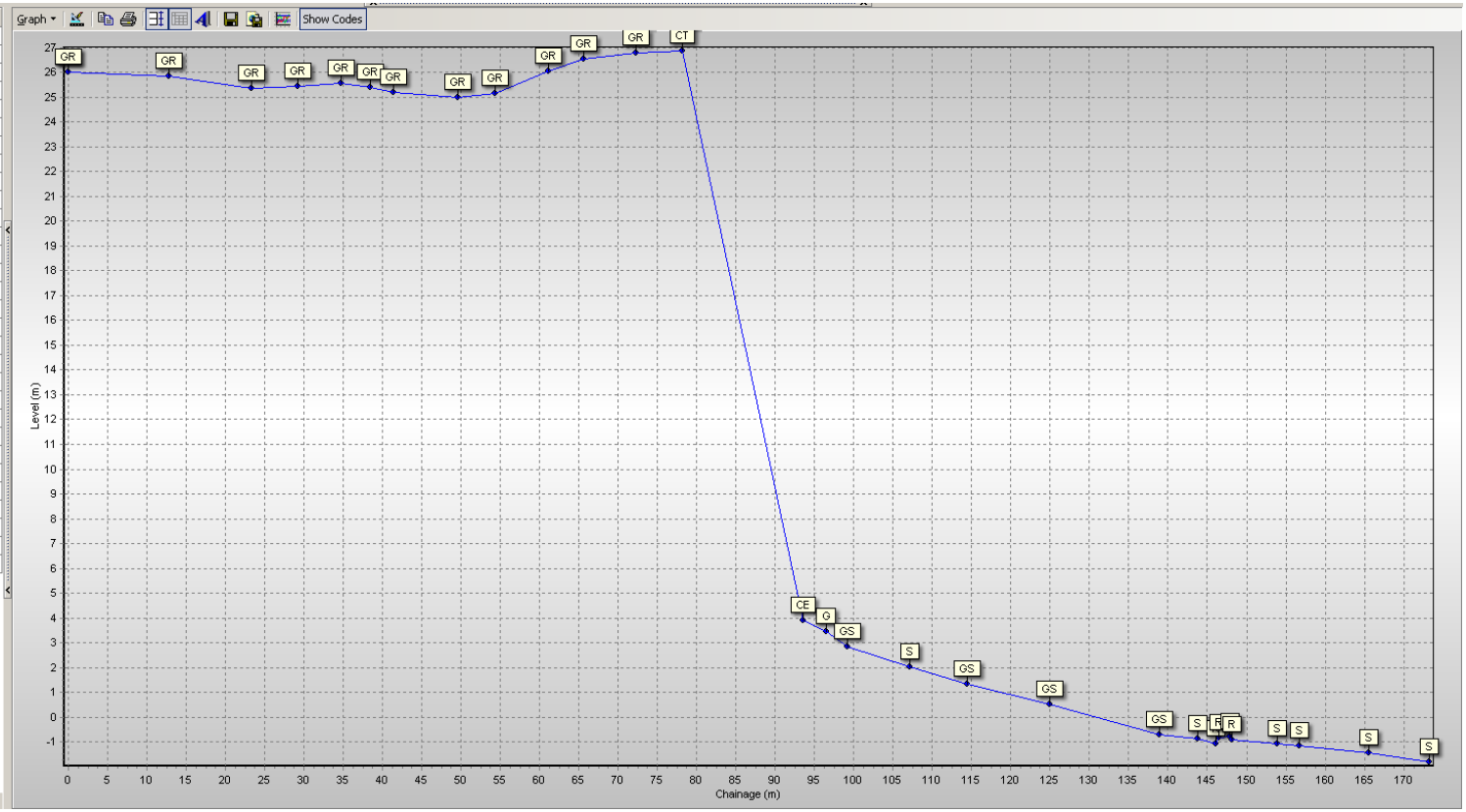
Chainage	Level	Code
0.000	26.008	
0.016	26.008	GR
3.804	25.988	GR
13.671	25.753	GR
25.840	25.415	GR
33.452	25.535	GR
41.451	25.102	GR
46.509	24.814	GR
52.583	24.569	GR
56.542	24.749	GR
60.298	25.170	GR
63.581	25.933	GR
66.163	26.433	GR
69.112	26.631	GR
75.135	26.691	GR
79.651	26.633	CT
95.934	4.777	CE
97.934	3.594	R
99.258	2.811	R
107.122	1.914	S
114.132	1.228	GS
125.857	0.321	GS
136.683	-0.708	GS
144.333	-0.892	S
152.830	-1.144	S
157.991	-1.244	S
165.810	-1.477	S
170.735	-1.848	S



