

REPORT

Cell 1 Regional Coastal Monitoring Programme

Halliwell Banks

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1 Introduction

1.1 Background

Halliwell Banks is a former limestone quarry located near the coastal margin at Ryhope, in Sunderland.

The site is currently owned by the Church Commissioners for England as 'landowner' and is used as farm land and rough grassland. It is bounded to both the north and south by natural surface water denes (the northerly dene is unnamed and the southerly dene is named Ryhope Dene). The site is fronted at its eastern margin by approximately 30m high sea cliffs which tend down to the fronting foreshore and North Sea. The west of the site is defined by the B1287 road and railway line.

Historical records indicate that, after quarrying ceased, Sunderland Corporation was involved with filling the site with domestic waste between the 1930s and 1960s before waste management licensing came into force. As such there are no records of the quantity and types of waste that was dumped. Legally, Sunderland City Council is classed as the 'appropriate person' for the historic landfill site.

1.2 Site Determinations

The historic landfill site was investigated by Sunderland City Council between 2005 and 2008 due to concerns raised by the Environment Agency about the potential for the site to contaminate groundwater and for ongoing erosion of the coastal cliffs to release waste that would pollute the local beaches.

These site investigations, undertaken adjacent to the eroding cliff face, established that a significant part of the site had been filled with a variety of wastes and within the fill were areas of perched hydrocarbons.

The Environment Agency and Natural England were consulted and both agencies concluded in 2008 that the site should be designated as contaminated land under Part 2A of the Environmental Protection Act 1990.

The Environment Agency also recommended in 2008 that, due to special circumstances, the site should also be designated as a Special Site. This is on the basis that the pollution of groundwater in the Principal Aquifer (i.e. the Upper Permian Magnesium Limestone), the North Sea and the Northumberland Coast Special Protection Area (SPA) is likely to be caused by mineral oil and other hydrocarbons.

This Special Site designation means that the Environment Agency (rather than Sunderland City Council) became 'regulator' of the site and will determine all necessary remedial action.

2 Previous Investigations

In December 2021, the local MP (Julie Elliott, Labour, Sunderland Central) raised questions about the environmental and public health assessments that have been made of the Halliwell Banks landfill site and the costs of mitigating potential negative impacts. The response from the Parliamentary Under-Secretary of State for Environment, Food and Rural Affairs (Jo Churchill, Conservative, Bury St. Edmunds) stated that a post determination report had been commissioned. The report examined issues at the site and was currently (as of December 2021) being jointly scrutinised by the Environment Agency and Natural England, who were expected to make a determination on its suitability in coming months.

Prior to this, it is known that the Environment Agency undertook some site investigation in 2016/17 although these reports are not available to the authors of this report (but one relevant figure from the report by Arcadis, showing an assumed boundaries of distinct 'cells' within the landfill, was provided). However, Royal Haskoning was involved in undertaking a study for the Environment Agency in 2008 which involved geophysical investigation of the 'edge of fill' and review of some pre-available reports and datasets (listed in Table 2.1).

Table 2.1 – Previous Investigations (2008 and Earlier)

Author	Title	Date	Comments
Royal Haskoning	Halliwell Banks, Ryhope – Determining the Edge of Fill	2008	Report to Environment Agency
GBGeotechnics	Halliwell Banks, Ryhope, Sunderland. Geophysical Investigation of Landfill.	2008	Report to Royal Haskoning
Royal Haskoning	River Tyne to Flamborough Head Shoreline Management Plan 2	2007	Report to the North East Coastal Authorities Group
AEA Energy and Environment	Coastal Erosion at Halliwell Banks, Ryhope	2006	Report to Sunderland City Council
AEA Technology	Land Quality Statement at Halliwell Banks, Ryhope	2006	Report to Sunderland City Council

3 SMP Policy & SMP Refresh

The Halliwell Banks frontage is located within Policy Unit (PU) 8.4, extending between Hendon and Pincushion, of the River Tyne to Flamborough Head SMP2. The headline policy is Retreat (R) in epoch 1 and Managed Realignment (MR) across epochs 2 and 3. At the time of the SMP2, the investigation of potential contamination from Halliwell Banks was ongoing. Since completion of the investigations, practice has technically been No Active Intervention (NAI).

The SMP states:

“Even under this policy there remains the potential threat of contamination from the Halliwell Banks Quarry. This is currently under investigation. If unacceptable levels of contamination were determined then under the above general policy, the recommendation of the SMP would be for potential contamination to be removed. Only if this were found to be excessively expensive and resulting in broader damage to the environment should consideration be given to protection to the area. This should then be considered in terms of whether protection at this position could be incorporated with the longer term policy of developing key control points on the coast. Fundamental to the above preferred policy would be the need to ensure that no additional development or infrastructure were placed in the open area above the existing cliff line.”

The recent SMP Refresh project in England highlighted that additional steps were required to redefine the headline SMP2 policies, with action planning to investigate the transition to MR in epoch 2 required.

In pursuance of this, the SMP Refresh North East work has:

- proposed that the short-term headline policy is amended to NAI (rather than R);
- qualified the present headline policy of MR for the medium and longer-term as being the need to slow and control long term erosion, while as far as possible allowing natural development of the cliff line; and
- clarified the need for a long-term management study of the site.

4 Available Datasets

4.1 Landfill Sites

The Environment Agency maintains a database of historic landfill sites (Figure 4.1). This currently shows two sites, named Ryhope Dene and Ryhope Dene North. These sites tally with location of past quarry sites, as shown on published historic maps (Figure 4.2).

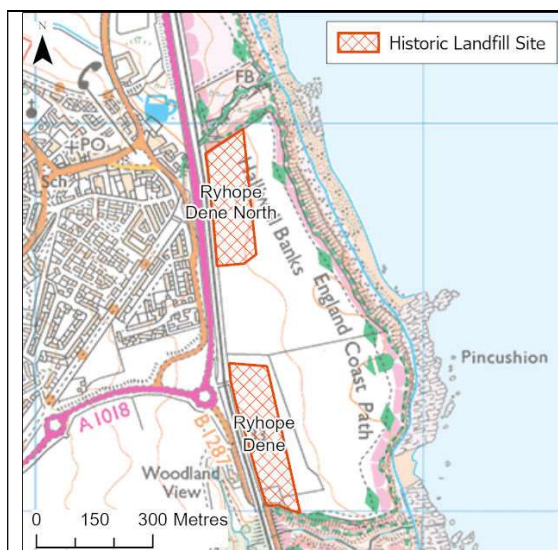


Figure 4.1 – Historic Landfill Sites from the Environment Agency's current database

