11d5 Seascale to St. Bees

(Technical report by Jacobs)

Policy area: 11d5 Seascale to St Bees

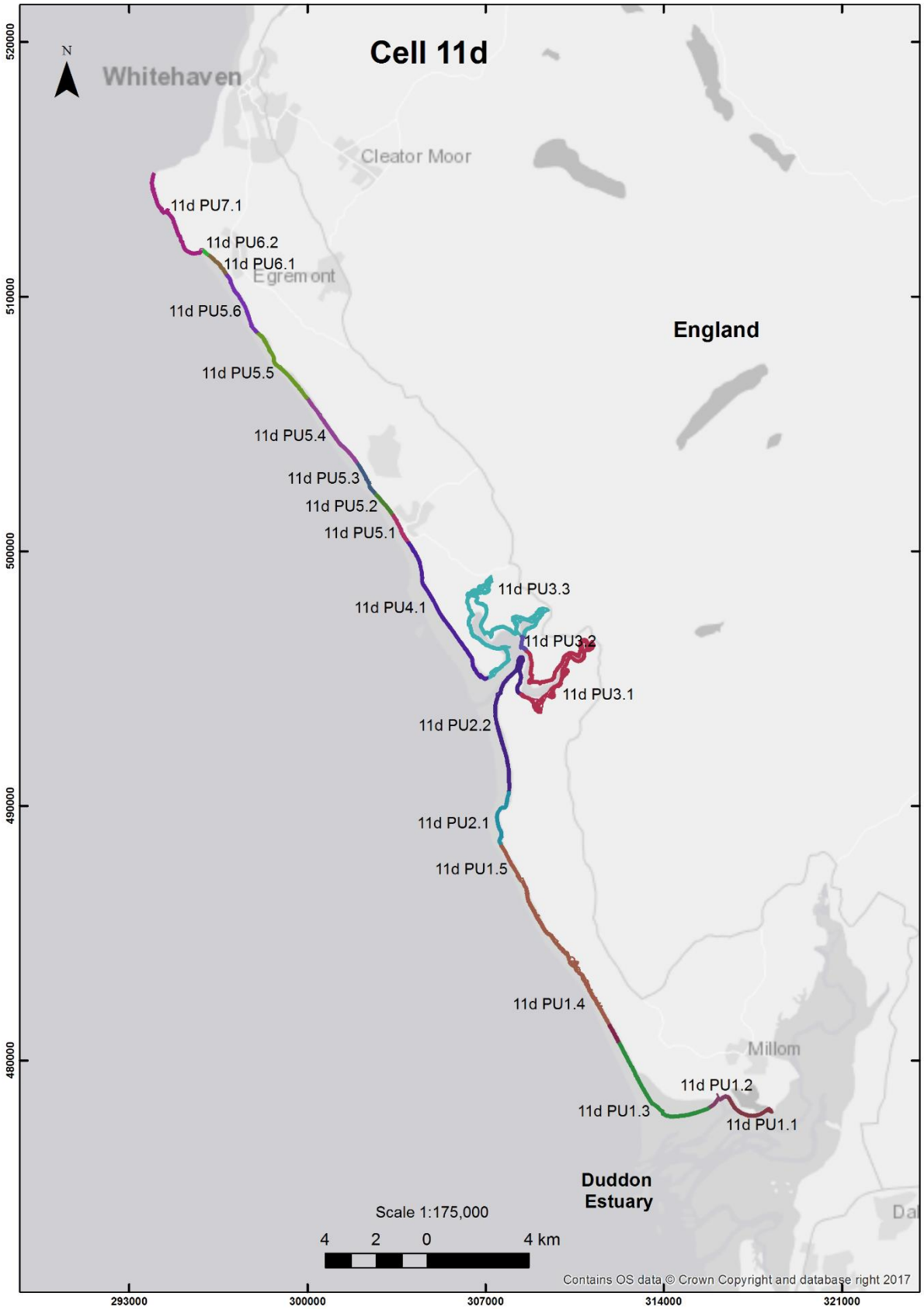

Figure 1 Sub Cell 11d Hodbarrow Point to St Bees Head Location Plan of policy units. Baseline mapping © Ordnance Survey: licence number 100026791