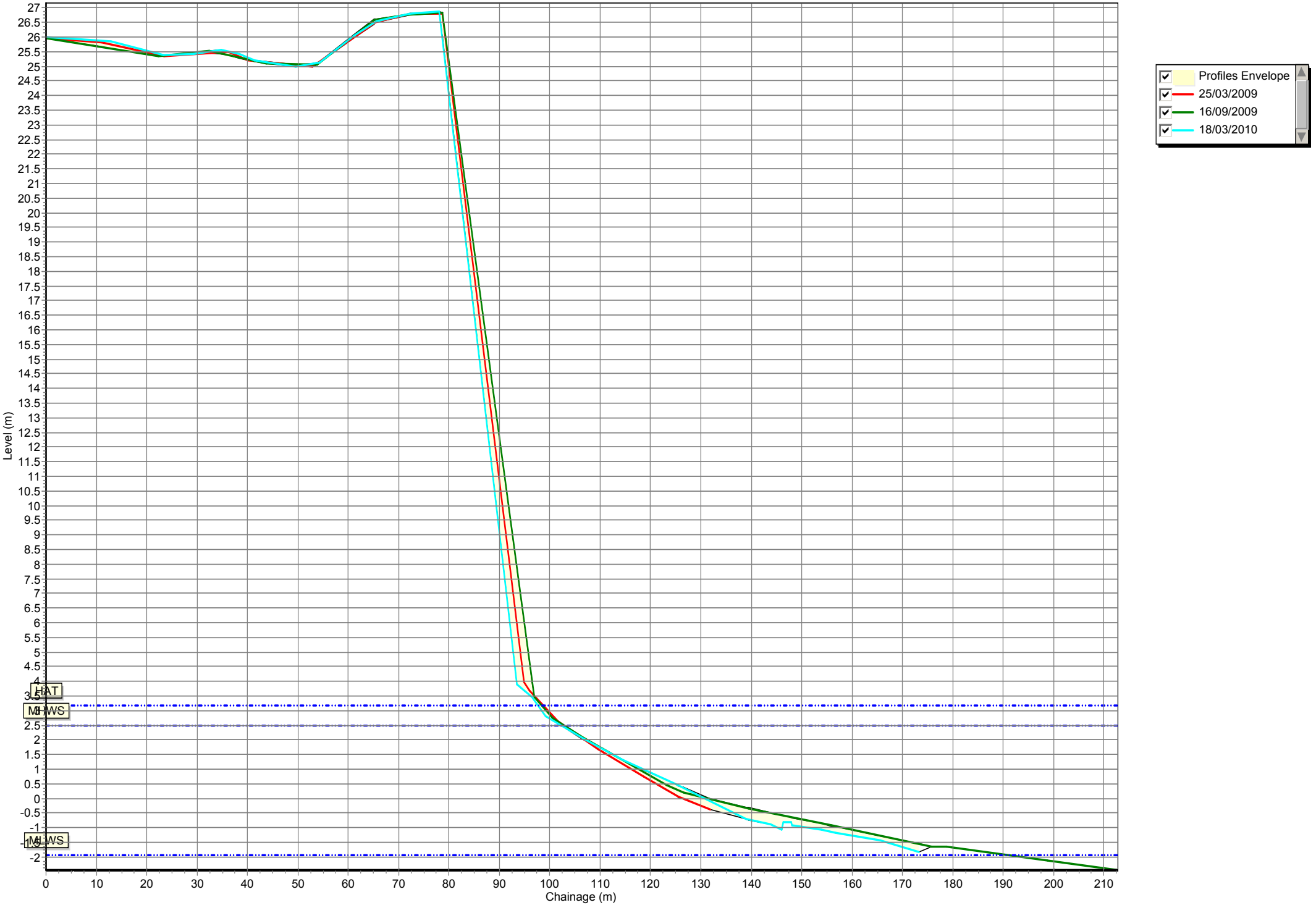
Beach Profiles: 1bSNS28

1bSNS29 - 18/03/2010

Chainage	Level	Code
0.000	26.000	
0.032	26.000	GR
12.842	25.849	GR
23.356	25.377	GR
29.255	25.436	GR
34.731	25.558	GR
38.437	25.419	GR
41.373	25.194	GR
49.641	24.992	GR
54.283	25.145	GR
61.122	26.047	GR
65.574	26.554	GR
72.224	26.805	GR
78.130	26.868	CT
93.510	3.901	CE
96.546	3.467	G
99.185	2.822	GS
107.095	2.006	S
114.389	1.314	GS
124.887	0.499	GS
138.897	-0.704	GS
143.775	-0.870	S
146.091	-1.060	R
146.437	-0.812	R
147.881	-0.806	R
148.108	-0.914	R
153.893	-1.070	S
156.728	-1.171	S
165.564	-1.427	S
173.257	-1.809	S

