Cell 1 Coastal Landfills Study

February 2019

Scarborough Borough Council

Cell 1 Regional Coastal Monitoring Programme
Coastal Landfills Study

Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Author	Authorised
1	0	Draft report for client review	04/02/2019	A Scullion	N J Cooper
1	1	Final report for client review	19/02/2019	A Scullion	N J Cooper

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[1] Scarborough Borough Council is acting as client on behalf of all Local Authorities within 'Coastal Cell 1'.

1. Introduction

Scarborough Borough Council, acting as lead authority on behalf of all authorities within Coastal Sediment Cell 1 (hereafter known as Cell 1), commissioned a non-statutory Strategic Assessment (SA), produced in line with Strategic Environmental Assessment (SEA) guidance, of the in-combination and cumulative impacts of implementing:

(i) the Action Plans from both the Northumberland & North Tyneside Shoreline Management Plan 2 (SMP2) and the River Tyne to Flamborough Head SMP2;
(ii) the government's 6-year Flood & Coastal Erosion Risk Management (FCERM) investment programme; and
(iii) published coastal strategies.

The SA (CH2M, 2017) was informed by a review of potential land contamination risks to coastal waters resulting from SMP2 'No Active Intervention' (NAI) policies. The purpose of the review was to identify areas of recent or historic land contamination that may present a risk to coastal waters, either currently or in the future, within Cell 1 as a result of either:

- leaching of contaminants from the site into the coastal waters; or
- erosion of the site, releasing debris and contamination directly in the coastal water.

The review was undertaken as a desk-based exercise and involved identifying sites of potential land contamination from GIS databases provided by local authorities, the Environment Agency, English Heritage and Natural England and then ranking those sites in areas with a NAI policy according to the risks they posed to coastal waters. The risk ranking was achieved by consideration of three criteria based on the 'source-pathway-receptor' model for land contamination risk assessments, namely:

- Contamination potential (source) – based on published datasets;
- Erosion risk under the NAI policy (pathway) – based on projected cliff top recession lines; and
- Receptor sensitivity (receptor) – whilst noting that it is an offence to pollute any controlled waters, this was based on proximity of the site to areas with international nature conservation designations such as Special Areas of Conservation (SAC), Special Protection Areas (SPAs) or Ramsar Sites.

Each criterion was ranked on a scale between 1 (very low risk) to 5 (very high risk) and the total risk ranking was normalised to a score of between 1 and 100 using the formula below:

$$\frac{\text{Contamination potential} \times \text{Erosion risk} \times \text{Receptor sensitivity}}{1.25}$$

Following this initial risk ranking, a manual modification was made to revise the scores for any sites where it was known that clear-up had been undertaken (e.g. Blackhall Colliery) or that further site investigations had been undertaken and contamination potential was lower than originally thought (e.g. Old Harbour Quarry).

Of the 104 sites considered[2] in areas with a NAI policy, 73% (76 no.) were deemed to be of 'Very Low' or 'Low' risk, with 11.5% (12 no.) classed as being of 'Medium' risk (**Figure 1**). Of the remaining 15% (16 no.), 7 no. sites were classified as posing 'High' risk and 9 no. were classed as posing 'Very High' risk.

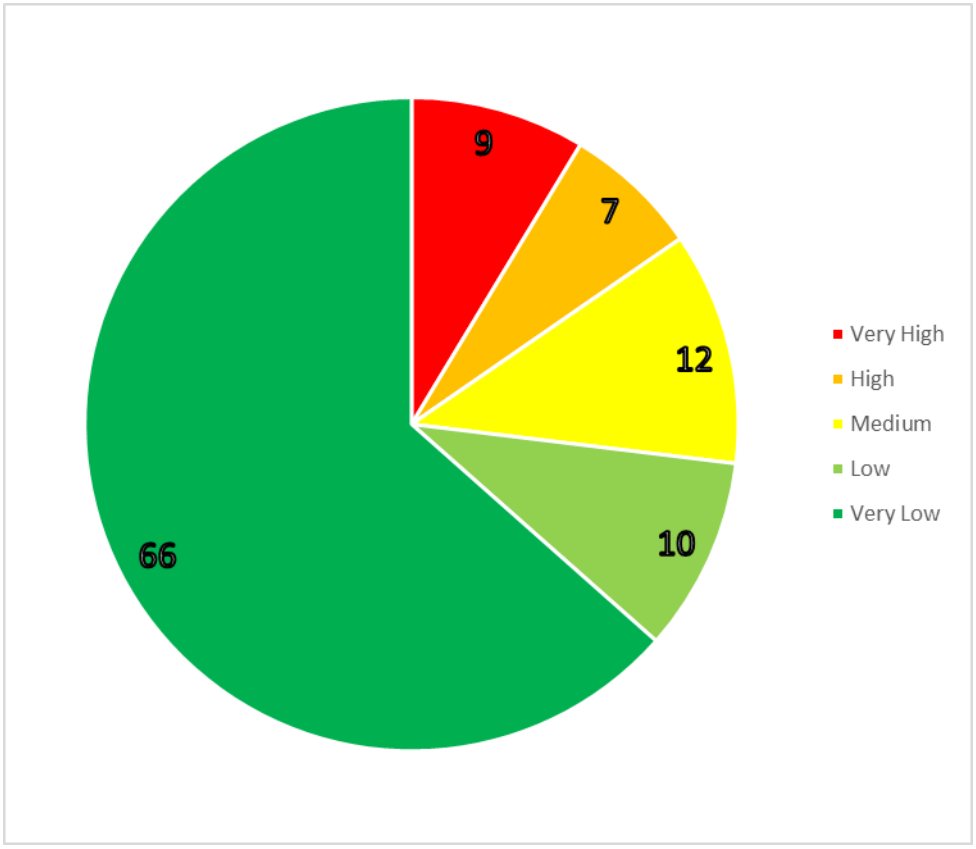


Figure 1 (Revised) Risk Ranking Results from previous review of potential land contamination risks to coastal waters resulting from SMP2 No Active Intervention policies

The purpose of the present study is to further investigate the top five ranked sites by means of Site Visit and Historic Trends Analysis (HTA) using available maps, photographs, site records and monitoring data to provide an improved understanding of the risks from the contamination potential and the past, contemporary and projected future coastal erosion considerations.

2. Top Ranked Sites

From the previous review of potential land contamination risks to coastal waters resulting from SMP2 No Active Intervention policies (CH2M, 2017), the 9 top ranked sites, each with 'Very High' risks are listed below in **Table 1**.

[2] The report states that 96 sites were considered, but 104 sites are listed in Table 5 of the report, each with an individual risk ranking.

Table 1 Top ranked sites (9 no.) with 'Very High' risks (after Cell 1 Appendix C Contaminated Land Assessment, CH2M, 2017)

Ref	Name	Local Authority	Description	Ref	Contamination	Erosion risk	Receptor	Risk Ranking	Recommendations
1	Holy Island, Shell Road	Northumberland	Historic Landfill no info, within Ramsar, SAC.	HR6 NNT PDZ1 MA5	5	4	5	**80**	Further desk study would likely reduce contamination potential.
2	Holy Island Sands	Northumberland	Historic Landfill no info, within Ramsar, SAC.	HR6 NNT PDZ1 MA4	5	4	5	**80**	Further desk study would likely reduce contamination potential.
3	The Dune Tip	Northumberland	Historic Landfill no info, within Ramsar, SAC.	HR7 NNT PDZ2 MA6	5	4	5	**80**	Further desk study did not identify further information. Site visit recommended.
4	Links Quarry	Northumberland	Historic Landfill complete from 1986, boundary of SPA and Ramsar.	HR16 NNT PDZ5 MA20	5	5	4	**80**	Further investigation required.
5	Area G East of Horden	Durham	Historic landfill, within Durham Coast SAC, landfill appears to be over a stream.	HR42 RTFH PDZ4 MA10	5	4	5	**80**	Further investigation required. Check proximity of stream to landfill. Further study identified this as a Historic Landfill, inert and industrial waste 1972-1973 (EA website). Part of the Horden Colliery site, but no information found relating to this specific area. Historic maps show no obvious signs of filling. A site visit is recommended to confirm the online findings.
6	Bowl Hole	Northumberland	Infilled pit, Cemetery/infilled pit, no erosion data but on edge of dunes.	HR62 NNT PDZ2 MA6	4	5	5	**80**	Further investigation to check source of fill + erosion potential.
7	near Lynemouth	Northumberland	Infilled land/pond unknown fill.	HR78 NNT PDZ4 MA19	4	5	5	**80**	Further desk study would likely reduce contamination potential.
8	near Spital Point	Northumberland	Area of infilled quarries (unknown fill).	HR80 NNT PDZ5 MA21	4	5	5	**80**	Further desk study would likely reduce contamination potential.
9	Land adjacent to Redcar Blast Furnace	Redcar and Cleveland	Mixed area of landfill (historic), infilled ponds, tip (marked on modern map as disused), factories, alongside Teesside Works, Redcar (Steelworks). Alongside SPA/Ramsar. No erosion data.	HR83 RTFH PDZ5 MA13	5	5	4	**80**	Further investigation recommended.

Of the nine reference sites listed in **Table 1**, the following groupings will be considered for analysis:

- Site references 1 and 2 are both on Holy Island (Northumberland): **Location 1**
- Site references 3 and 6 are both adjacent to each other at Bamburgh (Northumberland): **Location 2**
- Site reference 7 is in Lynemouth Bay (Northumberland): **Location 3**
- Site references 4 and 8 are both adjacent to each other near Links Quarry (Northumberland): **Location 4**
- Site reference 9 is at Coatham Sands: **Location 5**
- Site reference 5 is at Horden (County Durham): **Location 6**

Further information of each location is outlined below.

2.1 Location 1 – Holy Island

Holy Island (or 'the Holy Island of Lindisfarne' to give it its full name) is a tidal island off the northeast coast of Northumberland (**Figure 2**). Both reference sites at Holy Island are located within Berwickshire and North Northumberland Coast SAC, designated due to its "Mudflats and sandflats not covered by seawater at low tide", "Large shallow inlets and bays", "Reefs" and "Submerged or partially submerged sea caves" (JNCCa, undated). The site's flats and saltmarshes support internationally important wintering waterbirds such as the Bar-tailed Godwit *Limosa lapponic,* Golden Plover *Pluvialis apricaria* and is thus a designated SPA (JNCCa, undated). It is also a designated Ramsar site due to its saltmarsh and intertidal flat habitats, as well as its major dune system with well-developed dune slacks (JNCCa, undated).

2.1.1 History

Holy Island has a wealth of evidence of prehistoric activity and has been the subject of several archaeological field surveys and excavations.

An historic landfill identified in the north of Holy Island (Nessend) was found to be the site of a small limestone quarry to supply a lime kiln on the island, which was infilled by the 1920s. Due to the insignificant size and age of the infill, the site's contamination potential was reduced to 1 in the previous review of potential land contamination risks to coastal waters resulting from SMP2 No Active Intervention policies (CH2M, 2017), which reduced the overall risk ranking to 20 (and thus not classified as one of the nine top sites considered in the present study).

Another historic landfill identified on the west of the island was found to be elongated in shape and covering an area of several small historic metal/quarry works with a low contamination potential. This site was not considered to be a high risk and was not investigated further in the present study.

The island has a rich mineral resource of limestone, coal and iron ore which was exploited throughout the 19th century (Northumberland County Council, 2009). A number of lime kilns found across the island reveal the island's large lime production, believed to date back to the 1840s (Northumberland County Council, 2009).

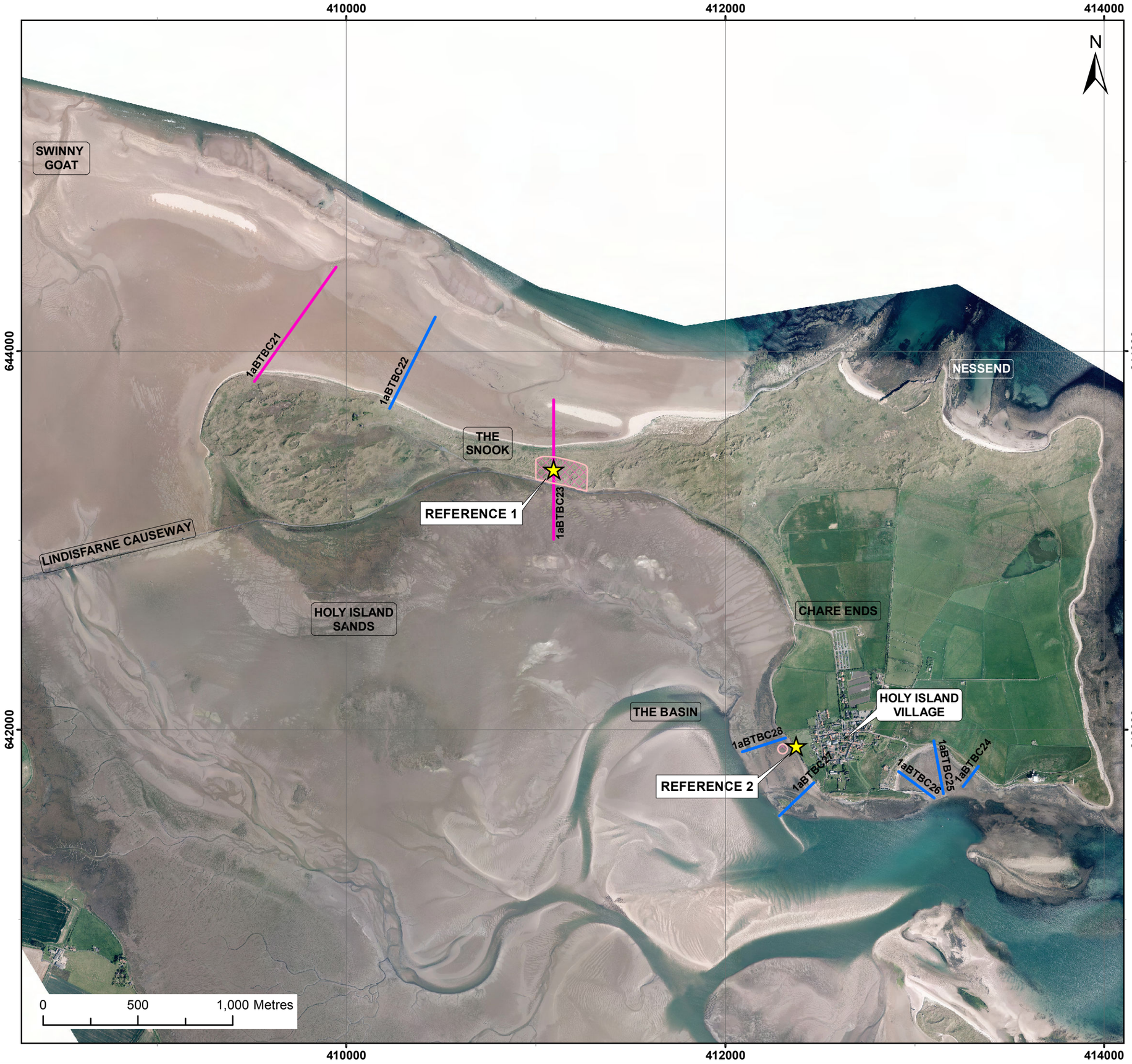
In 2012, the Department of Archaeology at Durham University examined the archaeology of Holy Island through desk-based archival work, a major geophysical survey and additional small scale fieldwork such as a walkover survey. Their work successfully identified a series of potential boundary features which could be related to early medieval monastery on the island (Petts, 2013).