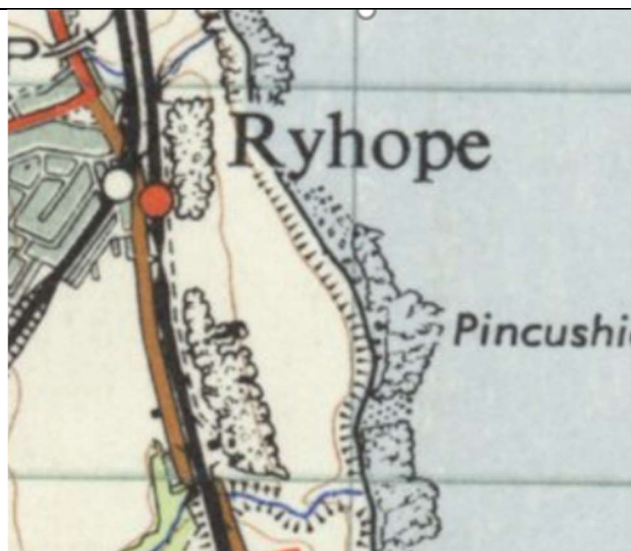


Figure 4.2 - OS map extract from 1955-61 showing quarry sites

In 2017, CH2M Hill undertook a review of potential land contamination risks to coastal waters resulting from SMP2 No Active Intervention (NAI) policies within Coastal Cell 1. This used GIS layers comprising the Environment Agency's 'historical landfills' datasets and mapping of historic landfills from local authorities gathered as part of councils duties under Part 2A of the Environmental Pollution Act 1990. It considered the pollution sources of pollution, erosion risk and sensitivity of receptors (based on nature conservation designations), providing an overall risk ranking of identified sites. This study identified Ryhope Dene landfill (closed by 1991) within its list of assessed sites but not specifically Halliwell Banks. The report also stated that *"the eroding landfill near the south of Sunderland City Council's area was not included because the SMP2 policy is Hold the Line"* (and not NAI, which formed the basis of the assessments). It is presumed that this sentence refers to Halliwell Banks; the site being towards the south of the council's area and it not being a NAI policy (although note that it is not a Hold the Line policy as stated by CH2M Hill, rather it is a Retreat (initially) and Managed Retreat policy).

However, the area of Halliwell Banks that formed the basis of the 'edge of fill' investigation for the Environment Agency by Royal Haskoning/GB Geotechnics in 2008 (see Box A) is not contained within the Environment Agency's 'historical landfills' database, and it may reasonably be anticipated that waste could have been tipped more widely across the area.

Box A – Summary of 2008 Non-Intrusive Geophysical Investigation

In April 2008, GB Geotechnics Limited undertook a non-intrusive geophysical investigation using Electrical Resistivity Tomography (ERT) methods to inform definition of the 'edge of fill' and characterise the nature of the cross profile of the fill within an area of investigation defined by the Environment Agency specifically at Halliwell Banks. The ERT investigation identified that the minimum width between the edge of the fill and the cliff edge is 18m and that this distance varies somewhat along the edge of the cliff, with the distance increasing up to 40m at the south of the site.

The ERT investigation also provided detailed information relating to the cross profile of the fill. The investigation found that the cross profile is sloped, dipping away from the sea. Although the exact angle of dip cannot be established, this does give a good indication that the width between the fill and the cliff edge is greater at the beach level than it is at the cliff top. Although this is the most preferable configuration for the fill profile, coastal erosion is still capable of resulting in a breach of the site. Erosion of the cliff toe is likely to result in slumping of the cliff top where the width between the fill and cliff is at its narrowest.

Also, the figure created by Arcadis from the intrusive investigative work commissioned by the Environment Agency in 2016/17 infers that assumed boundaries of distinct 'cells' within the historic landfill cover considerably wider areas of the cliff top (see Figure 4.3) than those reported in the Environment Agency Historic Landfill Database alone.

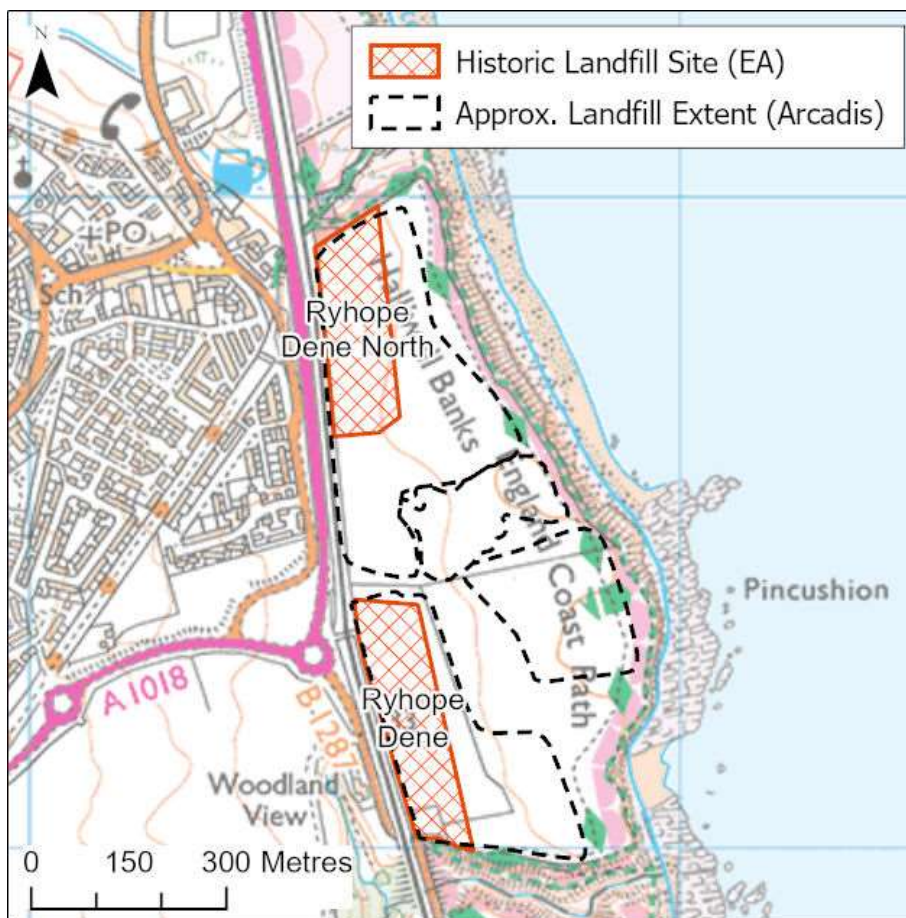


Figure 4.3 - Assumed boundaries of distinct landfill 'cells' based on Arcadis' report figure

4.2 Coastal Erosion Rates

AEA Energy and Environment (2006), reported on an investigation into the rates of coastal erosion at Halliwell Banks using comparisons of aerial photography from between 1996 and 2003. This data focused on the entire length of the site from the Northern to the Southern Dean and found maximum retreat rates of 30m over the seven year period. The retreat rates within the area of interest for this study were found to be closer to 25m over the same period. This indicates an average erosion rate for the site of approximately 3.5m per year.