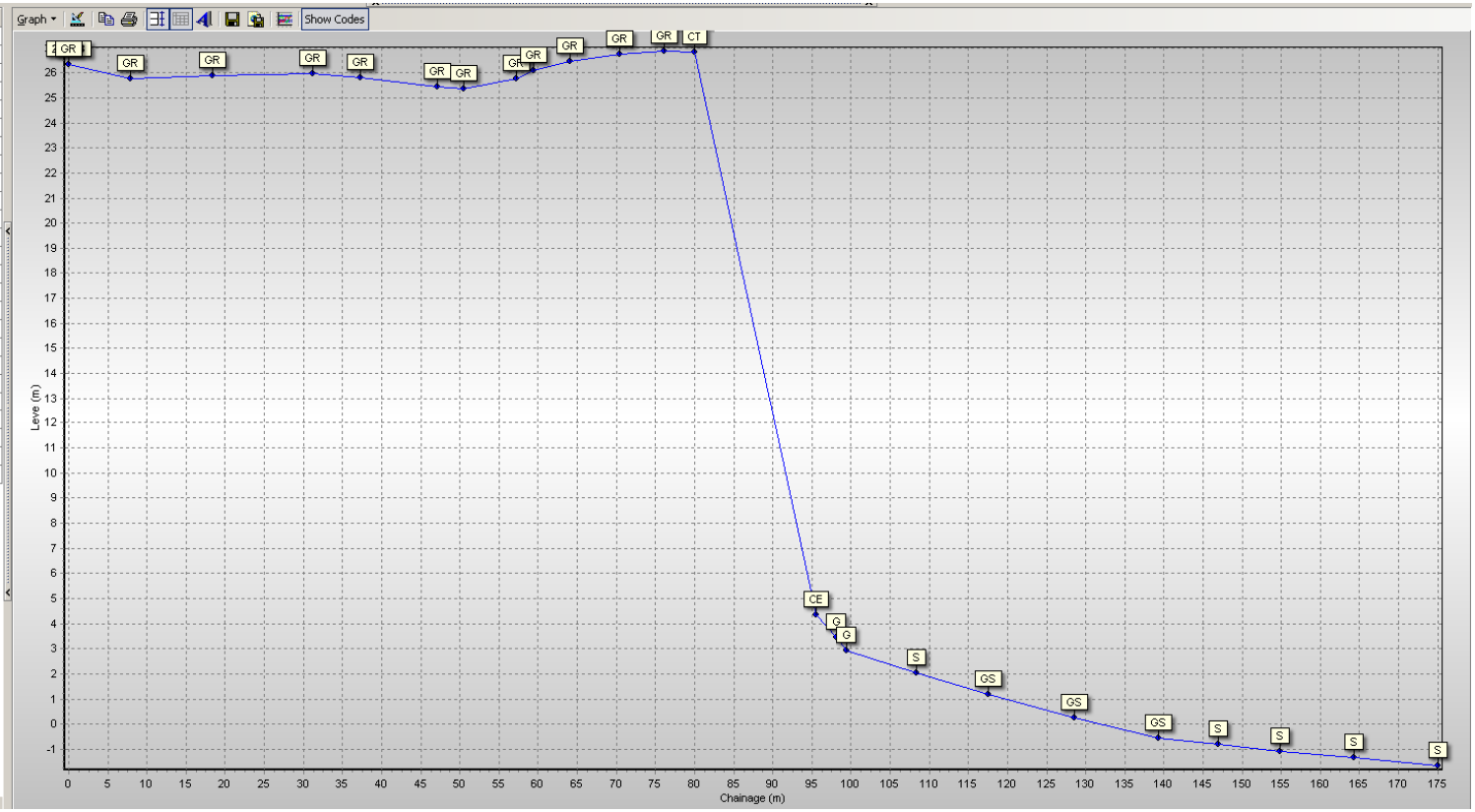


Beach Profiles: 1bSNS29

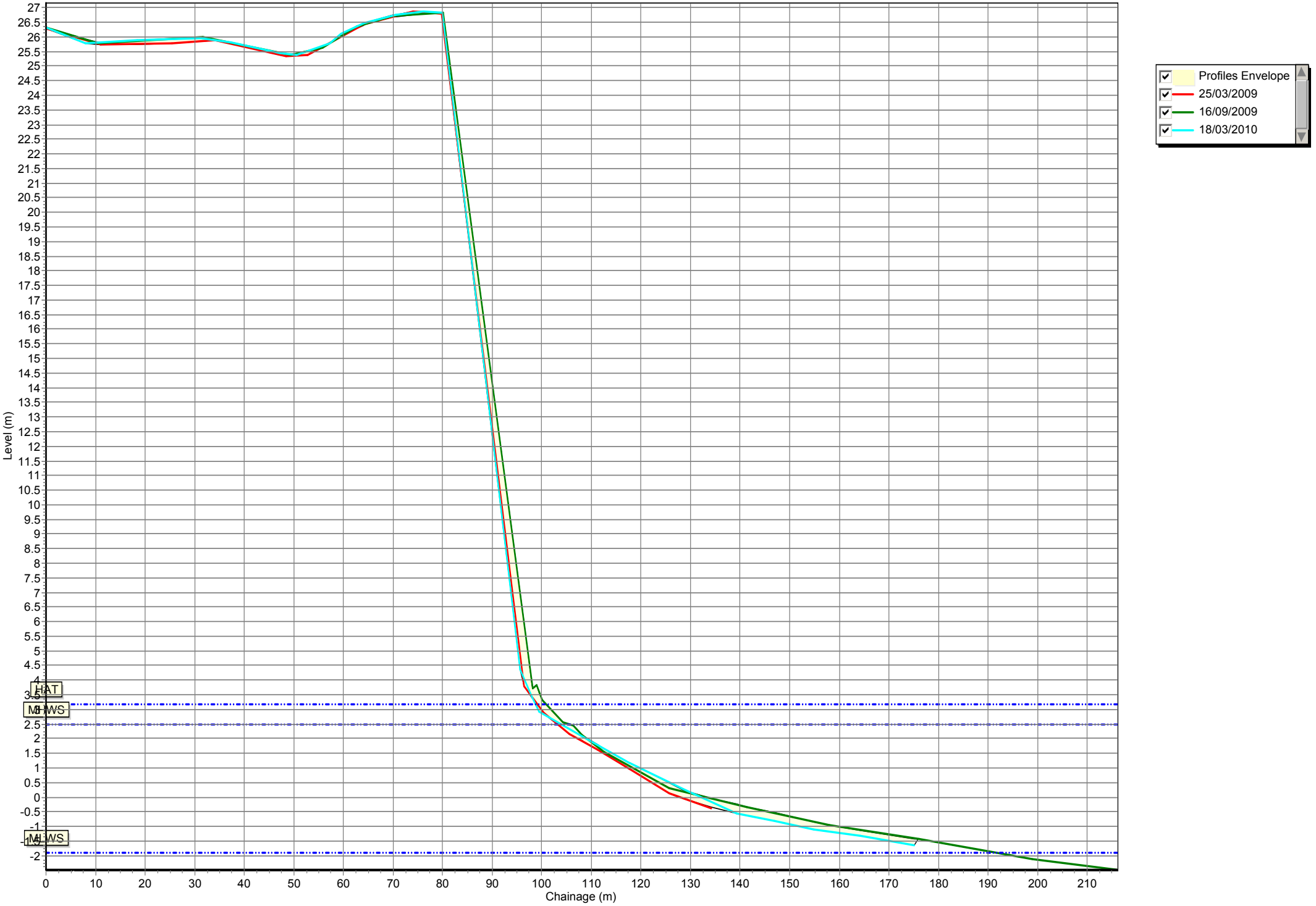


1bSNS30 - 18/03/2010

Chainage	Level	Code
0.000	26.333	
0.034	26.333	GR
7.961	25.774	GR
18.358	25.892	GR
31.227	25.961	GR
37.327	25.823	GR
47.127	25.449	GR
50.503	25.374	GR
57.198	25.768	GR
59.485	26.106	GR
64.070	26.457	GR
70.468	26.760	GR
76.113	26.864	GR
79.997	26.841	CT
95.578	4.355	CE
98.078	3.439	G
99.478	2.926	G
108.413	2.055	S
117.534	1.189	GS
128.524	0.254	GS
139.276	-0.565	GS
146.911	-0.801	S
154.827	-1.095	S
164.293	-1.322	S
175.036	-1.655	S