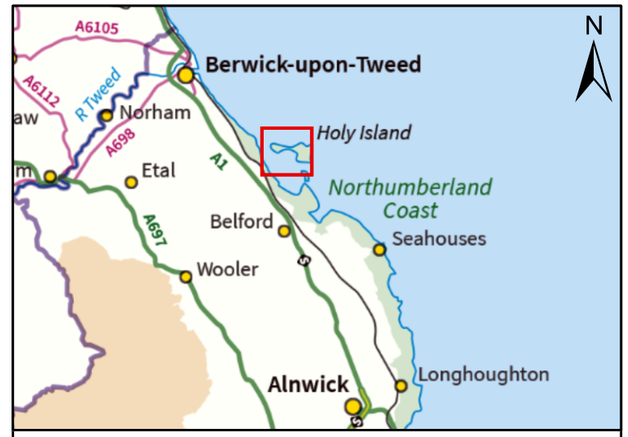
Walkover surveys identified several small 'middens' along the coastline, which are now being actively eroded. Middens are historic dumping sites associated with human activity, ranging from the disposal of domestic household waste to shells used for aquatic harvesting. They were commonly shared by a neighbourhood or community and are useful archaeological tools as they can contain human/animal bones or stone tools, useful for carbon dating (Petts, 2013). These features could date to as early as the Mesolithic, but could also be medieval or post-medieval due to utilisation of maritime resources (Petts, 2013).

The Fort on the Heugh, a scheduled monument located on the south of Holy Island, is built on top of stratified layers of a midden (Historic England, undated). The midden was discovered after coastal erosion opened a scar beneath the Fort, however this has since

been repaired. The lowest layers of the midden, containing animal bones, charcoal and flint waste, are thought to be prehistoric in date (Historic England, undated). A midden, discovered on the coastline close to Jenny Bell's Well, is relatively close (approximately 190 m) to the small Holy Island Sands (Reference 2) historic landfill.

The archaeological survey conducted by the Department of Archaeology at Durham University also identified various features located within the sand dunes on the west of Holy Island, "including a small rectangular enclosure along the Snook on aerial photographic coverage" (Petts, 2013). This rectangular enclosure is potentially the historic landfill identified by Environment Agency (Reference 1), however it requires further investigation on the ground.





Legend

- Reference point
- Historic Landfill Site

Topographic Profile

- Annual
- Bi-Annual

Client:	Project:
Scarborough Borough Council	Cell 1 Coastal Landfill Study

Title: **Location 1: Holy Island**

Figure: 2

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	23/01/2019	TC	AS	A3	1:20,000

Co-ordinate system: British National Grid

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2.1.2 Site Visit

A site visit to Holy Island was undertaken on 11th January 2019 by Alix Scullion and Nick Cooper of RHDHV.

Site reference 1 – Holy Island Shell Road

The inspection commenced along the Snook, where the dune frontage is high and well vegetated with some lower dipping dunes allowing easy access to the historic landfill site at Reference 1. The wrack line was along the toe of the dunes, indicating the extent of high spring tides. There are some areas of blowouts and dune fencing visible in the dunes adjacent to Reference 1, which was in a shallow, panned area approximately 40 m inland from the causeway (**Figure 3**).

Figure 3 Site of Reference 1 located in shallow, panned area of dunes along The Snook, Holy Island

Vegetation in the area was noticeably different to surrounding areas and was predominantly covered in a grey lichen (**Figure 4**). It is believed to be *Cladonia portentosa*, a lichen which favours acidic, sandy heaths and dunes and is common in lowland areas (Silverside, 2016). There is no landfill exposed at the site. To the west of the site, there is a small brickwork feature and flag pole (**Figure 5**), which has been visible since the earliest Google Earth imagery from 2003. The seaward side of the Snook is gently sloping and well vegetated.

Figure 4 Grey lichen *Cladonia portentosa* covering site Reference 1, Holy Island

Figure 5 Brickwork feature present on the western side of site Reference 1, Holy Island

Site reference 2 – Holy Island Sands

The inspection continued along the west of Holy Island to the foreshore of the Basin. No landfill is exposed on the intertidal flats at Reference 2, however, bricks, concrete, ceramics and glass are strewn on the upper beach close to the site (**Figure 6**). It is thought that this material was discarded on the lower beach at Reference 2 and over time has washed onshore, eroding landfill to boulder and cobble sized bricks and ceramics.

The low cliffs backing the upper beach contain partially eroded out bricks and ceramics (**Figure 7**).

Figure 6 Inert landfill comprising bricks, concrete and glass strewn on the upper beach at site Reference 2

Figure 7 Bricks and ceramics partially eroded out of low lying cliffs backing the beach at site Reference 2

2.2 Location 2 – Bamburgh

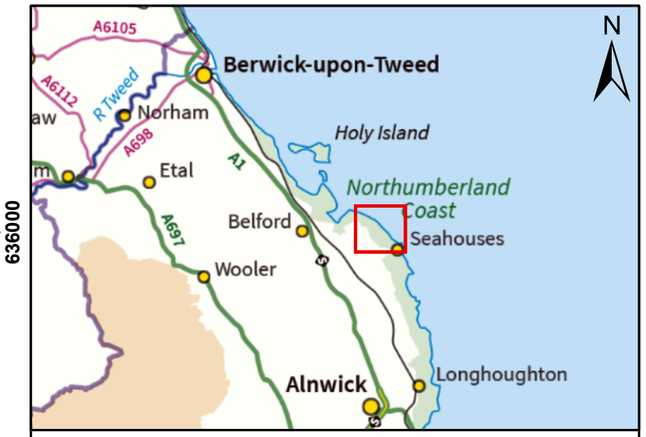
The Dune Tip (Reference 3) and Bowl Hole (Reference 6) sites are located within Bamburgh Dunes in Northumberland (**Figure 8**). Both sites are within the North Northumberland SAC, designated due to the presence of "Embryonic shifting dunes", "Shifting dunes along the shoreline with *Ammophilia arenaria*", "Fixed coastal dunes with herbaceous vegetation", "Dunes with *Salix repens ssp. Argentea*", "Humid dune slacks" and Annex II Petalwort species (JNCCb, undated). Both sites are also within Northumbria Coast SPA and Ramsar site, classified for its wading bird species.

2.2.1 History

Bowl Hole (Reference 6) is a burial ground located approximately 400 m south-east of Bamburgh Castle within a low-lying depression in the coastal dune fields. The burial ground was initially discovered in 1817, when stormy weather eroded a large volume of sand from the top layer of the dunes (Groves *et al*., 2009).

A number of excavations have been conducted since 1894, revealing at least two phases of burial at the site (Groves *et al*., 2009). The excavation of two trenches in the Bowl Hole during 1998 – 1999 discovered several human skeletal remains, dated to between the 6th and 8th century AD (Groves *et al*., 2009). The excavated fill was composed mostly of firm clay – silt with loose sand and some clay lumps, as well as animal bone fragments believed to be buried due to symbolic reasons (Groves *et al*., 2009). The location of these graves beneath a resilient turf layer or at depth suggests that erosion is not an active threat (Grove *et al*., 2009). However, the discovery of human bone eroded from the surrounding ground in the late 1960s implies that the area is prone to periodic erosion events (Northumberland Historic Environment Record 5252). Furthermore, analysis of 19th century Ordnance Survey maps reveal over 100 m of dune formed between the burial site and the high tide mark between c.1860 and c.1900, signifying a highly dynamic coastal environment (Grove *et al*., 2009).

Dune Tip (Reference 3), located 450 m from Bamburgh Castle, has no information available on the Environment Agency website. Bamburgh Castle, once an Anglo-Saxon metalwork production site, contributed significantly to the Northumbrian economy during the 8th to 14th century (Polcrack, 2017). During a series of digs from 2010 – 2013, metalwork waste in "industrial quantities" was uncovered including slag, hammerscale and charcoal (Polcrack, 2017). It is possible that the Dune Tip is also a slag deposit site.



Legend

- Reference point
- Historic Landfill Site

Topographic Profile

- Annual

Client:	Project:
Scarborough Borough Council	Cell 1 Coastal Landfill Study

Title: **Location 2: Bamburgh**

Figure: 8

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	23/01/2019	TC	AS	A3	1:20,000

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2.2.2 Site Visit

A site visit to Bamburgh was undertaken on 11th January 2019 by Alix Scullion and Nick Cooper of RHDHV.

Site Reference 3 – Dune Tip

The inspection commenced on the foreshore and proceeded through the high dunes to Reference 3, located approximately 97 m inland. The dune system contains large hummocks with low-lying marsh and damp hollows (**Figure 9**).

Figure 9 The Dune Tip (Reference 3) overgrown with bramble

Similar to Reference 1, grey lichen *Cladonia* is present at Reference 3 and large parts of the site are overgrown with bramble. General household waste is exposed across the site, including bricks, ceramics and glass and other large household items (**Figure 10** and **Figure 11**). The site appears to be capped with topsoil / sand. No metalwork waste was visible during the site visit.

Figure 10 Household waste present at site Reference 3 amongst bramble

Figure 11 Large item present at site Reference 3

Site reference 6 – Bowl Hole

Reference 6 is located approximately 200 m inland of Reference 3 and was accessed via the wooded area along the Links Road (**Figure 12**). The site is well vegetated with trees and capped with a sandy topsoil. There is no landfill exposed, however, isolated plastic eroding from the topsoil is visible on the seaward facing edge of the site (**Figure 13**).

Figure 12 Path to site Reference 6, accessed via Links Road

Figure 13 Plastic visible eroding out of sandy topsoil at site Reference 6

2.3 Location 3 – Lynemouth Bay

Lynemouth Bay extends between Snab Point in the north and Beacon Point in the south, passing the small, unconstrained, channel of the River Lyne (**Figure 14**). The beaches in Lynemouth Bay experienced extensive tipping of colliery spoil for many decades, resulting in an artificially advanced shoreface, which led to subsequent reclamation and development with the Lynemouth Power Station and coal stocking yard. The backing sea cliffs to the north of the power station and the backing sand dunes to the south became detached from marine processes and currently are stable, relict features, but the colliery spoil beaches in front of them are actively eroding landwards.

Landfill site Reference 7 is located across the northern section of Lynemouth Bay. However, Environment Agency mapping also identifies further landfill sites in the south of the bay and this report considers Lynemouth Bay as a whole, rather than only the site of Reference 7.

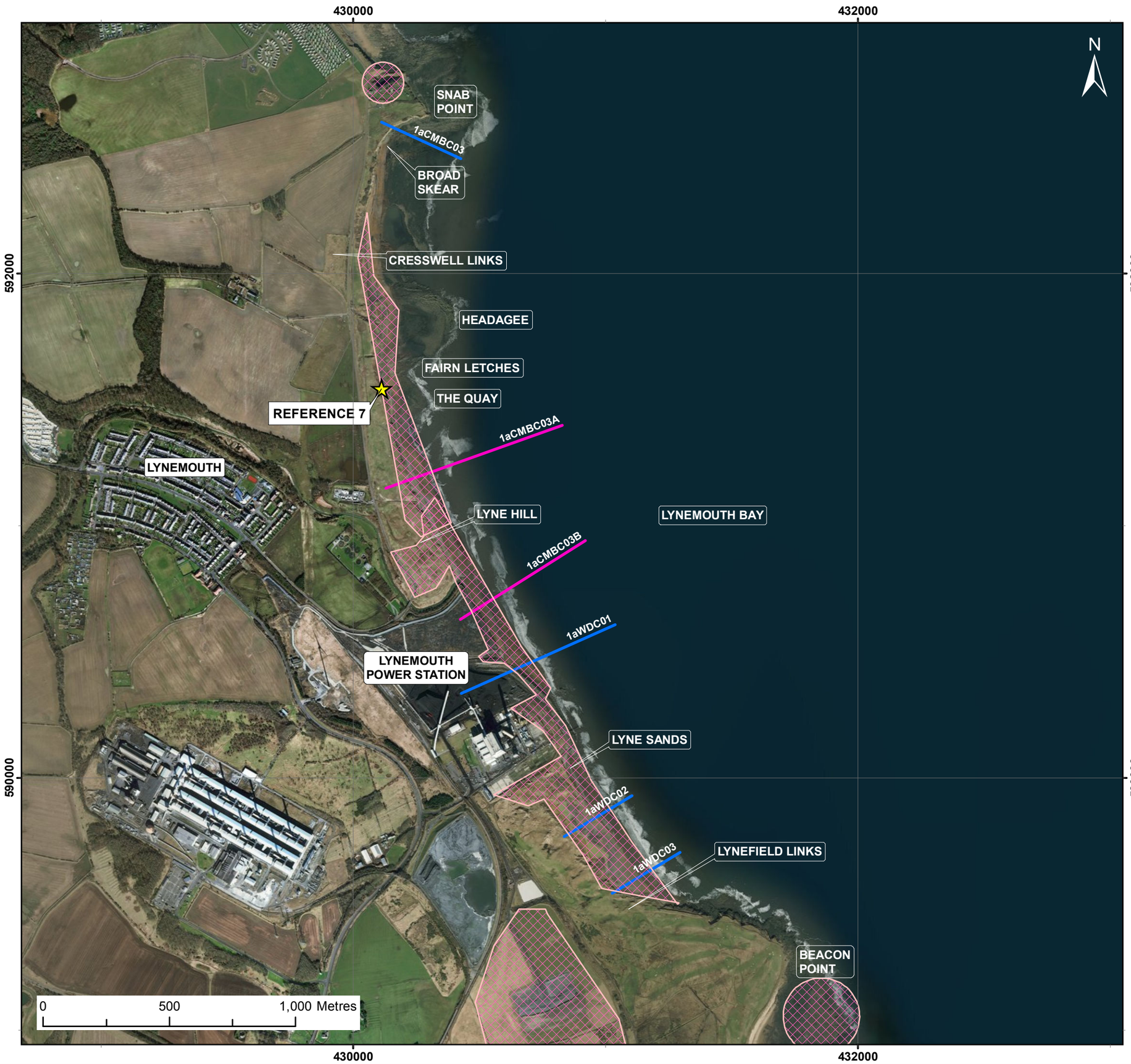
2.3.1 History

Lynemouth Colliery commenced production in 1934 and immediately began tipping waste onto the foreshore. It was later, in 1994, adjoined underground to the older Ellington Colliery, which opened in 1909 and began production in 1911. Ellington Colliery exclusively exploited a number of coal seams which run under the North Sea and by 1986 the colliery was producing approximately 45,000 tonnes of coal per week.