Halliwell Banks lies within Shoreline Management Plan 2 (SMP2) policy unit 8.4. The SMP2 states that the current policy for this unit is Managed Realignment over the next 100 years. The plan also highlights the rates of coastal erosion and provides a predicted shoreline plan for the next 20, 50 and 100 years. This plan shows projected erosion of up to half of the area in between the current cliff position and the B1287 within the next 100 years in close proximity of the area of interest. The average rate of coastal erosion used in the SMP2 for this area (Salterfen) is 1m per year, however, based on the plan described above; the rate is approximately 1.5m per year.

Sunderland City Council carried out monthly erosion measurements along the top of the sea cliffs at Halliwell Banks in order to gauge the rate of erosion along this frontage. The survey was commissioned in 2007 and consisted of monitoring the distance from the cliff edge to eleven wooden stakes inserted into the cliff top at 15m centres, initially 4m from the cliff edge (Figure 4.4). Each month, the distance from these stakes to the closest area of erosion was measured. Results of these measurements are shown in Table 4.1. The general trend suggests that the cliff experiences cycles of erosive behaviour defined by long periods of relative stability or quiescence, followed by rapid erosion or collapse events which result in a large movement of material within a very short period of time. As discussed above, Sunderland City Council collected cliff erosion data at Halliwell Banks by measuring the distance from a fixed marker stake to the closest area of erosion on a monthly basis. This method gives a useful indication of the recession rates, but has some inherent limitations in its accuracy.

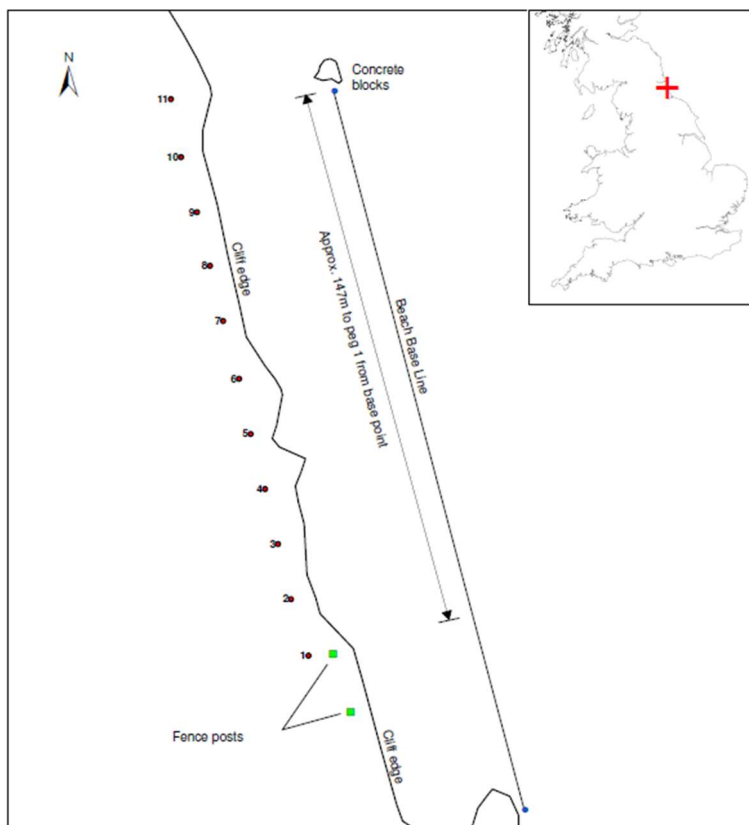


Figure 4.4 – Location of Sunderland City Council cliff top marker points for surveys in 2007/08

Table 4.1 - Distance from cliff top marker points to cliff edge recorded during Sunderland City Council's surveys in 2007/08

Stake No	Distance from cliff top marker point to cliff edge (in metres)					
	09/08/2007	07/09/2007	03/10/2007	12/11/2007	11/12/2007	30/01/2008
1	4.250	4.205	4.130	4.110	4.115	4.045
2	4.090	3.960	4.030	4.040	4.020	3.970
3	4.070	4.120	4.090	4.080	4.090	3.900
4	3.810	3.670	3.655	3.650	3.615	3.390
5	4.140	4.090	4.100	2.975 x	2.980	2.955
6	4.200	4.190	4.050	3.395 x	2.290	2.285
7	4.130	3.985	X	4.080 y	4.050	4.055
8	4.270	4.190	4.120	4.100	2.060	2.060
9	4.210	4.035	4.045	4.040	4.010	X
10	4.150	4.120	4.115	4.090	4.090	3.930
11	4.070	4.045	4.035	4.040	4.020	4.010

X = peg lost to erosion

x = chunk of cliff face collapsed onto beach

y = stake re-set 4m from cliff edge following erosion

Over this period, the projected maximum erosion rate reached 4.4m per year, based on a single erosion event of 2.2m every six months (as shown as a 'worst case' in this measured data at point 8). However, the failure mechanism responsible for this erosion event is not known. It is possible that these erosion events are a result of the cliff becoming unstable following heavy rainfall or increased wave activity during storm events. The rate of cliff erosion is also likely to be heavily influenced by the underlying geology and its degree of faulting. The rates estimated from the above erosion data reflect very closely the estimated rates of erosion reported by the AEA group for the period 1996 to 2003 from their analysis of aerial photographs. With only two relatively short data sets available, and due to the cyclic and unpredictable nature of erosion at Halliwell Banks, it was, at the time, deemed appropriate to err on the side of caution and assume an annual erosion rate of 4.4m per year. Based on a minimum width between the edge of the fill and the cliff top, and a 'worst case' conservative coastal erosion rate of 4.4m per year (based on the maximum observed short term change extrapolated over a full year), Royal Haskoning (2008) projected a worst case that the landfill at Halliwell Banks could be breached by coastal erosion within the subsequent 4 to 5 years, assuming that no preventative measures are implemented before that time.

Clearly, this has not happened in the intervening years, indicating that the average annual erosion projection was likely too conservative. If the assumed erosion rate is more akin to the rates used by Royal Haskoning (2007) in the SMP2 (1.5m/year), then the projected time until breaching would be more in the range 12 – 27 years from 2008 (given the distance to edge of fill of between 18 and 40 m measured in 2008).