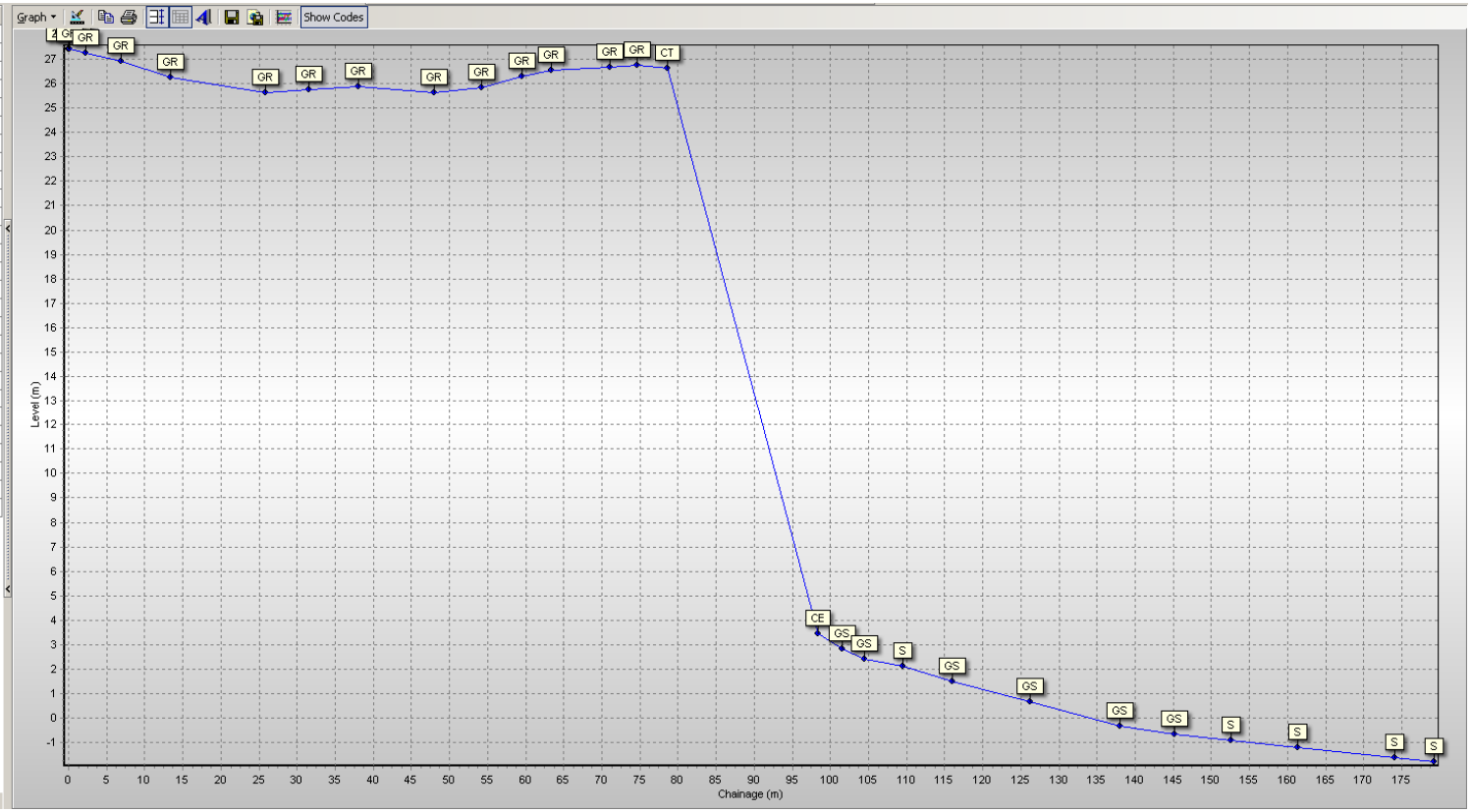


Beach Profiles: 1bSNS30

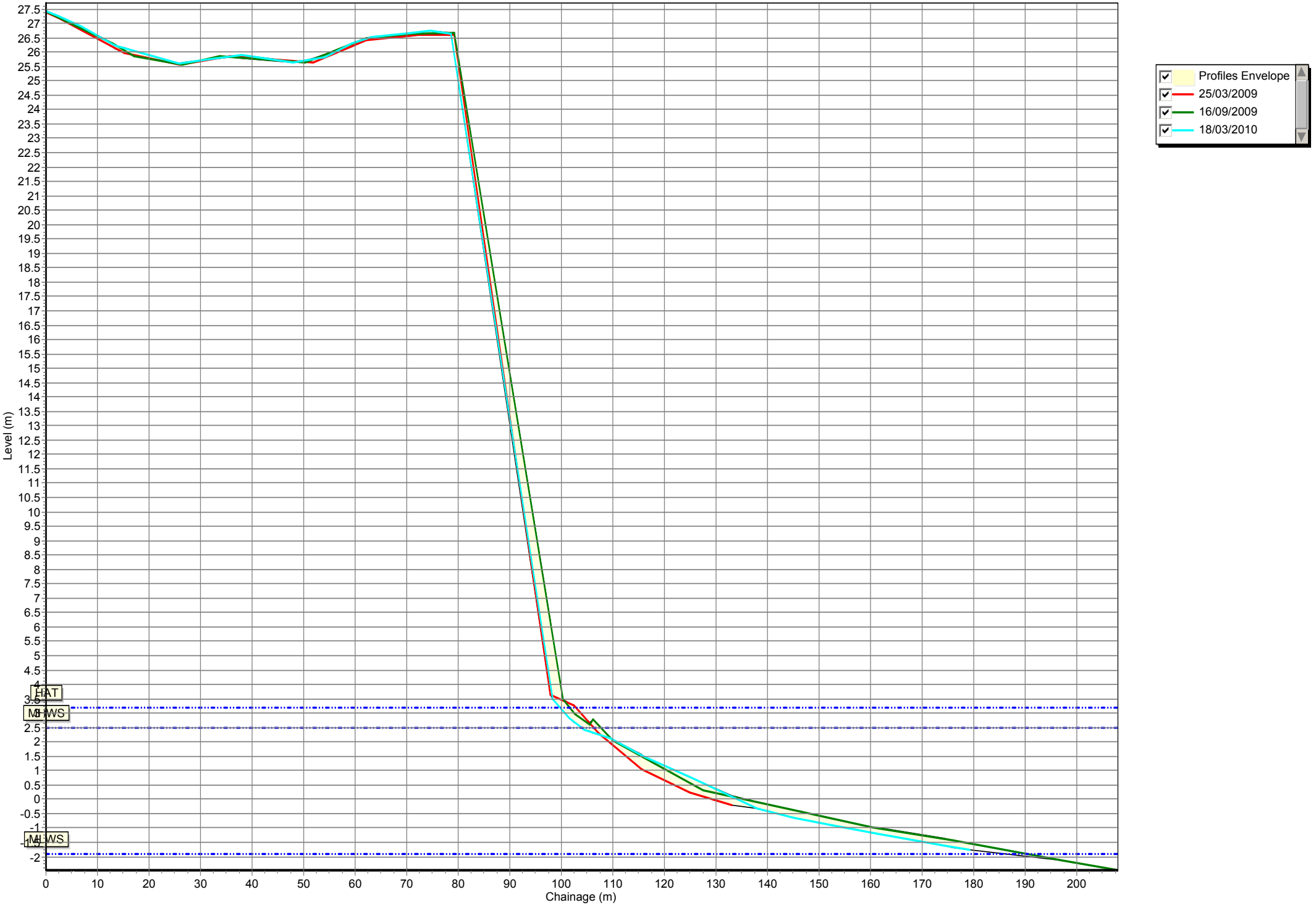


1bSNS31 - 18/03/2010

Chainage	Level	Code
0.000	27.411	
0.109	27.411	GR
2.284	27.255	GR
6.888	26.907	GR
13.416	26.237	GR
25.840	25.619	GR
31.599	25.763	GR
38.053	25.885	GR
47.941	25.644	GR
54.238	25.830	GR
59.464	26.304	GR
63.308	26.528	GR
71.105	26.661	GR
74.699	26.729	GR
78.559	26.638	CT
98.332	3.472	CE
101.586	2.814	GS
104.508	2.412	GS
109.564	2.127	S
115.980	1.499	GS
126.152	0.675	GS
138.072	-0.301	GS
145.195	-0.636	GS
152.624	-0.909	S
161.346	-1.189	S
174.110	-1.610	S
179.245	-1.774	S