Colliery spoil (minestone) was placed on the beaches at Lynemouth for several decades from 1934, resulting in an artificially advanced beach front (**Figure 15**) that facilitated the subsequent development of Alcan's coal-fired power station on the reclaimed land (now operated by Lynemouth Power Limited). The power station initially provided electricity to the nearby Lynemouth aluminium smelter but, following closure of the smelter in May 2012, it was converted into a biomass power plant.

The advanced beach front was maintained by tipping, which remained ongoing initially until 1995, but was sensitive to tipping volumes. For example, in 1994 minestone placement was temporarily stopped and rapid erosion of around 40m of the beach front occurred during storms in the 1994-95 winter. This led to sea flooding of the Alcan power station and a subsequent construction of rock armour revetment scheme in front of the power station in 1995.

This revetment was subsequently extended between October 2005 and March 2006 around the adjacent coal-stocking yard of the power station. This was needed due to greater reliance being placed on on-site coal stocking around this time because Ellington Colliery (which directly provided coal for the power station) was closed in 2005. Until closure of the colliery, ongoing tipping of waste directly in front of the coal-stocking yard provided some protection, but following cessation of tipping the shore began to erode.



Legend

- Reference point
- Identified RA Sites

Topographic Profile

- Annual
- Bi-Annual

Client:	Project:
Scarborough Borough Council	Cell 1 Coastal Landfill Study

Title:

Location 3: Lynemouth Bay

Figure: 14

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Co-ordinate system: British National Grid

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Figure 15 Deposition of colliery spoil along the foreshore at Lynemouth, creating an artificially advanced beach front

It is noted that a FEPA licence was issued to RJB Mining, the then owners of the re-opened colliery, in 1998 to allow beach tipping at the site to the north (only) of the power station until the originally planned closure date of 31st December 2000. However, earlier in 2000 the closure date for the colliery was set back (by between 1 and 4 years) due to receipt of additional government grants. Consequently, efforts were made at that time to secure a 5-year extension of the FEPA licence. This was supported by an investigation into alternative spoil disposal options by Estelle Warren which concluded that continued minestone placement on the foreshore was not only more viable than land-based disposal, but also continued to provide a coastal protection function and would have little or no 'additional' impact on the already adversely affected coastal and marine biological communities.

At the peak of the recorded tipping, over 1.5m tonnes was tipped and in each year from 1965 to 1983 around 1m tonnes was tipped. In total, it is likely that over 30m tonnes of colliery waste was tipped at Lynemouth over seven decades (Cooper *et al.*, 2017).

In an effort to reverse decades of industrial waste tipping along the foreshore at Lynemouth Bay, Northumberland County Council began Phase One of the Lynemouth Bay Regeneration in 2001 (Morpeth Herald, 2004). The initiative tackled over 45 hectares of surface deposits, costing approximately £1.8 million (Morpeth Herald, 2004).

The Lynemouth Bay Regeneration scheme in its entirety was intended to involve:

- The removal from the Demised Land, see **Figure 16**, of all Polluted Materials;

- The construction upon the Regeneration Site of a salt water lagoon or marshland with associated underground piping and equipment and with earthworks and landscaping on the remainder of the Demised Land including the planting of marram grass, trees and shrubs and thereafter to maintain the same during the Term. [Note: This was constructed but subsequently subsumed by the sea.];

- The landscaping works and the planting of marram grass, trees and shrubs on the Lessors' adjoining land;

- Thereafter to use and occupy the Demised Land for environmental amenity and recreational purposes.

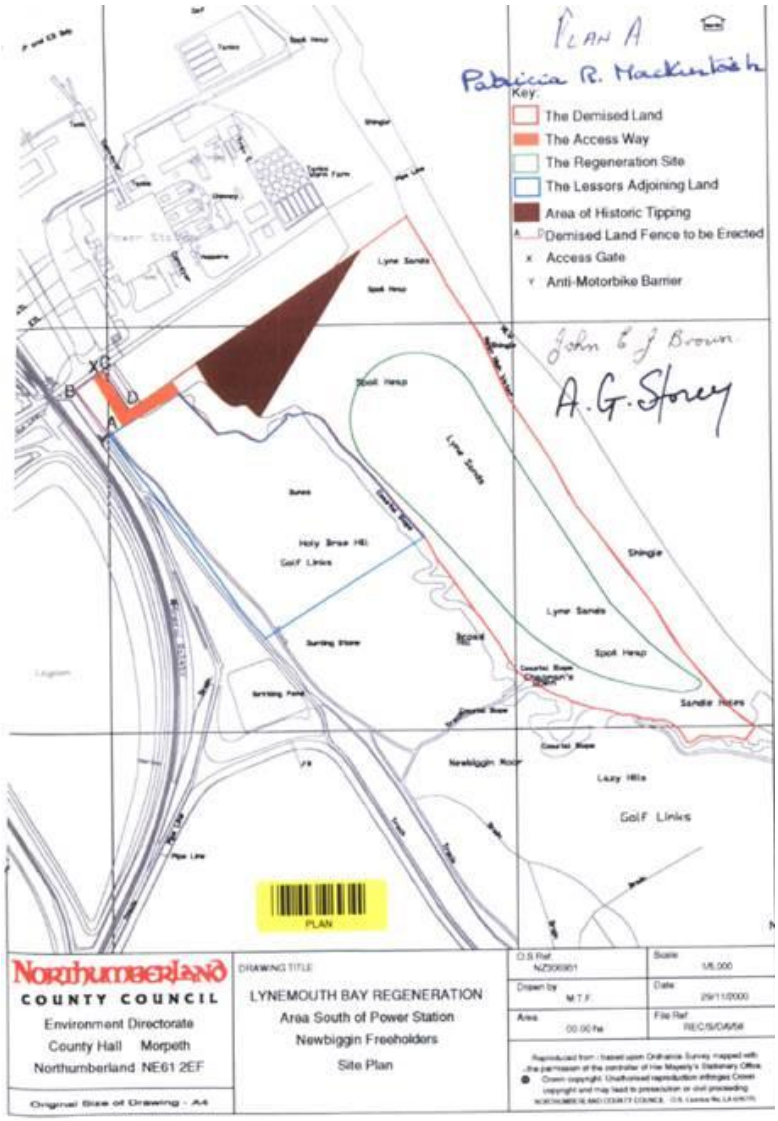


Figure 16 Plan of the Lynemouth Bay Regeneration Scheme, extracted from the Land Lease between Freeholders of Newbiggin-by-the-Sea and Northumberland County Council

With no further budget available, the project has now been terminated after Phase 1.

2.3.2 Site Visit

A site visit to Lynemouth Bay was undertaken on 11th January 2019 by Alix Scullion and Nick Cooper of RHDHV. A further visit was made on 24th January 2019 by Nick Cooper of RHDHV and David Green and Rebecca Croft, both of Northumberland County Council.

On the main visit of 11th January 2019, the inspection commenced in the north of Lynemouth Bay and was accessed via the Cresswell to Lynemouth coastal route. On the subsequent

visit on 24th January, the site was accessed to the south of Lynemouth Power station and proceeded to the mouth of the River Lyne and slightly further north.

Reference 7 is a continuation of the colliery spoil historic landfill present along Lynemouth Bay, which has been actively eroding into the sea for decades. Bricks, coal, glass, rubber tubing and other industrial waste are exposed along the extent of the spoil (**Figure 17** and **Figure 18**) and coal deposits are strewn along the middle to upper beach. The spoil is backed by high, well vegetated dunes.

Figure 17 Landfill seen visibly eroding out of colliery spoil beach at site Reference 7

Figure 18 Rubber tubing and other industrial waste eroding from colliery spoil at site Reference 7

During the second site inspection, undertaken on Thursday 24th January 2019, landfill, including rubber tubing, bricks, concrete and ceramics is visibly eroding from the colliery spoil cliffs at a section of open coastline north of the River Lyne and at another section inside the river mouth (**Figure 19** and **Figure 20**).

Figure 19 Landfill eroding from colliery spoil cliffs along open coastline north of the River Lyne

Figure 20 Landfill such as bricks and metalwork eroding out of the spoil cliffs along the banks of the mouth of the River Lyne

2.4 Location 4 – Spital Point / Links Quarry

The historic landfill site references at Links Quarry (Reference 4) and near Spital Point (Reference 8) are within the same location covering approximately 3.5 ha of open ground and fields (**Figure 21**). They are bounded by Newbiggin Bay in the north, a south-east facing bay bounded by rocky headlands (Church Point in the north and Spital Carrs in the south) and Wansbeck Estuary in the south.

The coastal frontage at the northern end of the site is composed of a low lying Sandstone ridge and rocky platform, with tipped construction waste along the foreshore. The Sandstone ridge continues to the south with an embankment of earth which was constructed in 1995 as an additional sea defence barrier during extremely severe storms (Royal HaskoningDHV, 2015). The earth embankment exhibits slumping in certain sections (Royal HaskoningDHV, 2015). The ridge is fronted by an extensive rocky shore platform. At the southern end of the historic landfill site, the coastal frontage is domainted by a Black Mudstone and Coal layer overlain by high Sandstone cliffs. The Mudstone and Coal are eroding at a faster rate than the Sandstone above, leading to rock falls and topples.

Northumbrian Water's Newbiggin Sewage Treatment Works are located north west of the site, with the Newbiggin Sea Outfall running eastwardly towards Spital Point headland. Both sites are on the boundary of the Northumbria Coast SPA/Ramsar, classified for its wading bird species.

2.4.1 History

Newbiggin-by-the-Sea has undergone chronic coastal erosion since the 1920s, leading to the construction of a series of coastal defence works. The promenade still visible today was built between 1929 and 1932, having undergone repairs due to storm damage in 1984 (North of England Civic Trust, 2008). The height of the crest of the sea wall at the northern end of the bay was increased considerably in 1993 with the construction of a scooped concrete flood defence wall (North of England Civic Trust, 2008). The Southwest Promenade rock revetment was constructed in 1992. The area's mining history is believed to be the cause of subsidence within the bay, estimated to have subsided 1-2 m since the 1960s (Atkins, 1996; 1998). Changes of the seabed level has led to changing wave propagation within the bay and caused erosion of sediment from the beach (Defra, 2005). This process led in 2007 to major engineering works to recharge the disappearing beach with sediment and construct a 200m long breakwater in the middle of the bay (North of England Civic Trust, 2008).

The area surrounding Newbiggin has a long history of sandstone quarrying (onshore and offshore). Quarry voids were infilled with demolition and construction waste, permitted under a number of landfill licenses, and it is believed that this is what has happened at References 4 & 8.

Ground investigations were conducted by Intersoils Limited within the former Links Quarry to assess the vulnerability of the site to current and future erosion by wave action. During two surveys conducted in 2015, 17 driven-in window samples, 19 trial pits and 11 probing holes were undertaken and results were summarised by Royal HaskoningDHV (2015).

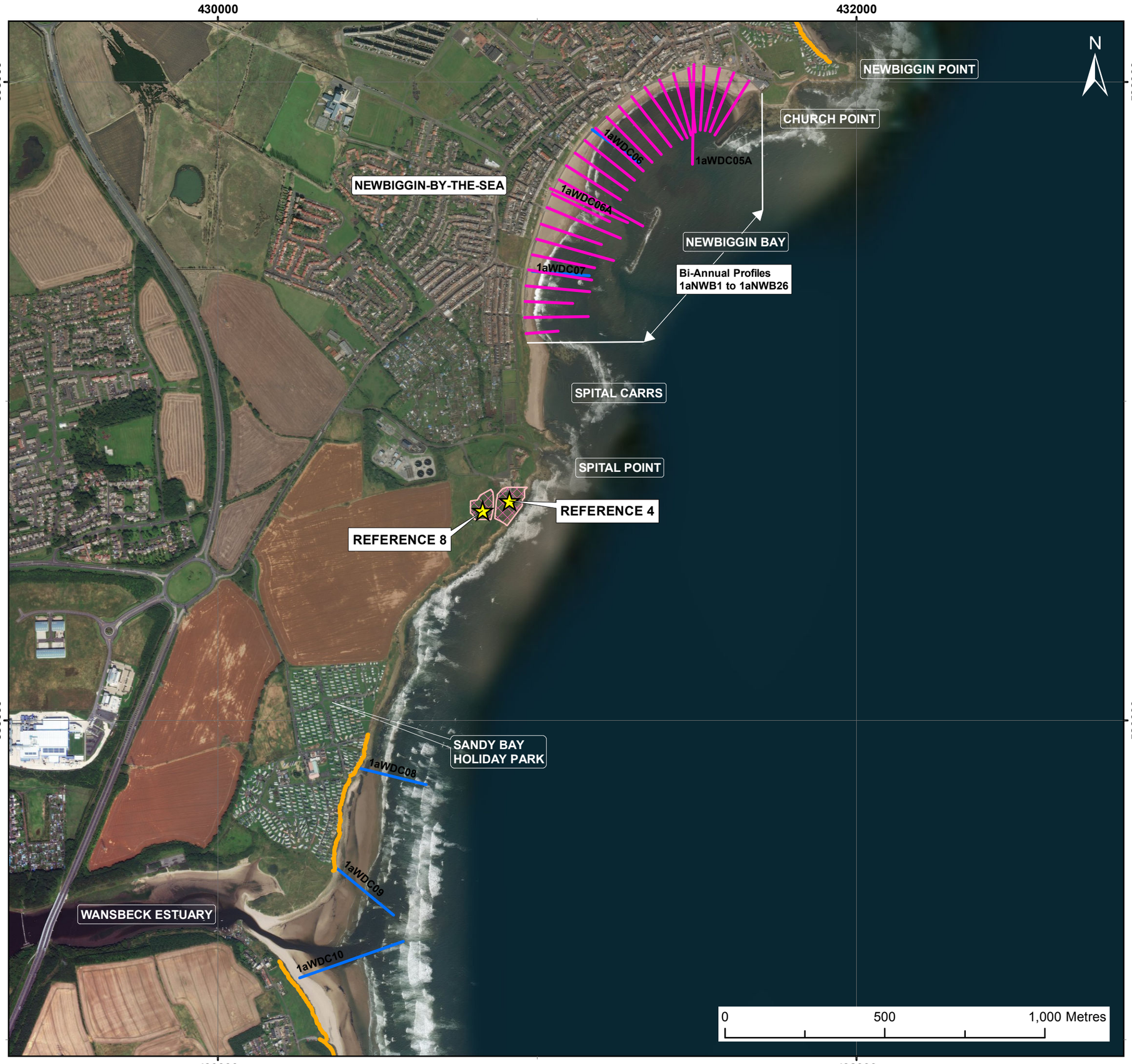
The Links Quarry location was divided into four main areas along the coastal margin;

Area 1: Made ground/topsoil with very dark red brown sand and occasional gravel and cobbles. Also contained rare pieces of glass, concrete and organics. This unit has a thickness ranging between 0.2 - 0.5 m.