1 Introduction

1.1 Location and site description

Policy units:	**11d5.1: Seascale (priority unit)** **11d5.2 Seascale to Sellafield (priority unit)** **11d5.3 Sellafield (priority unit)** **11d5.4 Sellafield to Braystones (priority unit)** **11d5.5 Braystones, Nethertown, Coulderton (priority unit)** **11d5.6 Coulderton to Sea Mill (priority unit)** **11d5.7 Sea Mill to Pow Beck (priority unit)**
Responsibility:	Copeland Borough Council Cumbria County Council (Highways) Network Rail Nuclear Decommissioning Authority Private landowners
Location:	The policy area falls within Sub cell 11d: Hodbarrow Point to St Bees Head and extends from the village of Seascale to Pow Beck. This frontage encompasses the villages and smaller communities of Seascale, Braystones, Nethertown and Coulderton, as well as the Sellafield nuclear site and the adjacent site for the proposed Moorside power station.
Site overview:	The coastline encompasses a diverse range of habitats including mud and sand flats, shingle and pebble beaches and honeycomb worm reefs. Generally, this is a rural setting with the major development at Sellafield being the exception to this. Other settlements along the coastal strip are linked by the Cumbrian Coastal Railway Line and coastal road. The expanding energy industries, together with the tourism sector are key employers in the area and add to the development pressure. There are expansion plans adjacent to Sellafield (Moorside Project) which will provide significant opportunities in the area, with potential impacts on the surrounding villages in terms of provisions of housing for increased workforce and transportation routes. Tourism and agriculture are likely to remain important contributors to the local economy. The Cumbrian Coastal Railway Line runs along the top of, or in front of, the till cliffs between Sellafield and St. Bees (11d5.4 to 11d5.7) which are prone to failure. Fringing beaches are present along this stretch of coastline and north of Nethertown sandstone bed outcrops dominates the foreshore. There is a variety of formal and informal defences along this stretch giving some protection to both the railway embankment and residential properties. Seaward of the railway line there are several permanent and seasonally occupied beach dwellings which have been constructed on the crest of the gravel beach and rely on the beach for protection from flooding and erosion. There are no statutory land based environmental designations along this frontage, but Drigg Dunes lie to the south of the frontage and these are designated as a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC). The notifications recognise the broad range of maritime habitats represented by the site which support a rich and varied range of flora, invertebrates and amphibian species. The dune heath along the northern end

	of Drigg is of particular significant as it is the largest example of this rare habitat on the west coast. The site is also part of the Drigg Coast European Marine Site. The intertidal and nearshore is part of the Cumbria Coast Marine Conservation Zone (MCZ), which extends from Saltom Pit to the mouth of the Ravenglass Estuary and protects intertidal and shallow subtidal habitats and the diverse range of plant and animal communities these habitats support.