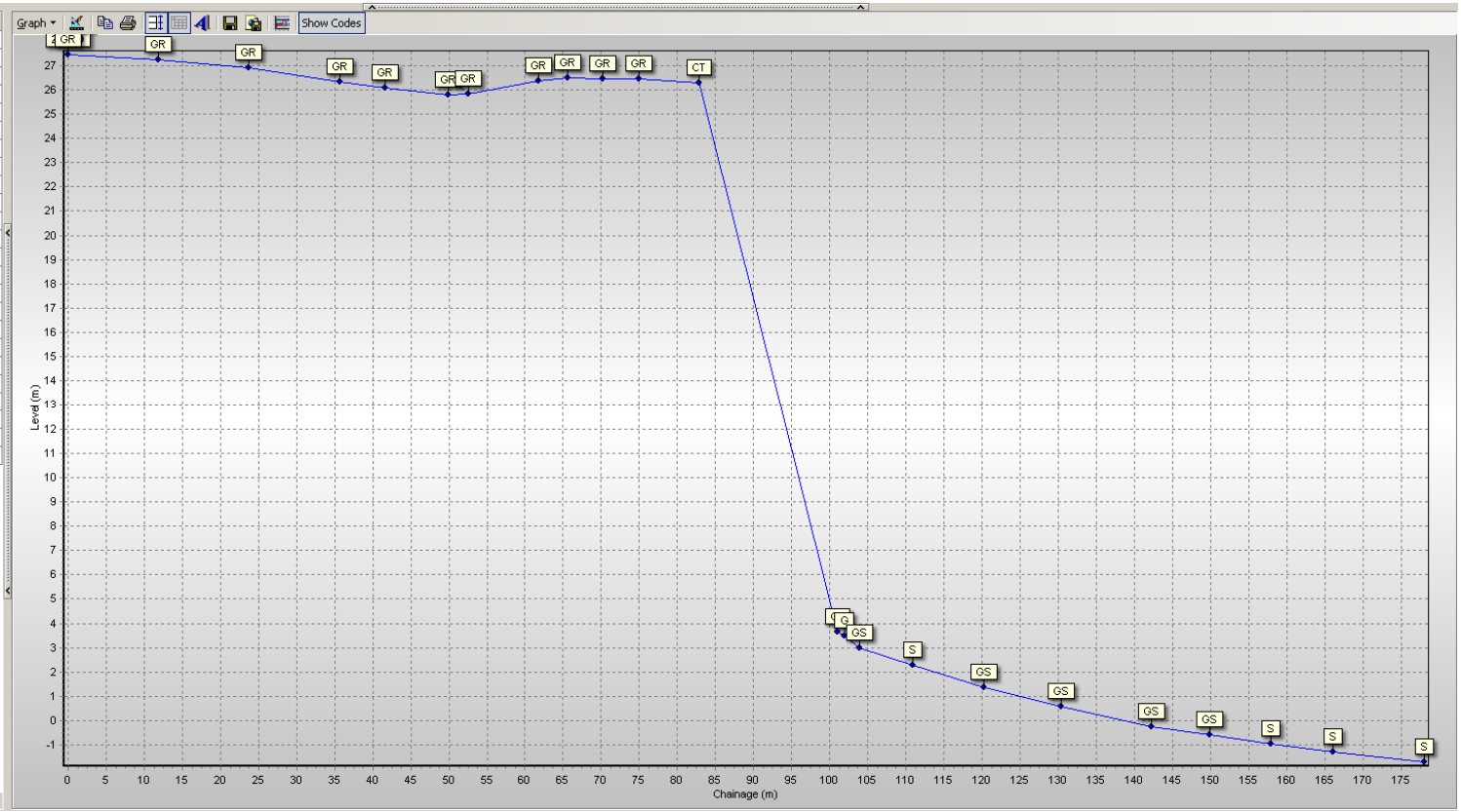


Beach Profiles: 1bSNS31

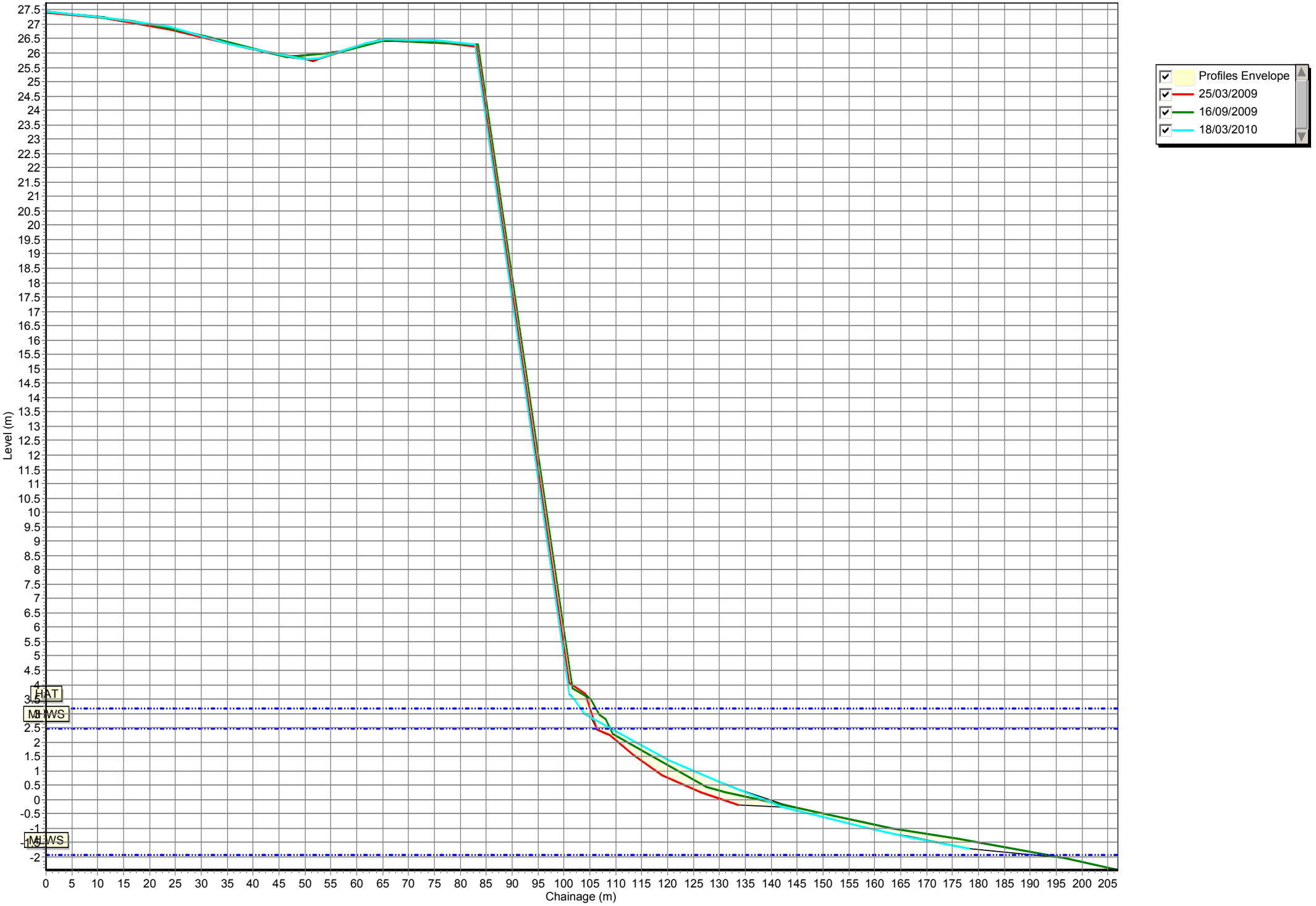


1bSNS32 - 18/03/2010

Chainage	Level	Code
0.000	27.439	
0.056	27.439	GR
11.914	27.230	GR
23.700	26.912	GR
35.642	26.309	GR
41.634	26.069	GR
49.889	25.770	GR
52.605	25.826	GR
61.754	26.343	GR
65.607	26.468	GR
70.266	26.439	GR
74.990	26.429	GR
82.827	26.277	CT
101.017	3.667	CE
101.942	3.506	G
103.912	2.986	GS
110.934	2.294	S
120.292	1.360	GS
130.447	0.579	GS
142.199	-0.251	GS
149.874	-0.594	GS
157.939	-0.955	S
166.132	-1.282	S
178.093	-1.693	S