Area 2: Made ground, heterogenous in nature containing brown and grey clay and rubble fill with varying proportions of black ash, brick rubble, concrete rubble, dressed stone, rounded boulders of sandstone, wire, cloth, asphalt, wood and plastic. The thickness of this material ranges from 1.0m to greater than 2.6m.

Area 3: Topsoil with a thickness of 0.1 – 0.2m. Made Ground, heterogonous in nature containing brown and grey Clay and rubble fill with varying proportions of black ash, brick rubble, concrete rubble, dressed stone, rounded boulders of Sandstone, wire, cloth, asphalt, wood and plastic. This ranged in thickness with maximum thickness of 4.1m. Isolated beds of grey black ash, comprised of gravels of ash, coke and clinker, also containing plastic and crockery. Sandstone and Mudstone were encountered above the heterogeneous made ground in this area. These isolated deposits could be up to 1m in thickness.

Area 4: 0.1 - 2.0m thick drift deposits red brown sand. 0 – 2.0m layer of broken and weathered Sandstone (Gravel, Cobbles and Boulders).



Legend

- Reference point
- Historic Landfill Site
- Clifftop Survey

Topographic Profile

- Annual
- Bi-Annual

Client:	Project:
Scarborough Borough Council	Cell 1 Coastal Landfill Study

Title:

Location 4: Spital Point / Links Quarry

Figure: 21

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	23/01/2019	TC	AS	A3	1:12,000

Co-ordinate system: British National Grid

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2.4.2 Site Visit

A site visit to Link Quarry was undertaken on 11th January 2019 by Alix Scullion and Nick Cooper of RHDHV.

Site reference 4 – Links Quarry

Links Quarry (Reference 4), now the site of a decorative artstone production facility, is situated on privately owned land and was therefore not accessible, however the historic landfill encompasses the adjacent foreshore which was accessed by a slipway next to the Newbiggin-by-the-Sea Storm Outfall.

The foreshore is littered with concrete rubble and other waste materials from the quarry and further along the coastline, bricks, concrete and plastic are visibly eroding out of the Made Ground cliffs (**Figure 22**).

A Coastal Vulnerability Assessment at Links Quarry undertaken by Royal HaskoningDHV (2015) characterised the sea cliffs as Sandstone, Mudstone and Coal. The typical cliff behaviour at this site is of rock falls and topples due to ongoing undercutting of the Sandstone through the erosion of much weaker Mudstone and Coal layers, particularly where these drop to beach level and become vulnerable to marine erosion in addition to more sub-aerial weathering (Royal HaskoningDHV, 2015). Toppled Sandstone and concrete rubble acts as rock revetment along this section of coastline, reducing the effect of marine erosion.

Figure 22 Foreshore littered with concrete rubble, with bricks, concrete and plastic eroding from Made Ground Cliffs along coastline of site Reference 4

Site reference 8 – Near Spital Point

Historic landfill Reference 8 is adjacent to, and landward of Reference 4. However, it is fenced off and not accessible to the public (**Figure 23**). The landfill is most likely a continuation of the Links Quarry landfill, however no landfill was visible from the England

Coast Path which runs along the southern perimeter of the site. To the north of site Reference 4, the land is being used for grazing.

Figure 23 Site Reference 4 inaccessible during site visit

2.5 Location 5 – Coatham Sands

The historic landfill, adjacent to Redcar Blast Furnace (Reference 9), is situated within the South Gare and Coatham Sands SSSI and adjacent to the Teesmouth and Cleveland Coast SPA and Ramsar site (**Figure 24**). It is one of two known historic landfills along the dunes, the other being Buzzer House located along South Gare peninsula. Buzzer House was identified as an area of infilled ponds/military land, but was not highlighted by the previous Cell 1 Contamination Study as a priority for further investigation. Coatham Sands has been strongly influenced by historic deposition of slag from local ironworks and is, in places, a mixture of slag deposits and natural marine deposited and wind-blown sand (Royal HaskoningDHV, 2018).

2.6.1 History

Coatham Sands, North Yorkshire, is close to the site of the former Teesside Steelworks - a continuous stretch of steelworks that existed along the south bank of the River Tees from Middlesbrough to Redcar. At its height, there were 91 blast furnaces within a 10-mile radius of Redcar.

The South Gare peninsula is a breakwater built on reclaimed land on the southern side of the mouth of the River Tees. It was created using 5 million tonnes of blast furnace slag and 18,000 tonnes of cement supplied by local blast furnaces (Davies, 2014).

In January 2017, stormy conditions eroded parts of Coatham Dunes and revealed former landfill with a “brick and masonry underbelly” (BBC, 2017). The storms initiated a stand-alone study by Royal HaskoningDHV facilitated through the Cell 1 Regional Coastal Monitoring Programme. Findings are reported in the Cell 1 Coatham Dunes Report 2018 (Royal HaskoningDHV, 2018).

2.6.2 Site Visit

As the site was previously visited during the stand-alone study in 2018 it has not been re-visited specifically for the present study. From previous field visits it is known that the historic waste material has become exposed on the seaward face of the dunes in the Majuba area where the covering of blown sand is absent, but this is not visible from the aerial photography.

Legend

- Reference point
- Historic Landfill Site

Topographic Profile

- Annual
- Bi-Annual

Client:	Project:
Scarborough Borough Council	Cell 1 Coastal Landfill Study

Title: **Location 5: Coatham Sands**

Figure: 24

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	24/01/2019	TC	AS	A3	1:20,000

Co-ordinate system: British National Grid

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2.5 Location 6 – Area G East of Horden

This historic landfill site east of Horden is within the Durham Coast SAC (390 ha), which represents the only vegetated sea cliffs on Magnesian limestone exposures in the UK (**Figure 25**). The cliffs consist of a unique vegetation of "paramaritime, mesotrophic and calcicolous grasslands", "tall-herb fen", "seepage flushes" and "wind-pruned shrub" (JNCCc, undated).

Although there is no information available from the EA website on this specific site, it is believed to be part of the Horden Colliery site, an area known to have been fouled with waste dumped from mines and with raw sewage deposited by the pit villages (Somerville, 2005).

2.5.1 History

Sinking of the Horden Colliery commenced in 1900, creating one of the largest mines in the country, primarily focused on working under-sea coal reserves. At its peak in 1935, the colliery employed 4,342 men and produced over 1.5 million tonnes of coal a year. The colliery closed in February 1987.

Colliery waste has been dumped on the beaches and sea bed off County Durham's coastline since as early as Victorian times (**Figure 26**). The number of dumping sites increased up to the 1920s and subsequently, after the Second World War, increased mechanisation led to substantial increases in production of coal and associated colliery waste. The disposal of waste at Horden and Blackhall was tipped directly on the beach from aerial flights.

Much of the tipping occurred prior to the introduction of environmental regulation and therefore went undocumented. Records of colliery spoil volumes being tipped at locations along the County Durham coastline (and also volumes being tipped at the offshore dump sites) began in 1976, following enactment of the Disposal at Sea (DAS) Act in 1974. It has previously been estimated that by 1970, around 40m tonnes of colliery waste was tipped in total on the County Durham beaches (HR Wallingford, 1970). At the peak of tipping, over 2.5m tonnes of waste was tipped in one year.

Following the decision that colliery waste tipping was ending, Durham County Council and Easington District Council produced a management plan in 1982 which advocated policies for cleaning-up the beaches. Some policies were implemented but beach tipping continued. Finally, in 1990, it was confirmed that the authorities would not renew licences for dumping waste and colliery tailings after 1995. After this decision was taken, tipping on the County Durham coastline actually stopped in 1993 as a result of closure of the pits.

Following cessation of tipping, marine erosion began the process of naturally removing spoil from the beaches, to bring them back to their natural position over future decades. Then, as part of the drive towards giving East Durham a more attractive environment and making it into a location in which new industry will wish to invest and people will choose to live and visit, the *Turning the Tide* project was introduced, aimed at accelerated efforts to restore the coastline to its former glory, including re-creation of a grandeur landscape and rich and diverse wildlife.

Legend

- Reference point
- Historic Landfill Site

Topographic Profile

- Annual
- Bi-Annual

Client:	Project:
Scarborough Borough Council	Cell 1 Coastal Landfill Study

Title:

Location 6: Area G East of Horden

Figure: 25

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	24/01/2019	TC	AS	A3	1:15,000

Co-ordinate system: British National Grid

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Figure 26 Colliery waste dumped on foreshore at Horden, Co. Durham

Turning the Tide was a partnership of 14 organisations that commenced in July 1997 and ran until March 2002. It received £10.5m of funding from various sources (£4.5m from Millennium Commission and contributions from English Partnerships, Countryside Agency, Durham County Council, District of Easington Council, Northumbrian Water, and European Regional Development Fund grant).

The aims of the project were to:

- restore, enhance and conserve the environmental quality of the Durham Coast;
- encourage sustainable use and enjoyment of the Durham Coast;
- rekindle social pride and a sense of ownership of the Durham Coast.

These aims were delivered through a co-ordinated programme comprising four inter-linked elements spread along the 18km length coastline of County Durham. In total over one hundred projects were delivered, within the following themes:

1. **Improving the Beaches** – based on the removal of derelict structures (conveyors and the concrete towers), debris and rubbish from the beaches, to enable their rejuvenation as attractive destinations for visitors.

2. **Removal of Colliery Spoil** – involving the removal of remaining spoil heaps at Easington and Horden, with over 1.3m tonnes of spoil material spread over the sites, capped and covered with top soil to create public open space at Easington and for habitat creation at Horden.

3. **Nature Conservation Landscape Enhancement** – with tree and shrub planting, the creation of limestone grassland on cliff tops to restore the area to the conditions that existed before the coal mines were developed.

4. **Coastal Recreation and Access** – including provision of new cliff top pathways and cycle tracks and artworks to encourage greater enjoyment of the coast by the local community and visitors, and accompanied by an extensive marketing campaign to

inform the public of the attractiveness of the coast, and to provide information in the history and heritage.

The work of the *Turning the Tide* project is being continued by the Durham Heritage Coast Partnership. For example, in 2006 a grant of £340k from the Heritage Lottery Fund was used at Nose's Point to improve access, seating, signs and information panels.

The historic landfill highlighted east of Horden, encompassing a wooded area known as Blackhills Gill, and is located approximately 200m from the coastline. At present, colliery spoil along the adjacent foreshore provides protection against cliff line erosion. Consequently, the current rate of erosion does not pose an immediate risk to the historic landfill. Therefore, **Location 5 is omitted from further investigation**. However, as infilling appears to be over a stream, erosion by fluvial processes are a greater issue and would require ongoing monitoring since release of any landfill materials into the Gill could ultimately affect the quality of coastal waters.

3. Historic Trend Analysis

The purpose of the Historical Trends Analysis (HTA) is to review historic maps and aerial photographs to determine changes in land use and coastal erosion at the top-ranked sites of historic land contamination which may present a risk to coastal waters.

All available aerial photos (historic and contemporary) from the Cell 1 Regional Coastal Monitoring Programme were downloaded from the North East Coastal Observatory website and viewed 'side by side' in ArcGIS to identify, describe and, where sufficient coastal change exists, quantify changes in the coastlines.

In addition, the selection of historic maps that is available from the National Library of Scotland website (which contains historic maps for the whole of the UK) was viewed on-screen for similar changes. [Note that the historic maps are not reproduced in this report due to copyright reasons].

The following table (**Table 2**) shows the year and source of historic maps and aerial imagery used for historic trend analysis at each location.