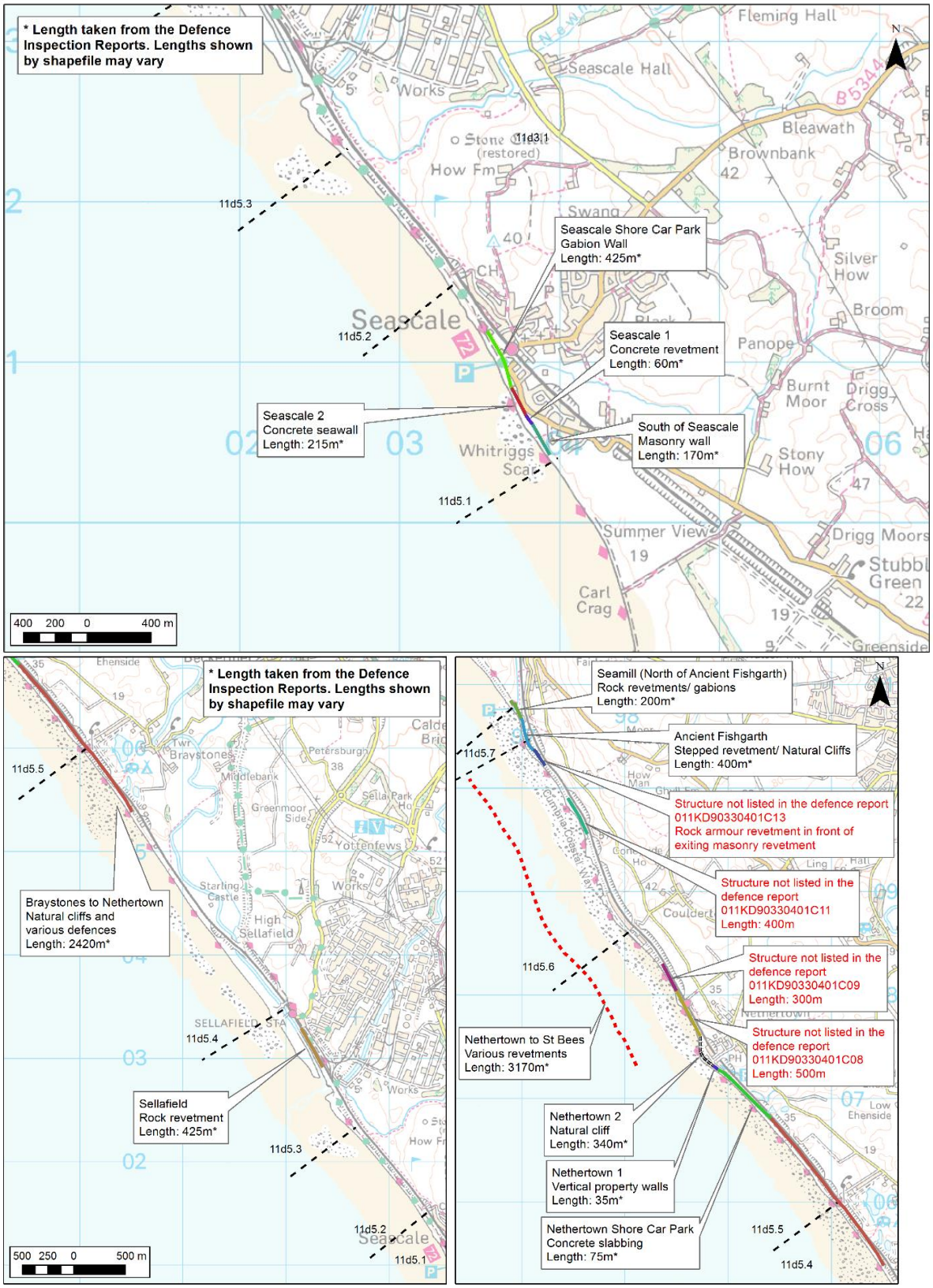

Figure 2 Policy unit location plan and defence overview. Baseline mapping © Ordnance Survey: licence number 100026791

1.2 Current SMP policy

The policy details for the whole policy area are shown in the table below, taken directly from the SMP2 (Halcrow, 2011).

Table 1 Current SMP policy for policy area 11d5.

Overview: *From Seascale to Sellafield the long term plan is to continue to manage flood and erosion risk due to the national significance of this facility. North of Sellafield to St Bees, consideration needs to be given to the existing and probable increasing risks to the railway which is particularly critical infrastructure. If the railway was re-routed and natural processes and erosion was allowed to resume, it could enable greater input of sediment to local beaches, further improving defence to the nuclear processing site and Drigg. Elsewhere, a policy of No active intervention will promote a naturally functioning coastline helping to maintain a number of habitats and SSSIs. A limited number of properties and localised sections of the coast will be at increasing risk of erosion.*