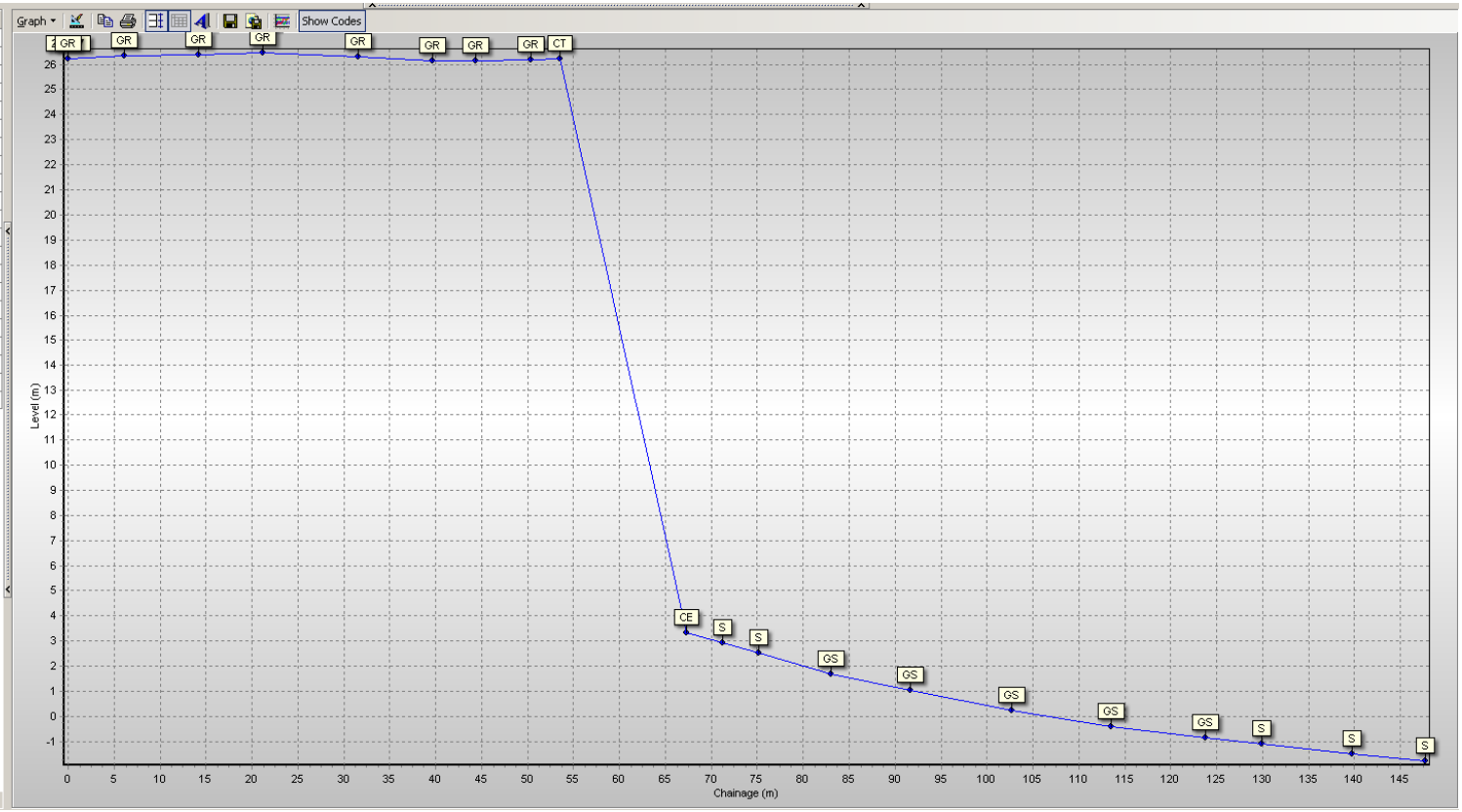


Beach Profiles: 1bSNS32



1bSNS33 - 18/03/2010

Chainage	Level	Code
0.000	26.227	
0.026	26.227	GR
6.102	26.331	GR
14.189	26.375	GR
21.189	26.463	GR
31.571	26.284	GR
39.618	26.156	GR
44.397	26.137	GR
50.403	26.194	GR
53.561	26.232	CT
67.259	3.324	CE
71.259	2.920	S
75.212	2.521	S
82.987	1.689	GS
91.618	1.040	GS
102.646	0.257	GS
113.563	-0.399	GS
123.790	-0.850	GS
129.933	-1.092	S
139.700	-1.498	S
147.707	-1.767	S



Beach Profiles: 1bSNS33

Appendix B

Cliff Top Survey