Due to the large uncertainty in projections of when the historic landfill will become breached by coastal erosion, Sunderland City Council is collating up to date available information on cliff recession at the site, based on outputs from the Cell 1 Regional Coastal Monitoring Programme.

5 Cell 1 Regional Coastal Monitoring Programme

As part of the Cell 1 Regional Coastal Monitoring Programme, relevant data on cliff erosion can be obtained from a combination of beach profile surveys, cliff top surveys and aerial photography and LiDAR surveys. Each is discussed in this section, with the latest (to spring 2022) survey data provided.

5.1 Beach Profiles

There are thirteen beach profiles covering the area of interest near Halliwell Banks as shown in Figure 5.1. All of the beach profiles are being surveyed at least annually and are covered by the 'Full Measures' (FM) survey in autumn each year, with nine of these beach profiles also included within the 'Partial Measures' (PM) update survey that is carried out each spring. Table 5.1 gives details of the survey frequency and survey dates for each of the Cell One beach profiles near Halliwell Banks.

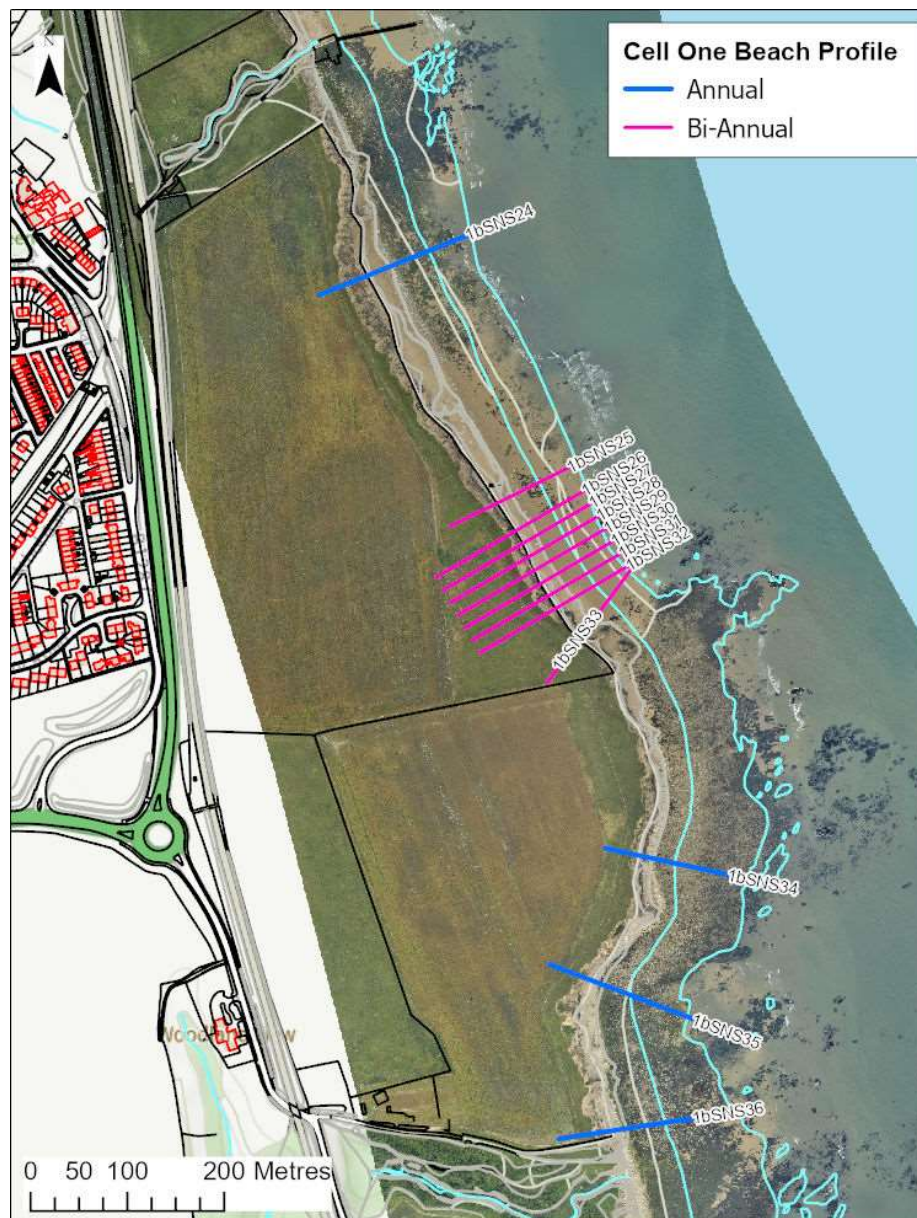


Figure 5.1 - Cell One Beach Profile Locations near Halliwell Banks

Table 5.1 - Survey Frequency and Survey Dates for Cell One Beach Profiles near Halliwell Banks

Profile Name	Frequency	First Survey	Most Recent Survey
1bSNS24	Annual	FM 2009	FM 2021
1bSNS25	Bi-Annual	FM2009	PM2022
1bSNS26	Bi-Annual	PM2009	PM2022
1bSNS27	Bi-Annual	PM2009	PM2022
1bSNS28	Bi-Annual	PM2009	PM2022
1bSNS29	Bi-Annual	PM2009	PM2022
1bSNS30	Bi-Annual	PM2009	PM2022
1bSNS31	Bi-Annual	PM2009	PM2022
1bSNS32	Bi-Annual	PM2009	PM2022
1bSNS33	Bi-Annual	FM2009	PM2022
1bSNS34	Annual	FM 2009	FM 2021
1bSNS35	Annual	FM 2009	FM 2021
1bSNS36	Annual	FM 2009	FM 2021

Using the available beach profile datasets, cliff top and cliff toe positions have been mapped for each survey (and provided to Sunderland City Council as AutoCAD files). Figure 5.2 shows the cliff top and cliff toe positions from the first and most recent surveys.