Table 2 Range of historic maps and aerial imagery incorporated into HTA

Location	Years Available	Source
1 – Holy Island	OS Mapping One Inch, 1885 – 1903 OS Mapping Six Inch, 1888 – 1913 & OS Mapping 25 Inch, 1892 - 1914 OS Mapping 1:25,000, 1937 – 1961 & OS Mapping One Inch 7th Series, 1955 – 1961 Note: Aerial Photography 1940 not available Aerial Photography 2003, 2006, 2007, 2011, 2018 Aerial Photography 2010, 2015, 2017	National Library of Scotland National Library of Scotland National Library of Scotland Channel Coast Observatory Google Earth North East Coastal Observatory
2 – Bamburgh	OS Mapping One Inch, 1885 – 1903 OS Mapping Six Inch, 1888 – 1913 & OS Mapping 25 Inch, 1892 - 1914 OS Mapping 1:25,000, 1937 – 1961 & OS Mapping One Inch 7th Series, 1955 – 1961 Aerial Photography 1940 Aerial Photography 2002, 2003, 2006, 2007, 2018 Aerial Photography 2010, 2015, 2017	National Library of Scotland National Library of Scotland National Library of Scotland Channel Coast Observatory Google Earth North East Coastal Observatory
3 – Lynemouth Bay	OS Mapping 1865, 1966, 1980-89 Aerial Photography 1940 Aerial Photography 2002, 2006, 2007, 2013, 2015, 2017	Landmark Channel Coast Observatory Google Earth
4 – Spital Point / Links Quarry	OS Mapping One Inch, 1885 – 1903 OS Mapping Six Inch, 1888 – 1913 & OS Mapping 25 Inch, 1892 - 1914 OS Mapping 1:25,000, 1937 – 1961 & OS Mapping One Inch 7th Series, 1955 – 1961 Aerial Photography 1940 Aerial Photography 2002. 2006, 2009, 2013 Aerial Photography 2010, 2015 (incomplete), 2017	National Library of Scotland National Library of Scotland National Library of Scotland Channel Coast Observatory Google Earth North East Coastal Observatory
5 – Coatham Sands	OS Mapping One Inch, 1885 – 1903 OS Mapping Six Inch, 1888 – 1913 & OS Mapping 25 Inch, 1892 - 1914 OS Mapping 1:25,000, 1937 – 1961 & OS Mapping One Inch 7th Series, 1955 – 1961 Aerial Photography 1940, 1999, 2009, 2010, 2012, 2015, 2017	National Library of Scotland National Library of Scotland National Library of Scotland North East Coastal Observatory

In addition, and where applicable, beach monitoring data from the Cell 1 Regional Coastal Monitoring Programme were also interpreted for changes in the coastlines over contemporary timescales**.**

3.1 Location 1 – Holy Island

3.1.1 Historic Maps

OS One Inch, 1885 – 1903

In the first available historic map, the morphology of the western "tail" end of Holy Island, known as the Snook, is significantly narrower than present day. The greatest change is the extent of the dunes on the north facing Snook (particularly towards where the Snook connects to the island), which have prograded significantly since the earliest map.

The stream (named Swinny Goat in subsequent maps) to the north west of the tail of Holy Island has migrated and is more sinuous compared to present day. In modern imagery, the stream dissects the "Sand Ridge" further north west, extending the area of inter-tidal sands and mud flats to the north west.

The present-day Lindisfarne Causeway roughly follows the mean high water (MHW) mark of the 1885 – 1903 map along the south of the Snook and around the tail to the west. The causeway is not visible in the early map, as it was not constructed until the mid-1950s. Instead, a double dotted line transects the intertidal Holy Island Sands from the mainland to "Chare Ends" on the island. This line of upright poles represents the Pilgrims Way, an access route across the intertidal sands and mudflats used for the last 1,300 years.

The MHW mark along the south of the Snook is undulating towards the bulbous tail, indicating uneven topography. This line is smoother in more recent maps, suggesting a change in topography.

The MHW mark generally follows present day shoreline morphology towards Holy Island village (close to Reference 2 in The Basin), however, in places the historic MHW mark was more seaward than present day, indicating net recession of the shoreline in this area.

OS Six Inch, 1888 – 1913 & OS 25 Inch, 1892 – 1914

The improved scale of the OS six inch maps from a similar period shows the Swinny Goat in a similar position to earlier maps.

The MHW mark along south of the Snook is more landward than earlier mapping, indicating net erosion of the southern side. However, the north of the Snook has prograded slightly since earlier mapping.

The MWH mark of the main island is roughly similar to earlier mapping, but does show some erosion and progradation in sections of the west facing coastline close to Holy Island village.

OS 1:25,000, 1937 – 1961 & OS One Inch 7th Series, 1955 – 1961

By the time of this map, the Swinny Goat appears to have migrated to flow parallel to the Snook. The MHW mark on the north side of the Snook has moved significantly landward and is now in line with vegetation, suggesting erosion along this side. Conversely, MHW mark has moved significantly seaward (particularly in the west where the Snook connects to the bulbous tail) along the south of the Snook, indicating accretion along this side. There is no large change in MHW mark between both maps along The Basin close to the village.

The vegetation line has remained roughly similar from earlier mapping, except on the north where the Snook connects to the island, where it has prograded and is roughly similar to present day configuration.

A rectangular feature amongst the dunes along the Snook is now visible on both maps where Reference 1 historic landfill site is located.

3.1.2 Aerial Imagery

In 2003 aerial imagery of the shoreline close to Reference 1, Lindisfarne Causeway remains in the same configuration as most recent image taken in 2018. Reference 1 historic landfill site is located among the dunes north of the causeway along the Snook and is visible as a rectangular feature in all images of the island. The narrowest point (from the vegetation line in the north to the vegetation line in the south) along the Snook in 2003 is approximately 126 m in width. There are several blowouts visible among the dunes, with two on the north east of the Snook measuring approximately 38 m and 30 m in width.

There is no discernible change of shoreline configuration close to Reference 2 between 2003 and 2018 imagery.

By the time of the next available imagery in 2006, there had been significant progradation of the narrowest point along the Snook of approximately 14 m. Both blowouts had not changed size. Embryo dunes had begun to fill in the troughs along the undulating shoreline adjacent to the blowouts.

There is no discernible change of shoreline configuration close to Reference 2 between 2003 and 2006 imagery.

The shoreline along the north of the Snook prograded from 2006 to 2007 by approximately 5 m to a width of 145 m. The two blowouts had not changed size. There was further growth of embryo dunes adjacent to the blowouts.

There is no discernible change of shoreline configuration close to Reference 2 between 2007 and 2006 imagery.

Between 2007 and 2010, the shoreline along the north of the Snook had prograded another 2 m to 147 m in width. The larger of the two blowouts visible on the north east of the Snook had not changed, however, the smaller blowout to the right had begun to show vegetation cover. There was further growth of embryo dunes adjacent to the blowouts, beginning to “straighten out” the shoreline.

There is no discernible change of shoreline configuration close to Reference 2 between 2010 and 2007 imagery.

Between 2010 and 2011, the shoreline along the north of the Snook had prograded another 5 m to 152 m in width. The larger of the two blowouts visible on the north east of the Snook had not changed, however, the smaller blowout to the right was increasingly vegetated. Images of embryo dunes adjacent to the blowouts are poor due to shadowing, however, their position remains roughly the same.

There is no discernible change of shoreline configuration close to Reference 2 between 2011 and 2010 imagery.

Between 2011 and 2015, the shoreline along the north of the Snook had prograded another 5 m to 157 m in width. The larger of the two blowouts visible on the north east of the Snook had not changed, however, the smaller blowout to the right had almost completely recovered. Embryo dunes adjacent to the blowouts had prograded further north.

There is no discernible change of shoreline configuration close to Reference 2 between 2015 and 2011 imagery.

The shoreline along the north of the Snook remained approximately the same width between 2015 and 2017 (157 m). The smaller blowout had completely recovered and another large blowout to the east had begun to show recovery. Embryo dune position adjacent to the blowouts remained roughly in the same configuration as 2015.

There is no discernible change of shoreline configuration close to Reference 2 between 2017 and 2015 imagery.

Between 2017 and 2018, the shoreline along the north of the Snook prograded 6 m to its most recent configuration (163 m in width). Over the 15-year period (2003 – 2018) of aerial imagery, the narrowest distance between shorelines along the Snook close to Reference 1 prograded by a total of 37 m. The small blowout north east of Reference 1 has complete vegetation cover and another blowout to the east has also begun to show recovery. The shoreline adjacent to the blowouts has prograded approximately 150 m north since 2003 (**Figure 27**).

Additionally, the area cut out of the dunes along the causeway adjacent to Reference 1 has shown increasing vegetation cover over the 15 year period.

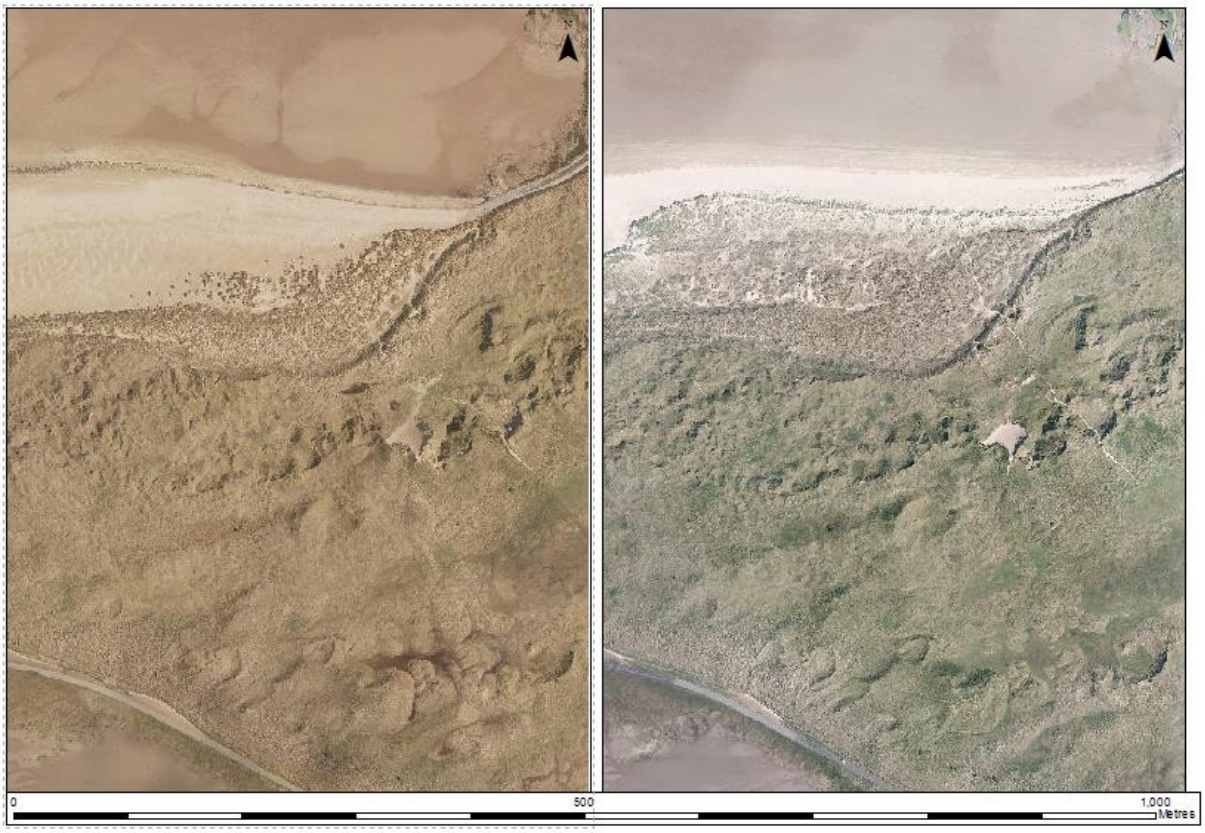

Figure 27 Progradation of embryo dunes along the north of the Snook between 2010 (left) and 2017 (right)

3.1.3 Cell 1 Regional Coastal Monitoring Programme

Holy Island is covered by eight beach profile lines for the Full Measures surveys (**Figure 2**). Profiles 1aBTBC21 to 1aBTBC23 are located on the northwest side of the island, along The Snook. 1aBTBC24 to 1aBTBC28 are located on the south side of the island in the vicinity of the castle and priory. 1aBTBC27 extends out to and across the small island upon which the remains of a chapel stand.

Since monitoring began on Holy Island in 2002, the overall change seen from the southern four profiles has been negligible, with the dunes and beach retaining the same form and position over time.

The three profiles along the Snook have shown marked progradation of the dune front since 2002. Profile 1aBTBC21 has advanced by c.20 m through the accumulation of nearly 2 m of sand and profiles 1aBTBC22 and 1aBTBC23 have shown a similar trend, although it is less pronounced.

The 2018 Walkover Inspection reported well-vegetated dunes at Snook Point, but did not specifically comment on the dunes at Reference 1. At Reference 2, the inspection reported locally active low cliffs along several lengths of the Basin, bare of vegetation and with occasional slumps (although these had not appeared to have worsened since the previous inspection in 2016). South of the Basin, the cliffs were reported as mostly stable with small section of erosion. There was no noticeable change to the beach, which has remained stable since the 2008 inspection.

These results corroborate HTA, that the dune front close to Reference 1 has prograded and the coastline along the Basin close to Reference 2 has remained stable over time. Overall, the recorded profiles and topographic surveys have presented no cause for concern.

3.2 Location 2 – Bamburgh

3.2.1 Historic Maps

OS One Inch, 1885 – 1903

In the first available historic map, the morphology of the coastline between Harkess Rocks, north of Bamburgh Dunes and Carr End in North Sunderland is significantly different to present day imagery. There has been significant growth of dunes along the Bamburgh frontage and in some sections along Shoreston Links towards Sunderland (approximately 100 m).

OS Six Inch, 1888 – 1913 & OS 25 Inch, 1892 – 1914

The improved scale of the OS six inch mapping from a similar period shows the MHW mark in a similar position along Bamburgh Dunes frontage as previous mapping, however its position is significantly seaward along Shoreston Links south east of Bamburgh, indicating accretion in this area.

The "Old Danish Burial Ground" appears within the Bowl Hole and the area close to the Dune Tip site is noted as a peak within the dunes.

OS 1:25,000, 1937 – 1961 & OS One Inch 7th Series, 1955 – 1961

There is no significant change in position of MWHM along Bamburgh Dunes or Shoreston Links between these maps and previous maps. There is progradation of the vegetation line in sections along the Bamburgh frontage, particularly where the coastline changes orientation towards the south east. There is no significant change in vegetation along Shoreston links towards North Sunderland.

Even at this time, vegetation immediately adjacent to Bamburgh Castle is landward of present day position, indicating further progradation since 1955 – 1961. As the coastline switches orientation to south east towards North Sunderland, the vegetation line is more similar to its present-day position.

3.2.2 Aerial Imagery

There has been significant progradation of the dunes at Bamburgh between 1940 and present day (**Figure 28**). This is most noticeable close to the castle, where the dunes have prograded by approximately 60 m, and at Shoreston Links, where the dunes have prograded by approximately 83 m. Dunes appear potholed with blowouts in 1940, becoming infilled with vegetation by present day. The Dune Tip (site Reference 3) is approximately 81 m from the shoreline in 1940, whereas it is 97 m from the shoreline in most recent aerial imagery in 2018. The historic landfill at Bowl Hole (site Reference 6) is located among the dunes on the north-eastern perimeter of a wooded area along Links Road. The site is indistinguishable from aerial imagery. A large circular blowout is present within the dunes close to Bamburgh Castle, measuring 47 m in diameter.

In imagery of 2002, The Dune Tip site is located 95 m from the shoreline and the large circular blowout now measures approximately 37 m in diameter.