Cliff Top Survey

Hendon to Ryhope

Thirty-two ground control points have been established between Hendon and Ryhope (Figure C1). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

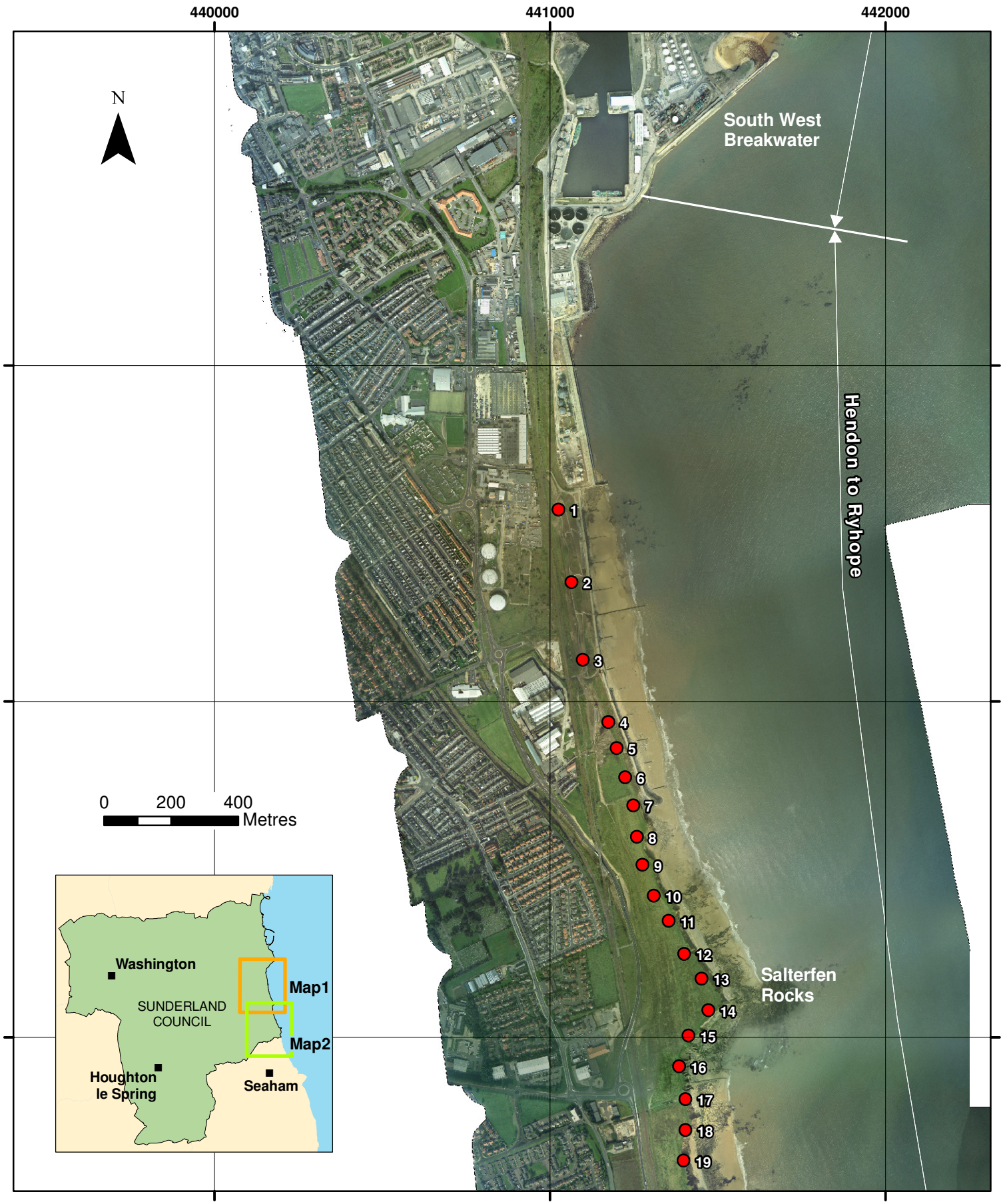
The cliff top surveys between Hendon and Ryhope are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. It is assumed that the accuracy of cliff top monitoring using this technique is ±0.2m. Therefore this should be taken into account when considering the calculated erosion rates in the table below.