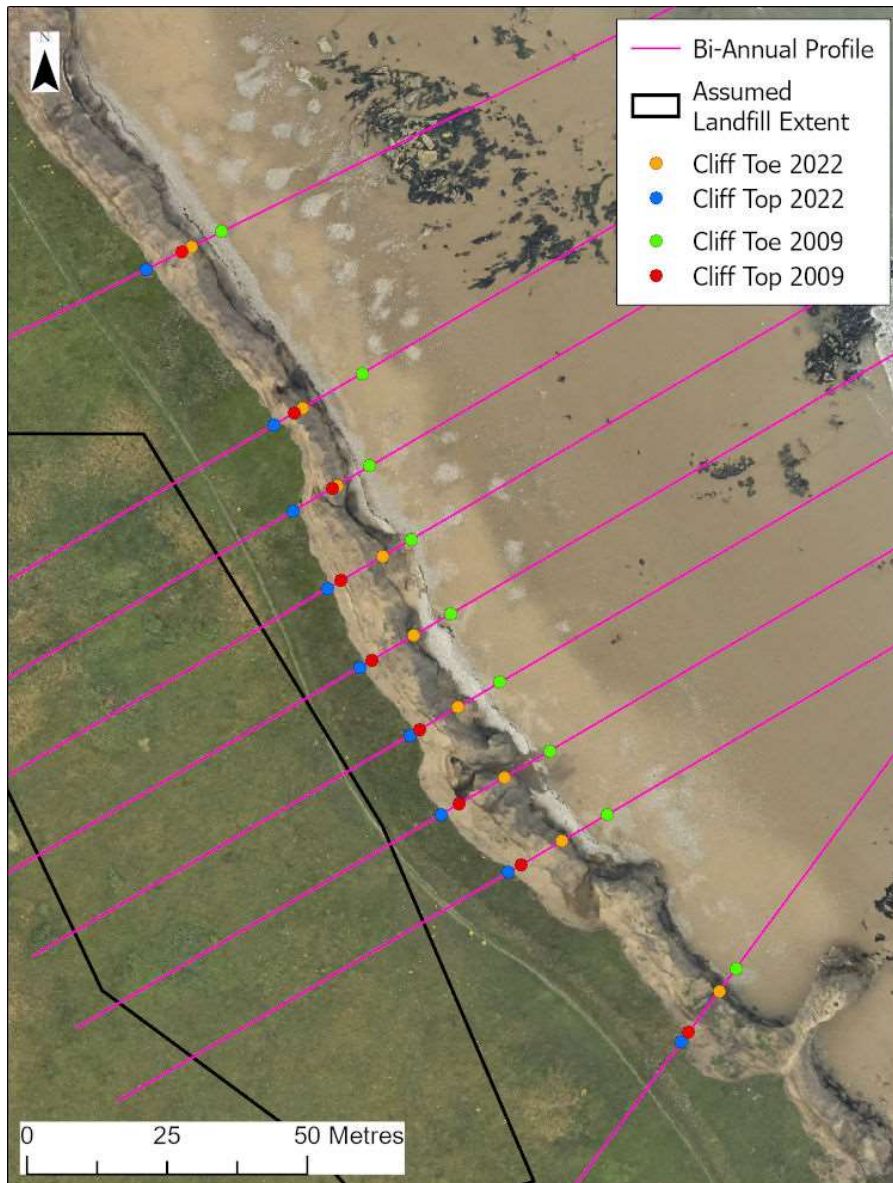


Figure 5.2 - Cliff top and cliff toe for first (2009) and most recent (2022) beach profile surveys overlaid upon 2021 aerial photo in relation to the 2008 investigation's assumed landfill extent near Halliwell Banks

Based upon analysis of a sub-sample of the most recent survey data, the following results are available:

- *Profile 1bSNS25 Horizontal retreat of the cliff top by approx. 7m between Sept 09 – Apr 22.*
- *Profile 1bSNS27 Horizontal retreat of the cliff top by approx. 8m between Mar 09 – Apr 22.*
- *Profile 1bSNS29 Horizontal retreat of the cliff top by approx. 2.5m between Mar 09 – Apr 22.*
- *Profile 1bSNS30 Horizontal retreat of the cliff top by approx. 2.0m between Mar 09 – Apr 22.*
- *Profile 1bSNS31 Horizontal retreat of the cliff top by approx. 3.5m between Mar 09 – Apr 22.*
- *Profile 1bSNS33 Horizontal retreat of the cliff top by approx. 2m between Sept 09 – Apr 22.*



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5.2 Cliff Top Surveys

There are twelve Cell One Virtual Cliff Top Survey Points that fall into the area of interest near Halliwell Banks, namely points 24 to 32, as shown in Figure 5.3. Each of these points is being surveyed twice a year, the first survey was carried out in Spring 2009 (with the exception of points 28A to 28C that were surveyed for the first time in Autumn 2009), and the most recent survey has been undertaken in Spring 2022.



Figure 5.3 - Cell One Virtual Cliff Top Survey Points

Results from the most recent (spring 2022) analysis are summarised in Table 5.2, showing a peak annual average erosion rate of just under 1m per year.

Table 5.2 – Cliff top surveys

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
			(°)	Mar 2009	Nov 2021	Apr 2022	Mar 2009 - Apr 2022	Nov 2021 - Apr 2022	Mar 2009 – Apr 2022
24	441624.4	552870.7	69	7.53	2.16	1.71	-5.82	-0.45	-0.45
25	441689.1	552758	70	14.58	2.32	2.18	-12.4	-0.14	-0.95
26	441715	552713.3	54	12.87	2.49	2.53	-10.34	0.04	-0.80
27	441749.2	552674.4	62	14.56	2.52	2.46	-12.1	-0.06	-0.93
28	441776.6	552629.9	57	8.62	2.45	2.44	-6.18	-0.01	-0.48
28A	441798.6	552586.3	56	13.63	6.15	5.44	-8.19	-0.71	-0.63
28B	441817.4	552542.4	64	12.3	8.39	8.35	-3.95	-0.04	-0.30
28C	441852.2	552502.6	52	13.11	12.45	12.39	-0.72	-0.06	-0.06
29	441880.1	552471.6	83	15.46	14.54	14.49	-0.97	-0.05	-0.07
30	441921.4	552269	97	8.55	4.21	4.25	-4.3	0.04	-0.33
31	441853.1	552094	75	11.2	2.1	2.11	-9.09	0.01	-0.70
32	441883.3	551988.5	96	9.82	2.54	2.62	-7.2	0.08	-0.55

5.3 Aerial Photography & LiDAR

Aerial photography and LiDAR surveys are usually flown as near concurrently as possible. Data are available for the following dates:

- 2010
- 2012
- 2015
- 2017
- 2019-20
- 2021.

In addition to this, there is historic aerial photography available for the 1940s which have been especially geo-rectified for the Cell One Monitoring Programme. It should be noted that the accuracy of this dataset is not of the same high resolution as contemporary surveys and has lower plan accuracy.

Digital ground models of the site, created using ArcGIS, are shown in Figure 5.4 for the 2010 and 2021 surveys. Note that changes between the surveys can best be viewed by opening and scrolling between the provided JPG images of the plots.