Moving southward (where coverage of 2002 imagery ceases and 2003 imagery begins), the vegetation remains in a similar position over time due to the dissipation of high energy

waves by intertidal rocks (“Greenhill Rocks” and “Monkshouse Rocks”). South of this section, along Shoreston Links, vegetation progrades approximately 17 m from 2003 – 2007. From 2007 – 2018, some sections erode by approximately 4 m, but no other change is noted.

By 2006, there is no discernible change at the Bamburgh Dune frontage or along the coastline until Shoreston Links towards North Sunderland, where small progradation has occurred (by approximately 10 m in some sections). A rectangular clearing (8 x 17 m) appears within the Bowl Hole site. This is ascribed to a geophysical survey conducted by the Archaeology Department at Durham University (Keys to the Past, undated).

There is no discernible change between 2006 and 2007.

By 2007, the rectangular clearing visible at the Bowl Hole site in 2006 has disappeared and become vegetated once again.

There is no discernible change in shoreline configuration between 2007 and 2010 / 2012, however, the large blowout close to Bamburgh Castle decreases in width to 29 m and becomes narrower in shape.

In images from 2015, the blowout to the west of the Dune Tip site is now vegetated and is indistinguishable from aerial images. Embryo dunes along Bamburgh Dunes have receded by approximately 12 m in some sections.

There is no discernible change in shoreline configuration along the remaining coastline between 2010 / 2012 and 2015.

By 2018, the large blowout close to Bamburgh castle has become vegetated at either side and now measures 27 m in width. There is no change at other blowouts within the dunes and shoreline configuration has not changed from 2017.

Figure 28 Dune frontage at Bamburgh in 1940 (left) and 2017 (right) with site Reference 3 in pink

Figure 29 Dune frontage at Bamburgh in 2010 (left) and 2017 (right) with site Reference 3 in pink

3.2.3 Cell 1 Regional Coastal Monitoring Programme

Bamburgh dunes are covered by one beach profile line for the Full Measures survey, however no profiles are recorded along Shoreston Links. Profile 1aBTBC29 is located approximately 750 m south-east of Bamburgh Castle. Since the beginning of monitoring, the dunes at this profile have not changed significantly and appear to be stable. The beach shows a redistribution of sediment over time, smoothening out the profile. The lowest beach levels were recorded during the period of the 'exceptionally' stormy winter of 2013/14, but had largely recovered by winter 2014.

There are insufficient profiles along the Bamburgh dune frontage or Shoreston Links to corroborate HTA, however, the location of profile 1aBTBC29 conforms to HTA in that there was little discernible change seen over the period of contemporary imagery (2002 – 2018).

The recorded profiles at Bamburgh have presented no cause for concern.

3.3 Location 3 – Lynemouth Bay

Lynemouth Bay was the subject of a previous Historical Trend Analysis by Royal HaskoningDHV (2014). For the study, digital historic maps were purchased at 1:10k scale from Landmark covering the dates 1865, 1966 and the period 1980-89. These were orthorectified and compiled as ArcReader files for viewing and the historic mapping was compared with 2014 OS maps to depict areas of change along the frontage.

3.3.1 Historic Maps

In the 1865 map, Snab Point headland at the northern end of Lynemouth Bay was in the same position and form as in the present day, with the foreshore rock outcrops of Broad Skear, Headagee, The Quay and Lyne Skear all well-defined in front of Cresswell Links which extended southwards along the frontage to the mouth of the River Lyne. Between these foreshore rock outcrops are Headagee Hole, Fairn Leiches and Lishey Hole. The River Lyne flowed to sea to the immediate south of Lyne Hill and immediately offshore from the mouth a small gravel bank was apparent. South of the mouth, the shoreline was characterised by Lynfield [sic] Links, Holy Brae Hill and Broad Hill, which extended southwards to meet the Beacon Point headland.

By 1966, the shape of the coastline south of Broad Skear had changed dramatically, with sediment infilling the foreshore hollows and covering much of the foreshore rocky outcrops to the north of the River Lyne. The line of mean high water prograded seawards markedly through the whole bay, most especially in the vicinity of the mouth of the River Lyne and in Lyne Sands to the south, due to tipping of considerable quantities of colliery spoil. Two conveyors were marked as being present north of Lyne Hill. At Lyne Hill, the high water mark moved 125 m seaward. At Lynemouth Cottage, at the northern end of Lyne Sands, just south of the mouth, the progradation was in excess of 400 m. Further south along Lyne Sands, the high water marked moved seaward, leaving Lynefield Links, Holy Brae Hill and Broad Hill stranded.

By the 1980-89 mapping, the shoreline had prograded further through the whole bay, but again most markedly between Lyne Hill and the Beacon Point headland. At the point of greatest change, in the immediate vicinity of the mouth of the River Lyne, the high water mark moved seawards by around a further 115 m compared to the 1966 mapping, marking a progradation of just under 500 m at this point since 1865. By this time, Lynemouth power station had been constructed on reclaimed land at the northern end of Lyne Sands, coving part of Lynefield Links and part of the spoil beach.

By the time of the present-day OS mapping, the high water line had retreated landward by around 25 m at the point of discharge of the River Lyne and by a similar distance immediately in front of the power station.

3.3.2 Aerial Imagery

In aerial imagery from 1940, Snab Point is in a similar position and form as present day. Further south, the aluminium smelter is visible, however the Power Station has not yet been constructed. At the location of the current Power Station, dunes are degraded with several blowouts and there is are double parallel lines of what are believed to be anti-tank obstacles present along the shoreline (**Figure 30**).

In aerial imagery taken in 2002, colliery spoil tipping is evident, with a network of vehicle tracks along ‘slag banks’ along the bay. Black spoil is visible on the foreshore. ‘Demised Land’ south of the power station is beginning to undergo redevelopment as part of the

Lynemouth Regeneration scheme, with a golf links evident on the land. A traveller's camp is present on the slag banks opposite Lynemouth. A rock revetment (approximately 230 m) is present protecting the station.

There is no significant change in shoreline position south of Snab Point between 2002 and 2006. Vehicle tracks onto the foreshore and the travellers camp adjacent to Lynemouth have largely disappeared following closure of the colliery and cessation of tipping in 2005. The vegetation line has not significantly changed since 2002.

Spoil on the foreshore between Lynemouth and south of the Power Station has eroded up to 13 m in places. The rock revetment had extended to the north to surround the entire power station (now measuring approximately 580 m).

By 2007, spoil on the foreshore between Lynemouth to the south of the Power Station has continued to erode by up to 11 m in places.

Images of 2013 are poor resolution, however slag appears to have continued to erode north and south of the Power Station.

Imagery from 2015 show the shoreline south of Snab Point until the slag bank adjacent to Lynemouth has not changed significantly since 2007, with some sections of minor erosion. North of the power station, there has been a significant landward erosion of spoil since 2006 / 2007, by up to 20 m in some sections. To the south of the power station, some sections of the spoil cliff appear to have slumped.

By 2017 there has been further erosion of the slag cliff north (c.10 m) and south (c.20 m) of Lynemouth Power Station (**Figure 31** and **Figure 32**), corroborated by the Coastal Inspection Report (2016) which describes "continuous erosion of the spoil cliff between the Power Station and Beacon Point".

Figure 30 Site of Lynemouth Power Station in 1940 (left) and 2017 (right)

Figure 31 Colliery spoil erosion north of the power station in 2010 (left) and 2017 (right)

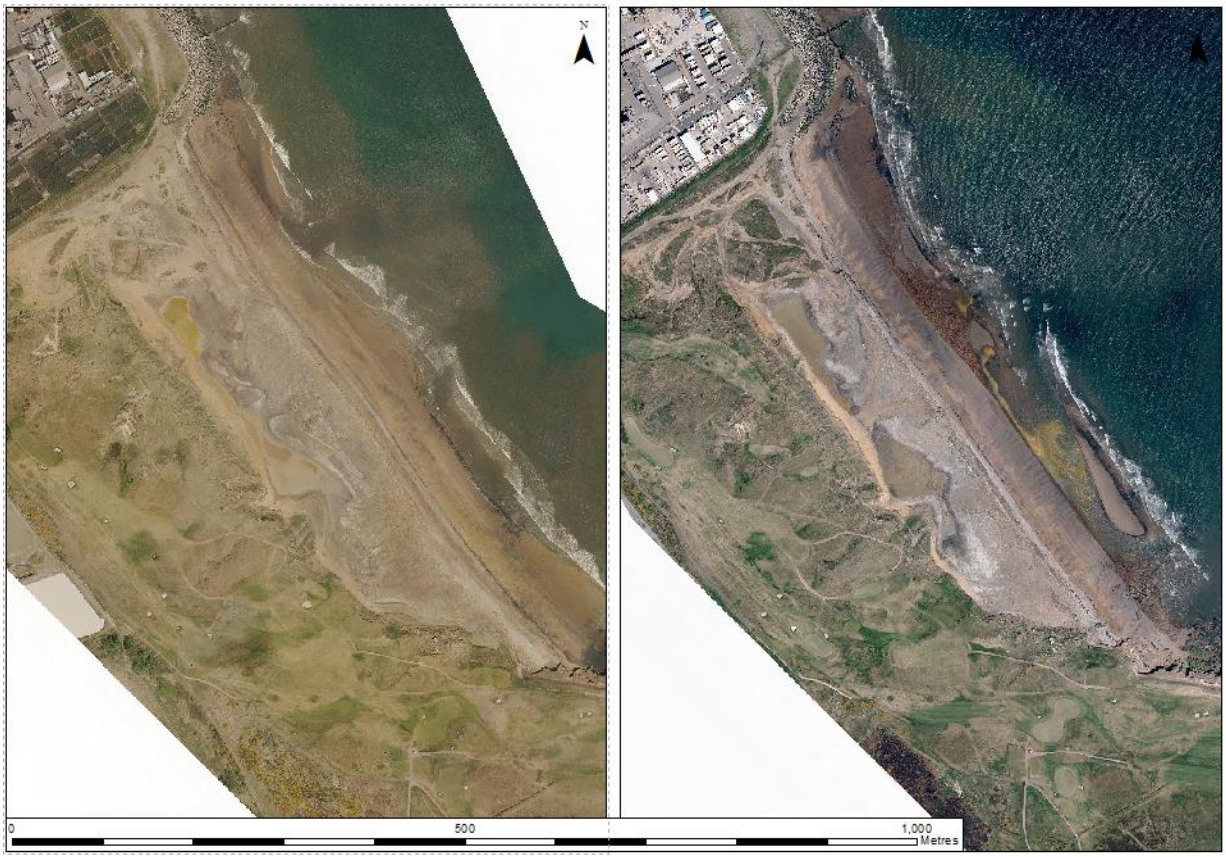

Figure 32 Colliery spoil erosion south of the power station in 2010 (left) and 2017 (right)

3.3.3 Cell 1 Regional Coastal Monitoring Programme

Lynemouth Bay is covered by five beach profiles for the Full Measures survey (**Figure 14**) (profiles 1aCMBC03, 1aCMBC03A, 1aCMBC03B, 1aWDC02 and 1aWDC03 began surveying in 2002. Profile 1aWDC01 is no longer surveyed and was not used for analysis. Profiles 1aCMBC03A and 1aCMBC03B began surveying in 2007).

Profile 1aCMBC03 at the very northern end of Lynemouth Bay has remained highly stable over the length of the survey record, with no change in cliff or rocky foreshore position. Profile 1aCMBC03a was introduced to the monitoring programme in 2007 and has shown a progressive landward movement of the spoil beach, with erosion at the high water mark of around 10 m. Profile 1aCMBC03b was also introduced to the monitoring programme in 2007 and is located in the area of most recent colliery spoil tipping. The profile has shown a progressive landward retreat since 2007 of almost 30 m. Profile 1aWDC01 is located just to the north of the power station, in the area now protected by the extension of the rock revetment around the coal stocking yard. The profile has shown a progressive landward retreat since 2003 in excess of 70 m. Profiles 1aWDC02 and 1aWDC03 are located to the south of Lynemouth power station along Lyne Sands. The spoil slag heaps have continuously experienced processes of wash-over, leading to landward migration of the seaward face and deposition of liberated material on the crest and landward slope of the bank. Along 1aWDC02 the high water line moved around 20 m landwards between 2002 and 2010 and along 1aWDC03 the migration was around 10 m landwards.

Overall, the five profiles in Lynemouth Bay corroborate results from HTA, exhibiting high rates of erosion of colliery spoil on the foreshore to the north and south of the Power Station. The rocky platform in the north of Lynemouth Bay does not exhibit high rates of erosion and there are not enough profiles covering the coastline spanning Reference 7 to corroborate HTA.

3.4 Location 4 – Spital Point / Links Quarry

3.4.1 Historic Maps

OS One Inch, 1885 – 1903

In the first available historic map, the shoreline between Church Point to the north of Newbiggin Bay and Wansbeck Estuary to the south of Links Quarry is significantly seaward than present day. Newbiggin Beach appears as a wide expanse of sand between headlands, however, now appears as a narrow beach front backed by extensive sea and flood defences. Cliff top erosion has occurred in sections from Spital Point to Wansbeck Estuary.

The morphology of Wansbeck Estuary is considerably different to present day. This is attributed to the construction of a tidal weir in 1974/75 (Royal Haskoning, 2009). The weir was built to flood the intertidal flats upstream of the A189 road bridge which had been used as colliery spoil tips and most recently, for recreational purposes as the Wansbeck Riverside Country Park. The weir has dramatically reduced tidal influence within the estuary which is visible from the earliest map.

OS Six Inch, 1888 – 1913 & OS 25 Inch, 1892 – 1914

The improved scale of the OS six inch mapping from a similar period shows that the MHW mark north of Newbiggin Point is slightly seaward, indicating accretion in this area. However, the MHW mark within Newbiggin Bay and south towards the Wansbeck Estuary is landward since 1885 – 1913 mapping, particular adjacent to Links Quarry (noted as Old Quarry on mapping).

Hunkleton Stone, believed to be an erratic boulder deposited during the Ice Age, is noted on the centre of the beach in this map.

OS 1:25,000, 1937 – 1961 & OS One Inch 7th Series, 1955 – 1961

By the time of this map, MHW mark north of Newbiggin Point is in a similar position to previous mapping. There has been considerable erosion at Church Point at the north headland of the bay, attributed to a combination of mining subsidence and increased wave activity.