Table B1 provides information about these ground control points and results from the 2009 (baseline), previous and present cliff top surveys showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table B1 – Cliff Top Surveys between Hendon and Ryhope

Ground Control Point Details					Distance to Cliff Top (m)			Total Erosion (m) Negative values = retreat Positive values = advance (heave prior to collapse)		Erosion Rate (m/year)
Ref	**Easting**	**Northing**	**Level (mODN)**	**Bearing (º)**	**Baseline Survey (Mar 2009)**	**Previous Survey (Sep 2009)**	**Present Survey (Mar 2010)**	**Baseline (Mar 2009) to Present (Mar 2010)**	**Previous (Sep 2009) to Present (Mar 2010)**	**Baseline (Mar 2009) to Present (Mar 2010)**
1	441026	555571	75	18.9	8.2	11.0	7.8	Landscaping (earthworks) behind the sea wall was undertaken in 2009. March 2010 now represents the new baseline.		
2	441064	555355	85	17.3	7.1	8.0	7.2			
3	441098	555124	82	17.9	10.0	10.6	10.4			
4	441174	554939	65	17.0	10.3	10.2	10.0	-0.3	-0.2	-0.3
5	441199	554861	65	20.0	7.7	7.7	7.5	-0.2	-0.2	-0.2
6	441224	554774	71	22.4	10.8	11.0	10.7	-0.2	-0.4	-0.2
7	441248	554690	74	22.8	10.2	10.4	10.4	0.2	0.0	0.2
8	441259	554597	101	22.5	10.1	9.9	10.1	0.0	0.2	0.0
9	441276	554513	66	23.0	10.5	10.6	10.5	0.0	-0.1	0.0
10	441309	554421	58	22.0	8.8	9.1	9.0	0.2	-0.1	0.2

Ground Control Point Details					Distance to Cliff Top (m)			Total Erosion (m) Negative values = retreat Positive values = advance (heave prior to collapse)		Erosion Rate (m/year)
Ref	**Easting**	**Northing**	**Level (mODN)**	**Bearing (º)**	**Baseline Survey (Mar 2009)**	**Previous Survey (Sep 2009)**	**Present Survey (Mar 2010)**	**Baseline (Mar 2009) to Present (Mar 2010)**	**Previous (Sep 2009) to Present (Mar 2010)**	**Baseline (Mar 2009) to Present (Mar 2010)**
11	441354	554346	68	19.9	8.2	8.3	8.2	0.0	-0.1	0.0
12	441400	554248	56	20.5	6.2	6.3	6.1	-0.1	-0.1	-0.1
13	441452	554175	63	22.9	11.6	11.6	11.7	0.1	0.1	0.1
14	441472	554081	127	23.3	7.3	7.5	7.5	0.1	0.0	0.1
15	441413	554005	122	22.9	7.8	7.9	7.9	0.1	0.0	0.1
16	441385	553913	90	23.6	9.9	9.9	10.0	0.1	0.0	0.1
17	441404	553815	93	21.2	6.3	6.5	6.4	0.0	-0.1	0.0
18	441404	553724	119	24.6	8.1	8.1	8.2	0.1	0.0	0.1
19	441398	553633	78	25.4	8.2	8.4	8.4	0.2	0.1	0.2
20	441438	553453	71	26.8	10.1	10.2	10.2	0.1	0.0	0.1
21	441506	553256	62	27.7	8.6	8.7	8.6	0.0	-0.2	0.0
22	441550	553159	103	26.5	6.6	6.6	6.7	0.1	0.1	0.1
23	441585	553076	64	18.7	8.1	8.2	8.3	0.1	0.0	0.1
24	441624	552871	69	28.1	7.5	7.9	7.4	-0.2	-0.5	-0.2
25	441689	552758	70	28.0	14.6	10.5	9.4	-5.2	-1.0	-5.2
26	441715	552713	54	28.0	12.9	12.9	12.9	0.0	0.0	0.0
27	441749	552674	62	27.4	14.6	15.0	10.4	-4.2	-4.6	-4.2
28	441777	552630	57	26.9	8.6	8.7	5.0	-3.6	-3.7	-3.6
28A	441799	552586	56	26.8	-	13.6	13.2	-	-0.4	-0.8
28B	441817	552542	64	26.5	-	12.3	11.9	-	-0.5	-0.9
28C	441852	552503	52	26.3	-	13.1	13.1	-	-0.1	-0.1
29	441880	552472	83	26.1	15.5	15.5	15.5	0.0	0.0	0.0
30	441921	552269	97	25.1	8.6	8.6	7.9	-0.6	-0.6	-0.6
31	441853	552094	75	26.4	11.2	9.8	9.0	-2.2	-0.8	-2.2
32	441883	551988	96	27.4	9.8	9.8	9.6	-0.2	-0.2	-0.2



Cliff Top Monitoring Points

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

Appendix B - Map 1 Sunderland Council Frontage

Update Report 2
'Partial Measures' Survey 2010

Drawing Scale 1:15,000 at A4

ROYAL HASKONING

Royal Haskoning
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

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

Halcrow

Halcrow Group Ltd
Lyndon House
62 Hagley Road
Edgbaston
Birmingham
B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44 (0)121 456 1569
www.halcrow.com

Drawn by:	TC	Date: 25/05/2010
Checked by:	MD	Date: 04/06/2010
Approved by:	NC	Date: 04/06/2010

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Cliff Top Monitoring Points

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

Appendix B - Map 2 Sunderland Council Frontage

Update Report 2
'Partial Measures' Survey 2010

Drawing Scale 1:15,000 at A4

ROYAL HASKONING

Royal Haskoning
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

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

Halcrow

Halcrow Group Ltd
Lyndon House
62 Hagley Road
Edgbaston
Birmingham
B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44 (0)121 456 1569
www.halcrow.com

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