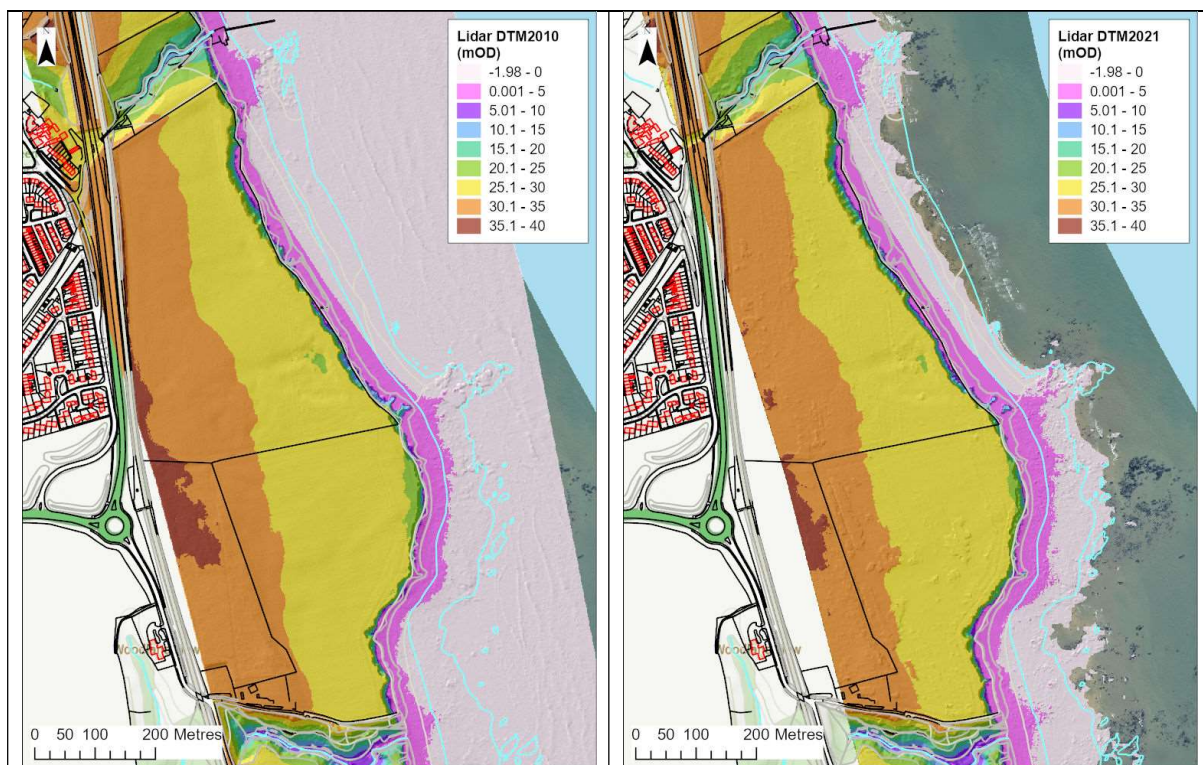


Figure 5.4 – Topographic contours of the site from 2010 and 2021

A difference in the topography between each survey is shown in Figure 5.5. Note the band of erosion (red) all along the cliff edge, indicating ongoing recession over this period of time.



Figure 5.5 - Change in elevation between 2010 and 2021
(areas in red = erosion, areas in blue = accretion)

Figure 5.6 shows the slope surfaces from the 2010 and 2021 DGMs. These are useful for clearly defining the cliff edge. Note also the 'triangular' shaped ground depression in the vicinity of the 2008 geophysical investigation. Note that changes between the surveys can best be viewed by opening and scrolling between the provided JPG images of the plots.

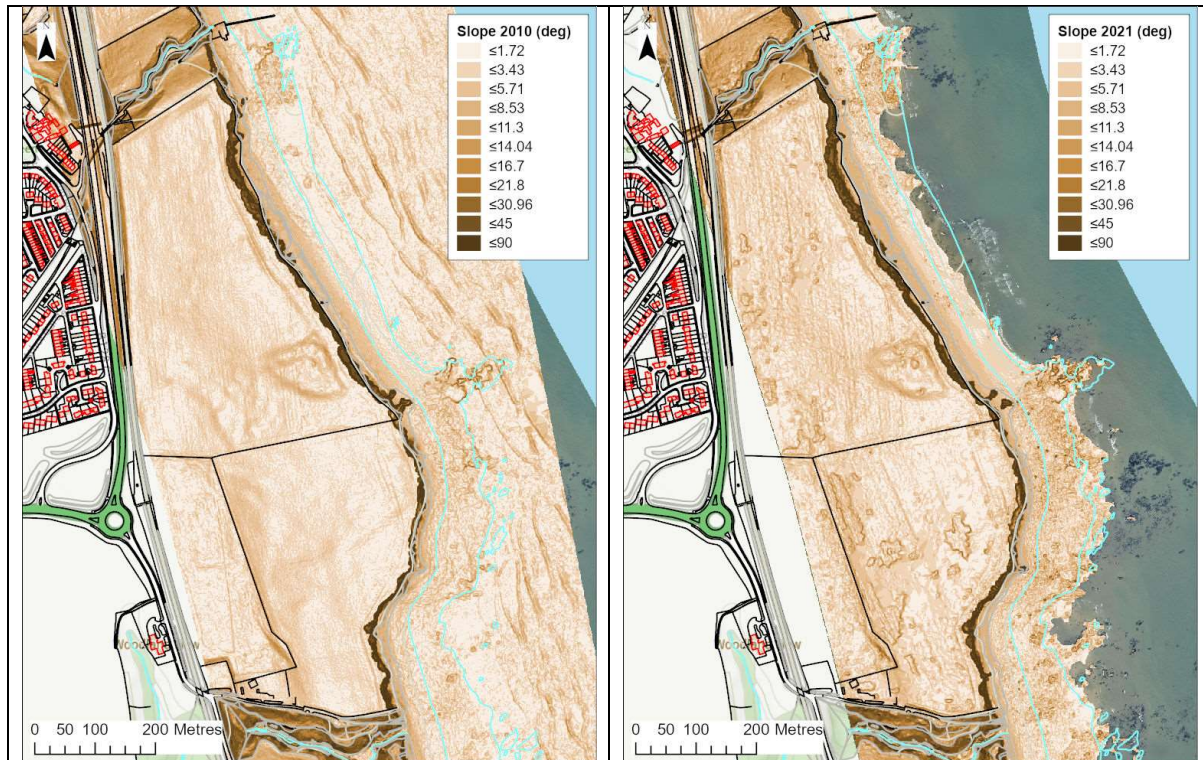


Figure 5.6 - Slope surfaces derived from 2010 and 2021

Based upon distinct definition of the surface slopes, the cliff edge can be clearly mapped. Figure 5.7 shows the cliff top position from the 1940s (aerial imagery only, no supporting LiDAR) and the 2010 and 2021 aerial and LiDAR surveys.