Location		Policy and Approach (from 2010)		
		0-20 years	20-50 years	50-100 years
11d5.1	Seascale	**Hold the line –** By maintaining the rock gabions at Shore car park and maintaining or re-constructing the seawall fronting the B5344.	**Hold the line –** By maintaining defences and potential requirement for extending revetment adjacent to the B5344 & address outflanking to the south.	**Hold the line –** By constructing larger defences.
11d5.2	Seascale to Sellafield	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.
11d5.3	Sellafield	**Hold the line –** Maintain linear revetment and rock armour defences.	**Hold the line –** Maintain and construct larger defences.	**Hold the line –** Maintain and construct larger defences.
11d5.4	Sellafield to Braystones	**No active intervention –** Monitor flood and erosion risk to railway, only carry out works if the railway is at risk. Undertake a study to assess tidal risks in the Ehen flood plain upstream of SMP boundary.	**No active intervention –** Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.
11d5.5	Braystones, Nethertown, Coulderton	**Managed realignment** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk. Develop adaptation strategy for properties on beach. Subject to consent, ongoing beach management could help reduce risks in the short term. No further development should be permitted along the beach	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk. Not technically viable or economically justified to defend properties on beach in medium or long term. No further development should be permitted along the beach.	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk. No further development should be permitted along the beach.
11d5.6	Coulderton to Sea Mill	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.	**No active intervention** – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.
11d5.7	Sea Mill to Pow Beck	**Hold the line** – With limited intervention, monitor erosion risk to railway, then maintain and upgrade railway defences as necessary.	**Hold the line** – With limited intervention until the railway is at risk, maintain and upgrade railway defences as necessary.	**Hold the line** – Maintain and upgrade railway defences as required. (No active intervention if railway no longer operational).

2 Appraisal of priority units

There are seven policy units within Seascale to St Bees Head (11d5): all have been defined as priority policy units for the strategy:

- 11d5.1 Seascale
- 11d5.2 Seascale to Sellafield
- 11d5.3 Sellafield
- 11d5.4 Sellafield to Braystones
- 11d5.5 Braystones, Nethertown, Coulderton
- 11d5.6 Coulderton to Sea Mill
- 11d5.7 Sea Mill to Pow Beck

2.1 Existing approach to flood and coastal erosion risk management

2.1.1 Justification of current SMP policy

Section 1.2 sets out the SMP policies for this priority unit. The primary justifications for the policies at the SMP level were:

- Social: 11d5.1 Maintains the integrity of Seascale, associated residential assets and infrastructure and allows for maintenance of railway as transport linkage, including use by nuclear site. Where properties lie at the back of the beach the short term policy allows ongoing beach management and development of an adaptation strategy for properties. But the SMP stated that continuing to defend these properties will be unsustainable in the future as sea level rise, resulting in the loss of properties on the beach crest in the long term.
- Environmental: Works with natural processes and avoids potential contamination risks (11d5.3). No known designated conservation sites[1] or intertidal habitat present to constrain a Hold the line policy.
- Economic: At 11d5.1 policy is economically viable and social and community benefits add to justification sufficient to justify maintenance of defences in the long term. At Sellafield economic values and potential contamination issues would justify defences, whilst elsewhere there is no justification for intervention until railway is at risk, when viability would depend on overall case for railway.

2.1.2 Current defences

The frontage from Seascale to Pow Beck includes a variety of formal and informal coastal defences. Table 2 provides defence structural details, with the following text provides further detail regarding current condition and recent management, based upon information taken from the most recent asset inspection report (CH2M, 2017a) and previous inspection reports by Coastal Engineering UK and Capita Symonds (reported in CH2M, 2017a). Additional information has been provided by Network Rail, identifying key works required along their network; this is summarised in Table 3.