Within Newbiggin Bay, MHW mark has moved slightly seaward, presumably as a result of the construction of coastal defence works between 1929 and 1932. There is little discernible change in MHW mark adjacent to Links Quarry between the two maps. The cliff top running adjacent to Sandy Bay Holiday Park until Wansbeck Estuary has undergone significant erosion during this period. Within the river mouth, progradation has occurred on both banks.

Even at this time, the cliff section of coastline from Newbiggin Point to Wansbeck Estuary is notably seaward of its present-day position, indicating measurable erosion has occurred along this section of cliff top over the last 50 years.

3.4.2 Aerial Imagery

In the first available aerial imagery of this area in 1940, the promenade is clearly visible along the entire length of Newbiggin Bay, however the offshore and northern breakwater are not present. Spital Point remains in a similar position and form as present day. South of this, Links Quarry is visible and has not been infilled yet (**Figure 33**). Sandy Bay Holiday Park is

not present and the shoreline along this section is straighter and less undulating than present day. There has been significant change to the north of the Wansbeck River mouth, with progradation of vegetation between 25 – 45 m (**Figure 34**).

By 2002, rock revetment is visible in front of the southern 500 m of promenade in Newbiggin Bay and Church Point on the north headland is protected by a seawall. The Sandy Bay Holiday Park is now visible, located 600 m south of Links Quarry close to the cliff edge. Imagery from 2002 does not cover the Wansbeck Estuary.

By 2006, there is little discernible change within the bay, with small sections of cliff erosion between Links Quarry and the Wansbeck Estuary. The intertidal flats upstream of the tidal weir are now flooded.

Aerial imagery from 2009 only covers the southern half of Sandy Bay Holiday Park and reveals no significant change in coastline morphology.

By 2010, a 200 m breakwater is now present in the centre of the bay, with a build-up of sediment shoreward of the structure. The rock revetment protecting the promenade has largely disappeared since 2006. There are no other significant changes.

Aerial imagery taken in 2013 is poor resolution, however there does not appear to be any significant changes in coastline morphology.

By 2015, the promenade in the south of the bay is fronted in parts by sparse rock revetment. South of Links Quarry, there are small sections of cliff top erosion. There are no significant changes in cliff top position adjacent to Sandy Bay Holiday Park.

There are no discernible changes within the bay by 2017. Small sections of cliff erosion are apparent south of Links Quarry towards Sandy Bay Holiday Park, with small sections of progradation of vegetation on the northern bank of the river mouth.

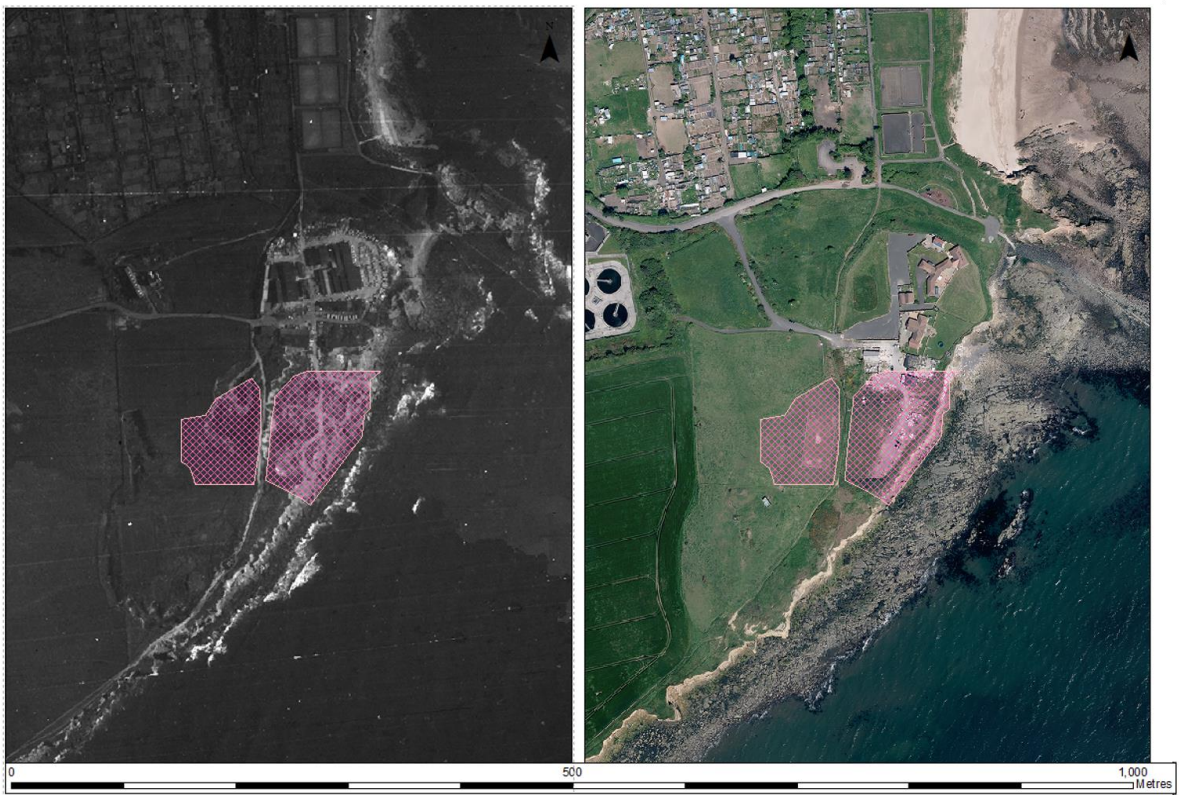

Figure 33 Spital Point / Links Quarry in 1940 (left) and 2017 (right) with site References 4 and 8 in pink

Figure 34 Wansbeck Estuary in 1940 (left) and 2017 (right)

Figure 35 Spital Point / Links Quarry in 2010 (left) and 2017 (right) with site References 4 and 8 in pink

3.4.3 Cell 1 Regional Coastal Monitoring Programme

The coastline north of Church Point is covered by one profile, 1aWDC05. Newbiggin-by-the-Sea is covered by four beach profile lines for the Full Measures survey (Appendix A). Two of these, profiles 1aWDC05A and 1aWDC06A, were added to the programme in October 2007 specifically to help assess the performance of the capital scheme involving beach replenishment and construction of an offshore breakwater. In addition, a further 26 profiles (1aNWB1 to 1aNWB26) have been surveyed since September 2010 as part of a topographic survey of Newbiggin Bay. The coastline adjacent to Links Quarry is not covered by any beach profiles. To the south, the coastlines at Sandy Bay Holiday Park and Wansbeck river are covered by profiles 1aWDC08 to 1aWDC10.

Profile 1aWDC05 to the north of Church Point shows no significant change of the rocky platform from 2002 – 2018, with erosion of up to 1 m at the toe of the vegetated dunes. Within Newbiggin Bay, profile 1aWDC05a shows progressive steepening of the upper beach profile from 2007 to 2018, with no real change along the exposed rocks at the toe of the beach. Profile 1aWDC06 shows no significant change from 2002 to 2007, where the profile changes greatly in response to the beach recharge scheme, with accretion in the upper beach of approximately 5 m. From 2007 to 2018, the middle to upper beach loses between 2.2 – 3.4 m of sediment whilst the middle to lower beach profile smoothens out. At profile 1aWDC06a, an upper beach berm moves landward from 2007 to 2018 whilst the middle to lower beach smoothens out over time. Profile 1aWDC07 exhibits the same large accretion of the beach recharge scheme in 2007, but steepens progressively until 2018.

At Sandy Bay Holiday Park, the vegetated dunes and rock revetment at profile 1aWDC08 don't change significantly from 2002 – 2018, with minor sections of erosion at the crest and face of the cliff. In 2018, the upper beach has eroded to a similar level as 2002 whilst the middle to lower beach remains in a medium range of previous survey levels. Profile 1aWDC09 shows significant landward movement of the cliff face by up 11 m and erosion of the dune toe of 0.5 m from 2002 to 2018. Profile 1aWDC10 to the south of the Wansbeck River shows alternating patterns of erosion and accretion from 2002 – 2018. The cliff face has eroded by c. 3 m from 2011 (the first year the cliff face is surveyed) to 2018. Beach levels are generally similar to that of 2002 with sections of erosion and accretion in the order of ±0.5 m.

3.5 Location 5 – Coatham Sands

Coatham Sands was the subject of a previous Historical Trend Analysis by Royal HaskoningDHV (2018), the results of which are reproduced below.

3.5.1 Historic Maps

OS One Inch, 1885 – 1903

In the first available historic map, the morphology of the Tees estuary is very different from the present day, with extensive areas of inter-tidal mud flat and salt marsh exposed at low tide, especially across Seal Sands and Bran Sands.

South Gare appears to be a natural spit at the mouth of the Tees estuary, with rail tracks along its length. The German Charlies slag banks were not present in the nearshore zone at this time and so the sand accumulated in the lee of the spit was more parallel with the spit than in the present day (the beach immediately in the lee of the German Charlies has built out as a small embayment in the present day).

At the root of the spit the MHW mark was in a considerably more landward position than in the present day, indicating that sand dune accretion has occurred at this western end of the frontage over the long term. However, this accretion has not only occurred in the vicinity of the spit at Tees Mouth; along the whole length between the spit and what is now known as the Majuba Road car park the historic MHW mark was more landward than in the present day (although the width of progradation decreases with progression to the east so that the historic MHW mark is very close to the present day in the vicinity of the caravan park).

The MHW mark is not a smooth 'bay' shape, but does have some jagged undulations towards the western section, perhaps indicating some differences in the topography or maybe even a former channel mouth.

Conversely, along Majuba Road towards Redcar (and beyond to the east), the historic MHW mark was more seaward than in the present day, indicating net recession of the shore in this area.

OS Six Inch, 1888 – 1913 & OS 25 Inch, 1892 – 1914

The improved scale of the OS six inch mapping from a similar period, shows the South Gare Breakwater clearly present and the dunes in the vicinity of the present day caravan park named as Coatham Bank. The MHW mark was considerably landward of its present day position from Tees Mouth to the present day caravan park, indicating accretion along this length, with recession evident further to the east. The point at which the dunes switch from accretion to erosion between the historic maps and the present day is exactly at the western end of the Majuba Road car park.

OS 1:25,000, 1937 – 1961 & OS One Inch 7th Series, 1955 – 1961

By the time of this map, the German Charlies had been placed and started to modify the morphology of the dunes in their lee. The jagged undulation in MHW mark was particularly pronounced just to the west of Warrenby Slag Works which by now were present (and presumably responsible for the German Charlies slag banks).

Even at this time, the MHW mark was landward of its present day position along most of the frontage, but the 'switch-point' between the accretion and erosion had migrated to the western end of the caravan park. This indicates that the caravan park frontage has been under some pressure since around the mid 1950s.

3.5.2 Aerial Imagery

In the 1940 aerial imagery, the dunes adjacent to South Gare had not built out along the seaward edge of the spit in the manner that is observed in the present day, but instead occupied a bulbous shape, with a distinct ingress of sea water into a saline lagoon, with only a thin azimuth of land between the lagoon and the Bran Sands area of the River Tees estuary (**Figure 36**).

The Warrenby Slag Works are present in the 1940 imagery and slag deposits appear to push the shoreline seaward in locations immediately adjacent to the works, although the coastline here was still somewhat landward of its present-day position in 1940 (**Figure 37**).

In the Majuba area, the present-day caravan park had not been constructed in 1940 and whilst a seawall appeared to be present from the Redcar frontage towards the area of the present day Majuba car park, the car park itself was also not constructed at this time. It is notable that the dunes at this location were experiencing some vegetation loss and encroachment by the sea in the 1940s, even before the caravan park was built on this area.

By the time of the next available aerial photography from the Cell 1 Regional Coastal Monitoring Programme in 1999, the shore adjacent to the South Gare was undergoing change. It appears that sand or slag may have been artificially deposited to the east of the South Gare at this time, although the present-day alignment had not yet been fully attained.

There had been continued progradation of the shore in the centre of the frontage, in the vicinity of the Warrenby Slag Works and the frontage by 1999 was appearing much more like a 'natural' dune system, with vegetated sand at the seaward limit, as opposed to a probable sand/slag mix present at the shore face in 1940.

Both the caravan park and the car park had been constructed in the Majuba area by 1999.

By 2009, the shore adjacent to South Gare had continued to experience change, again likely in the form of sand/slag deposition and, due to the presence of the German Charlies in the nearshore, natural sand deposition in the now-sheltered areas. This resulted in quite a growth in the shore adjacent to the South Gare and stability in the dunes at the western end of the frontage.

Elsewhere along the frontage there was little change from 1999 to 2009, other than some exacerbation of areas of blow outs or bare dune vegetation to the immediate west of the caravan park in the Majuba area.

There was little discernable change along the dunes at Coatham Sands between 2009 and 2010.

The shoreline adjacent to South Gare appeared to contain greater quantities of material (sand/slag) and was more widely vegetated in 2012 than in 2010.

At the Majuba area, part of the dunes adjacent to the caravan park were covered with hard-top and being used for car parking and portacabins in 2012. Presumably this was the Contractor's compund for the duration of construction of the Redcar Sea Defence Scheme.

It is also noticeable that the seaward row of caravans seen in the 2010 imagery had been removed by 2012, indicating a risk from erosion or sea flooding at that time.

The shore adjacent to South Gare showed some further growth between 2012 and 2015, but elsewhere along the Coatham Sands frontage there was no significant difference in the shore between the 2012 and 2015 imagery, indicating that if the December 2013 storm did cause localised damage, there had been natural recovery by 2015.

Following completion of the Redcar Sea Defence Scheme, the Contractor's portacabins at the caravan park in the Majuba area had been removed by 2015, but the hard-top remained intact. The most seaward row of caravans seen in the 2015 imagery had been restored since being (temprarily) removed before the 2012 imagery.

Imagery from 2017 show that in the immediate lee of the South Gare breakwater, the trend continued to be one of accretion in the shelter of the structure, with a notable increase in the extent of dune vegetation. Some areas of 'scalloped' dune evident in the 2017 aerial photography was also present in the photography that was collected in 2015 and appears not to have worsened. Arguably in some areas it may have marginally recovered, although remaining heavily scalloped.

Some areas that were anecdotally described as 'breaching' or 'severely eroding' during the January 2017 storms, were clearly in such a state before the 2015 photography was collected and thus the damage to these dunes cannot be ascribed to the January 2017 storms alone.