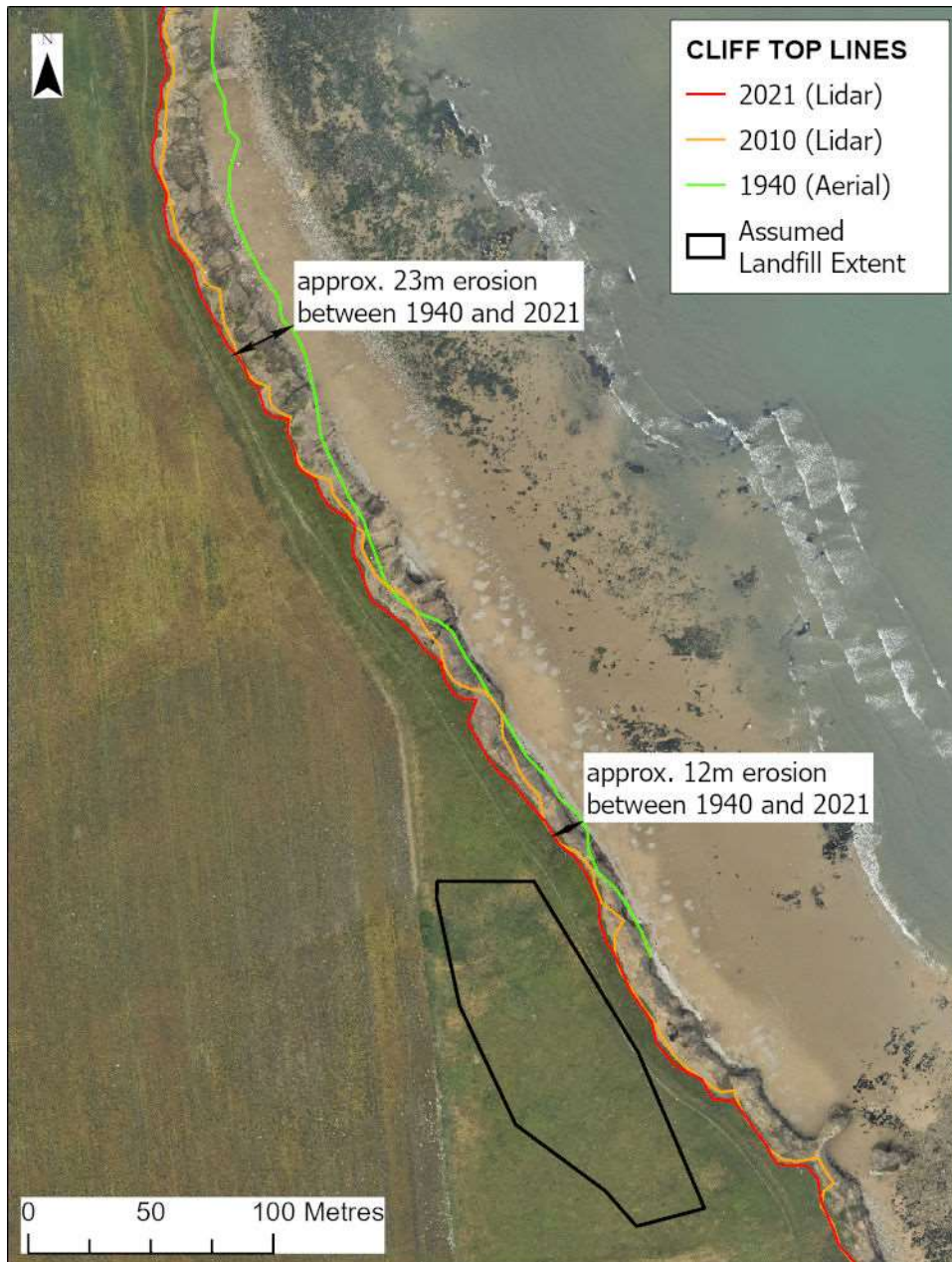


Figure 5.7 - Cliff top lines for 1940 (Aerial), 2010 (LiDAR) and 2021 (LiDAR) in relation to the 2008 investigation's assumed landfill extent near Halliwell Banks

The 2008 study's assumed landfill area of investigation can also be plotted in association with the aerial imagery and an oblique view created. This is done for 2010 and 2021 in Figure 5.8 and Figure 5.9, respectively. Note that changes between the images can best be viewed by opening and scrolling between the provided JPG images of the plots.



Figure 5.8 – Cliff top position in 2010 (red) and 2021 (orange) superimposed upon 2010 aerial imagery



Figure 5.9 – Cliff top position in 2010 (red) and 2021 (orange) superimposed upon 2021 aerial imagery

The 2008 study's assumed landfill area of investigation can also be plotted in association with the LiDAR contours and an oblique view created. This is done for 2010 and 2021 in Figure 5.10 and Figure 5.11, respectively. Note that changes between the surveys can best be viewed by opening and scrolling between the provided JPG images of the plots.

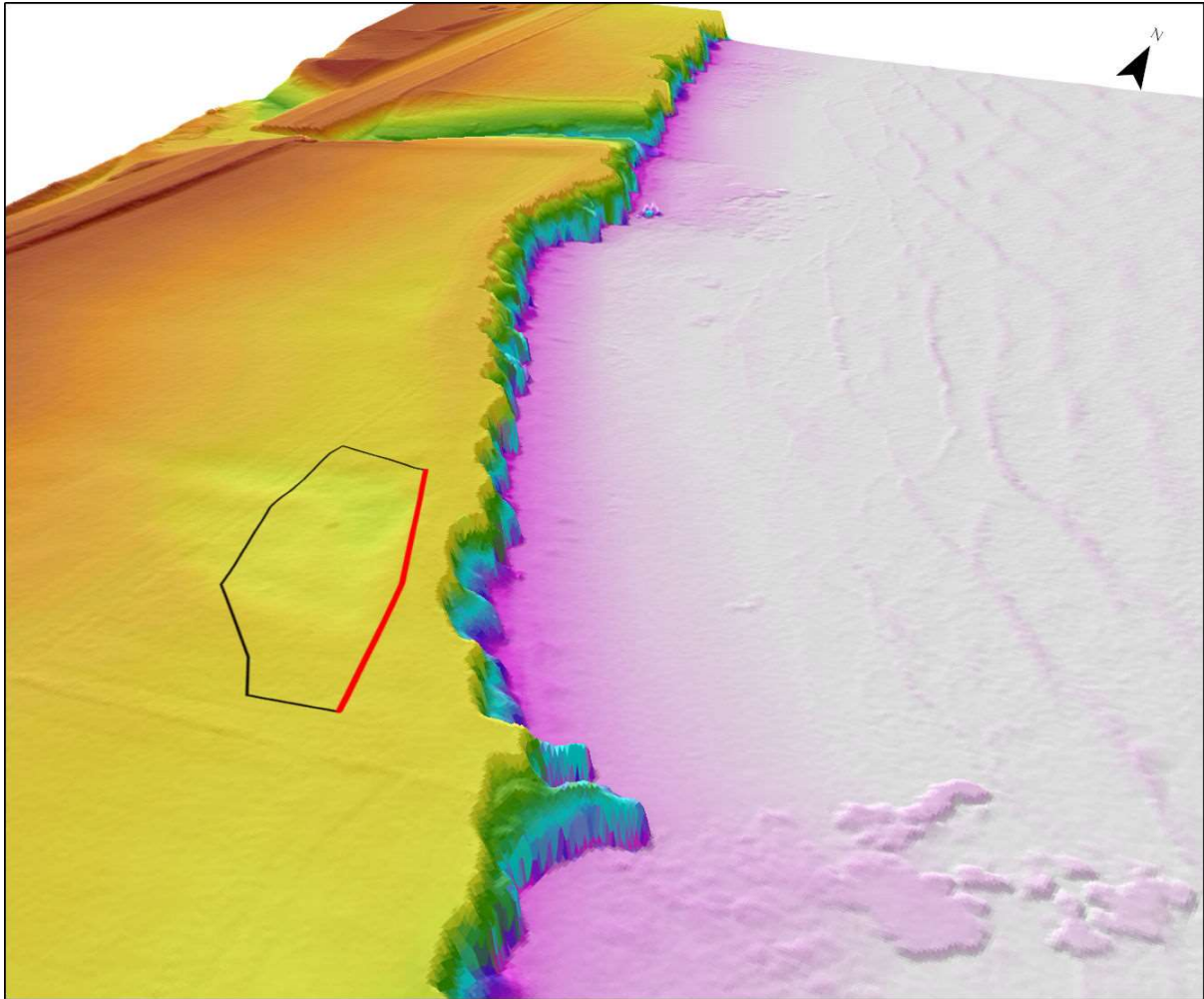


Figure 5.10 – Cliff top position in 2010 superimposed upon 2010 LiDAR contours

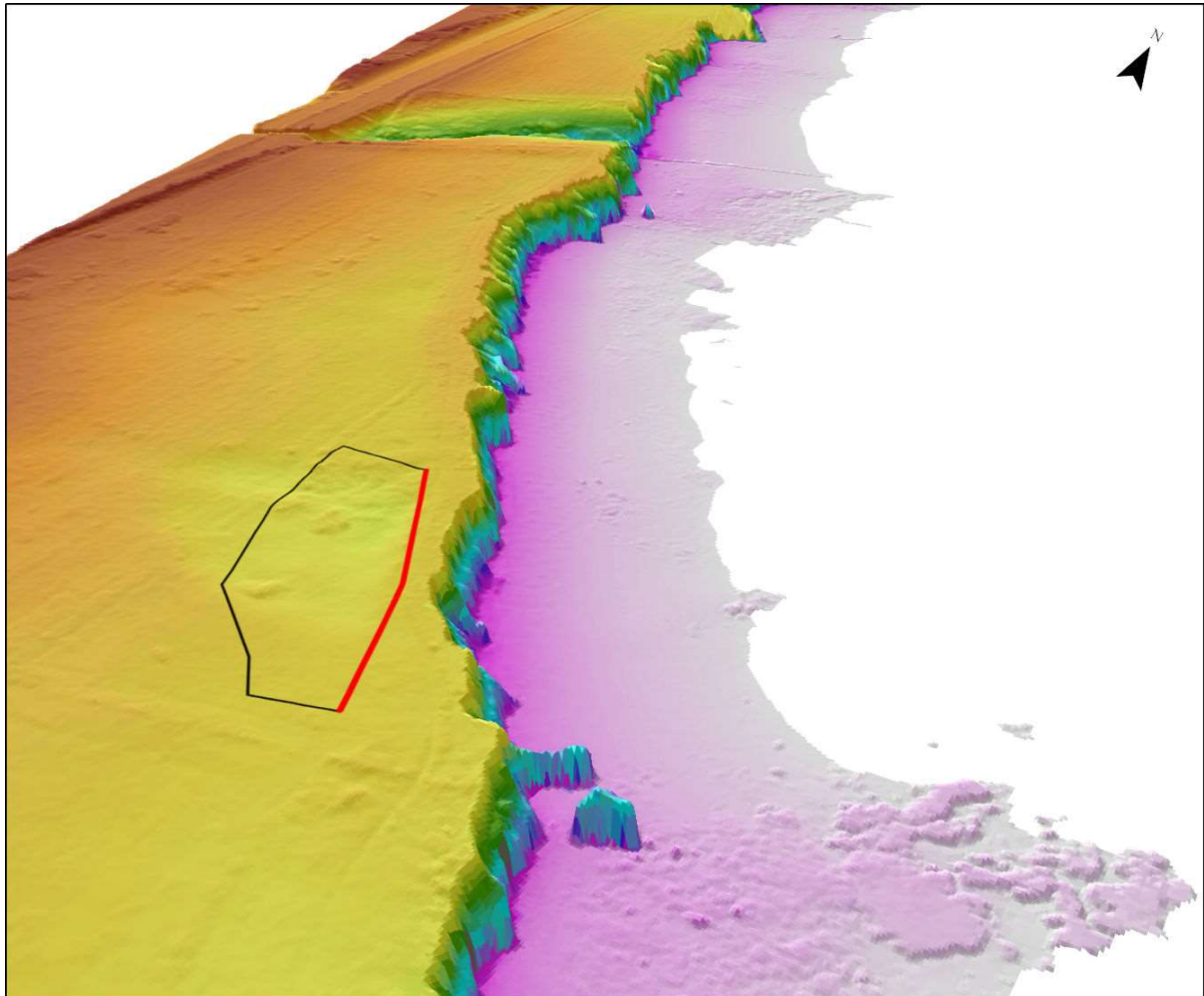


Figure 5.11 – Cliff top position in 2021 superimposed upon 2021 LiDAR contours