Figure 36 South Gare in 1940 (left) and 2017 (right) with site Reference 9 in pink

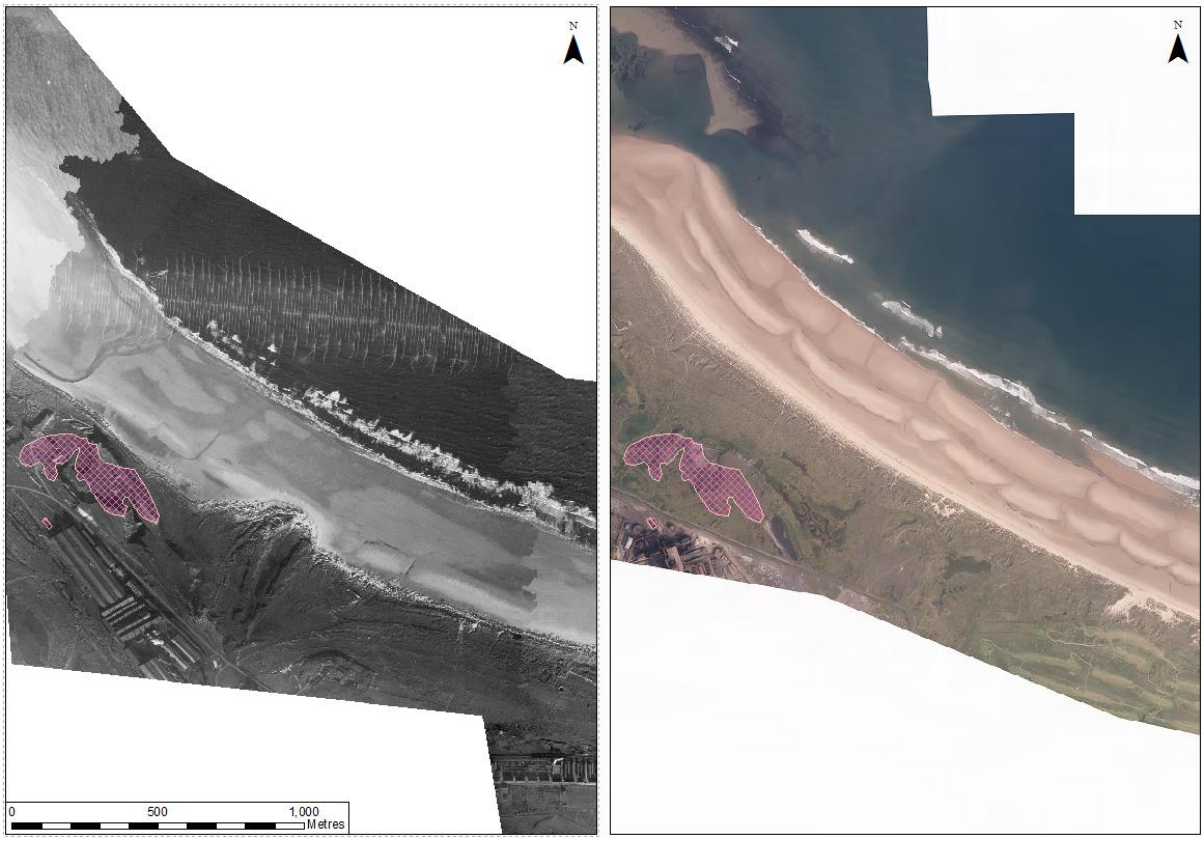

Figure 37 Warrenby Slag Works in 1940 (left) and 2017 (right) with site Reference 9 in pink

3.5.3 Cell 1 Regional Coastal Monitoring Programme

Coatham Sands is covered by four beach profile lines during the Full Measures survey (**Figure 24**) (1cRC1 to 1cRC4).

Profile 1cRC1 is located approximately 300 m south of the South Gare breakwater, in the lee of the German Charlies slag banks. The dunes in the upper profile have remained stable since surveys began in 2008 and are currently at their highest level recorded (April 2018). At profile 1cRC2, the dunes in the upper profile have remained stable / prograded from 2008 to 2018, with a seaward movement of the dune face of approximately 40 m. Overall, beach levels across the profile have accreted over the same period and are at a medium range of previous surveys. The dunes at profile 1cRC3 have progressively accreted from 2008, with an accretion of the dune crest by up to 1.8 m, however the dune face upper beach have eroded over the same period by up to 1.0 m and are now at their lowest level. Profile 1cRC4 is the beginning of the defended section at Redcar and in general has remained stable since 2008.

The results from the Cell 1 Monitoring Programme profiles corroborate HTA, showing a general trend of stability in the immediate lee of the South Gare breakwater and along the northern Coatham Dunes fronting Reference 9. The most vulnerable section of Coatham Sands, verified by Royal HaskoningDHV (2018), is the Majuba area to the east of site Reference 9.

4. Conclusions

In 2017, nine reference sites within the Cell 1 coastal frontage were classified as presenting 'Very High' potential land contamination risks to coastal waters resulting from SMP2 'No Active Intervention' (NAI) policies.

The present study has further investigated eight of these nine original reference sites, with one site (Area G East of Horden) being omitted since it is located along a wooded area known as Blackhills Gill, some 200m from the coastline adjacent to the banks of a beck. Whilst erosion of the banks of the beck within Blackhills Gill could potentially result in release of any locally-stored landfill materials and pollution of the beck and, ultimately, coast, this site is sufficiently far inland upstream in the beck to not directly be affected by SMP2 policies.

The eight remaining sites, have been grouped into five distinct locations along the Cell 1 frontage, namely:

- Location 1 - Holy Island (2 sites)
- Location 2 – Bamburgh (2 sites)
- Location 3 – Lynemouth Bay
- Location 4 – Spital Point / Links Quarry (2 sites)
- Location 5 – Coatham Sands

Analysis of historic maps and aerial photographs within the context of an Historic Trends Analysis (HTA), combined with analysis of survey data from the Cell 1 Regional Coastal Monitoring Programme and a site visit undertaken to most locations in January 2019 have been used to re-assess the Risk Ranking of each site previously classified as being of 'Very High' risk.

4.1 Risk Ranking Evaluation

4.1.1 Location 1 – Holy Island

Low-lying hollows on the causeway side of the dune system of the Snook could potentially act as an inlet for flood waters during storms (if the dunes become breached), however as there is no exposed landfill across the site and a topsoil / sand cap exists beneath the grey lichen vegetation, it is believed that Reference 1 historic landfill poses a lower than previously assessed contamination risk to coastal waters. Additionally, from the HTA of Holy Island, the Snook has been relatively stable / prograding since approximately 1885 – 1903, with increasing vegetation coverage at the site. The erosion risk at the site is therefore very low.

It is recommended that Reference 1 contamination potential is lowered to 1 and erosion potential is lowered to 1, downgrading the overall risk ranking to 4, 'Very Low'.

Although no landfill is exposed on the tidal flats at Reference 2, inert waste such as bricks, glass and ceramics are exposed along the upper beach and eroding out of the low-lying cliffs backing the beach. This waste is not believed to pose a contamination risk to coastal waters and in some areas was a substrate for kelp growth. From the HTA of Holy Island, the coastline along the Basin has been stable since approximately 1955 – 1961 and therefore the erosion risk at the site is very low.

It is recommended that Reference 2 contamination potential is lowered to 1 and erosion potential is lowered to 1, downgrading the overall risk ranking to 4, 'Very Low'.

4.1.2 Location 2 – Bamburgh

The landfill exposed at Reference 3 is inert household and commercial waste and the area is capped with topsoil / sand. The site is situated 140 m from the coastline and is well vegetated with marram grass and brambles, thus it is unlikely to suffer from coastal erosion or blowouts. Additionally, the HTA of Bamburgh has revealed that the dunes have been relatively stable / prograding since 1885 – 1903. The only erosion risk to the site is in the form of trampling and removal of the topsoil / sand. Thus, Reference 3 does not pose any contamination risk to coastal waters.

It is recommended that Reference 3 contamination potential is lowered to 1 and erosion potential is lowered to 1, downgrading the overall risk ranking to 4, 'Very Low'.

Reference 6 is situated approximately 340 m from the coastline and is well vegetated with trees and capped with topsoil / sand. There is no landfill exposed. There is virtually no risk of coastal erosion or erosion from blowouts. There is a public path through the wooded area from Links Road to the car park adjacent to Bamburgh Castle and therefore the removal of topsoil / sand through trampling is also unlikely.

It is recommended that Reference 6 contamination potential is lowered to 1 and erosion potential is lowered to 1, downgrading the overall risk ranking to 4, 'Very Low'.

4.1.3 Location 3 – Lynemouth Bay

Reference 7 is a continuation of the colliery spoil deposited on the foreshore along Lynemouth Bay since the 1930s. The progressive deposition of colliery spoil has created an artificial bank of spoil which has continued to provide a coastal protection function to the

dune system backing the beach. However, as seen through HTA of Lynemouth Bay (Royal HaskoningDHV, 2014), there has been significant landward erosion of colliery spoil north and south of the Power Station since the cessation of colliery spoil tipping in 2005, with concerns regarding the outflanking of the rock revetment in front of the Power Station and coal-stocking yard.

In terms of contamination potential, the erosion of colliery spoil at Reference 7 to coastal waters has 'little or no additional impact on the already adversely affected coastal and marine biological communities', however from the site inspection undertaken at the mouth of the River Lyne, the continuous erosion of industrial waste out of the spoil cliffs are of concern.

It is recommended that Reference 7 contamination potential remains at 4 and erosion potential remains at 5, ensuring the overall Risk Ranking of 80, 'Very High' remains in place.

Further investigation of the effect of erosion of the colliery spoil (and other wastes embedded within the spoil) to public health and marine biological communities should be undertaken. However, given the scale of spoil (and waste) tipping within Lynemouth Bay, efforts to clear-up the debris or to protect the eroding spoil north and south of the Power Station and along the mouth of the River Lyne would be extensive.

4.1.4 Location 4 – Spital Point / Links Quarry

Given the proximity of Reference 4 to the coastline, there is a potential coastal erosion risk to the site. However, given the placement of toppled Sandstone and concrete rubble at the base of the cliffs, coupled with the minor erosion rates found in HTA, the erosion risk to Reference 4 is low. Additionally, landfill is predominantly composed of inert concrete rubble at the seaward margin and presents no contamination risk (although other materials may be buried further inland).

It is noted that in the previous study, the receptor potential score was only rated as 4, which realistically should have been 5 for consistency with Reference 8, so this has been updated. Also, it is recommended that Reference 4 contamination potential is lowered to 3 and erosion potential is lowered to 3, downgrading the overall risk ranking to 36, 'Low'.

Reference 8 is located approximately 50 m from the coastline and is a continuation of the Links Quarry landfill. Given the present land use of the site and its distance from the coastline, it is recommended that Reference 8 contamination potential is lowered to 3 and erosion potential to 2, downgrading the overall risk ranking to 24, 'Low'.

4.1.5 Location 5 – Coatham Sands

Reference 9 is located approximately 320 m from the coastline and is most likely landfill composed of a mixture of slag from local ironworks and bricks / masonry. Given the distance of the landfill to the coastline, coupled with the relative stablility of the dunes in the lee of the South Gare breakwater and northern section of Coatham Dunes, the potential erosion risk to the site is low.

It is recommended that Reference 9 contamination potential remains at 5 and erosion potential is lowered to 1, downgrading the overall risk ranking to 32, 'Low'.

4.2 Revised Risk Ranking

Risk Ranking Scores

0-20	20-40	40-60	60-80	80-100

Table 3 Updated Risk Ranking of site References 1 - 9

Ref	Name	Local Authority	Description	Ref	Contamination risk	Updated Contamination risk	Erosion risk	Updated Erosion risk	Receptor	Risk Ranking	Updated Risk Ranking	Summary and Recommendations
1	Holy Island, Shell Road	Northumberland	Historic Landfill no info, within Ramsar, SAC.	HR6 NNT PDZ1 MA5	5	1	4	1	5	80	4	Further desk study and site visit found this site to have a low contamination and erosion risk and it was therefore downgraded to 4. There are no further recommendations.
2	Holy Island Sands	Northumberland	Historic Landfill no info, within Ramsar, SAC.	HR6 NNT PDZ1 MA4	5	1	4	1	5	80	4	Further desk study and site visit found this site to have a low contamination and erosion risk and it was therefore downgraded to 4. There are no further recommendations.
3	The Dune Tip	Northumberland	Historic Landfill no info, within Ramsar, SAC.	HR7 NNT PDZ2 MA6	5	1	4	1	5	80	4	Further desk study and site visit found this site to have a low contamination and erosion risk and it was therefore downgraded to 4. There are no further recommendations.
4	Links Quarry	Northumberland	Historic Landfill complete from 1986, boundary of SPA and Ramsar.	HR16 NNT PDZ5 MA20	5	3	5	3	5	80	36	Ongoing monitoring of erosion of the site is recommended by means of visual inspection and further testing of the land should be undertaken if erosion releases waste.
6	Bowl Hole	Northumberland	Infilled pit, Cemetery/infilled pit, no erosion data but on edge of dunes.	HR62 NNT PDZ2 MA6	4	1	5	1	5	80	4	Further desk study and site visit found this site to have a low contamination and erosion risk and it was therefore downgraded to 4.
7	near Lyne-mouth	Northumberland	Infilled land/pond unknown fill.	HR78 NNT PDZ4 MA19	4	4	5	5	5	80	80	Further desk study and site visit found this site to have a high erosion and contamination risk. The site is actively eroding into the sea and further investigation into the composition of the spoil and associated waste in hot-spots of erosion around the mouth of the River Lyne is recommended.
8	near Spital Point	Northumberland	Area of infilled quarries (unknown fill).	HR80 NNT PDZ5 MA21	4	3	5	2	5	80	24	Erosion potential is lower than Reference 4 as it is located further inland. Ongoing monitoring of erosion of the site is recommended associated with Reference 4.
9	Land adjacent to Redcar Blast Furnace	Redcar and Cleveland	Mixed area of landfill (historic), infilled ponds, tip (marked on modern map as disused), factories, alongside Teesside Works, Redcar (Steelworks). Alongside SPA/Ramsar. No erosion data.	HR83 RTFH PDZ5 MA13	5	5	5	2	4	80	32	Further desk study found this site to have a high contamination risk, but a relatively low erosion risk. It was therefore downgraded to 32. However, continued monitoring of erosion risk is recommended at the vulnerable area of Majuba dunes, which is also located along Coatham Sands.

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