[1] Since the SMP2 was developed the Cumbria Coast MCZ protecting habitats on the beach and intertidal zone was designated in 2013

Table 2 Details of existing defences: 11d5. Information taken from the latest asset inspections (CH2M. 2017a)

Location		Structure Type	Length (m)	Crest Level (mOD)	Foreshore Toe Level (m)	Condition	Residual Life (years)
11d5.1	Seascale Shore Car Park	Gabion Wall	425	+7.3	-0.04-2.72		10-20
11d5.1	Seascale 2	Concrete Sea Wall	215	+6.5	+1.05-1.72		5-20
11d5.1	Seascale 1	Concrete Revetment	60	+6.5			10-20
11d5.1	South of Seascale	Masonry Wall	170	+5-10			20-50
11d5.3	Sellafield	Rock revetment (1-4t rock armour)	425	+9.9	No data	Fair	20-50
11d5.4 11d5.5	Braystones to Nethertown	Natural Cliffs and Various Defences	2,420	+6.0-12.0	+5.19-10.23	Fair/Good	20-50
11d5.5	Nethertown Shore Car Park	Concrete Slabbing	75	+8.0-10.0	+7.5-8.0	Fair/Poor	10-20
11d5.5	Nethertown 1	Vertical Property Walls	35	+8.0-10.0	+7.5-8.0	Fair	20-50
11d5.5	Nethertown 2	Natural Cliff	340	+5.0-8.0	+4.86-6.82	Fair	20-50
11d5.5 11d5.6	Nethertown to St Bees*	Various Revetments	3,170	+8-10	+2.7-8.6	Fair/Good	20-50
11d5.6 11d5.7	Ancient Fishgarth*	Stepped Revetment/Natural Cliffs	400	+9.7	+5.41-7.39	Fair/Poor	10-20
11d5.7	Sea Mill (North of Ancient Fishgarth)	Rock Revetment (1-4t rock armour) and Gabions	200	+7.0	+4.76-5.88	Poor	10-20

Table 3 Network Rail Assets

Policy unit	Name	Number	Additional Notes	Work Required	Implement Year
11d5.3	Calder Viaduct and Approaches	1521546		Maintenance and protection works of pitching. Essential review and options or solutions required to enhance the resilience of the defence.	2017/2018
11d5.3	Sellafield Pitching	1508991	Coastal defence located between Seascale and Sellafield stations. The defence comprises of stone and concrete pitched revetment with square protruding concrete sections (dragon's teeth) equally spaced and rock armour at the toe in some locations.	The revetment has suffered significant scour with random areas of missing and damaged dragon's teeth. Large voids along the rock armour section. Preventative repair works also required to stone and concrete pitched revetment with works to replace missing dragon's teeth. Essential preventative works are required to infill areas of large voids.	2017/2018

11d5.4 and 11d5.5	Braystones Embankment	1521421	Coastal defence centred at Braystones Station. Comprises an embankment protecting the railway along the rear of the shore. There are isolated areas of rock armour and gabion basket present, but the majority of the frontage is unprotected. The defence is fronted by a sloping shingle beach and a non continuous terrace supporting beach huts/dwellings at the toe of the rail embankment.	There are areas along the defence that are showing signs of erosion. Protection measures are needed at the toe to improve the resilience of the defence.	2017/2018
11d5.5 to 11d5.7	Nethertown-St Bees Sea Walls	1521421		Littoral drift and erosion to embankment. Essential review and options/solutions required to enhance the resilience of the defence.	2018/2019

Policy unit 11d5.1 (Seascale)

Along the Seascale frontage (Figure 3) the concrete revetment along the southern section is susceptible to damage from lowering beach levels and potential outflanking from erosion of unprotected cliffs to the south.

Along the car park, the condition of the gabion wall and rock is generally Fair (see Figure 4). Winter storms of 2013 and 2014 damaged gabions in front of car park which has resulted in intermittent armour stone protection being provided. Remaining unprotected gabion sections are vulnerable to damage in future, which could lead to armour protection being extended across the whole frontage, north of the jetty (CH2M, 2017a). Cumbria Highways have already undertaken some work to enhance toe protection. Ongoing exposure could lead to breach of the existing defences, erosion of the hinterland and an increase in flood risk from overtopping.

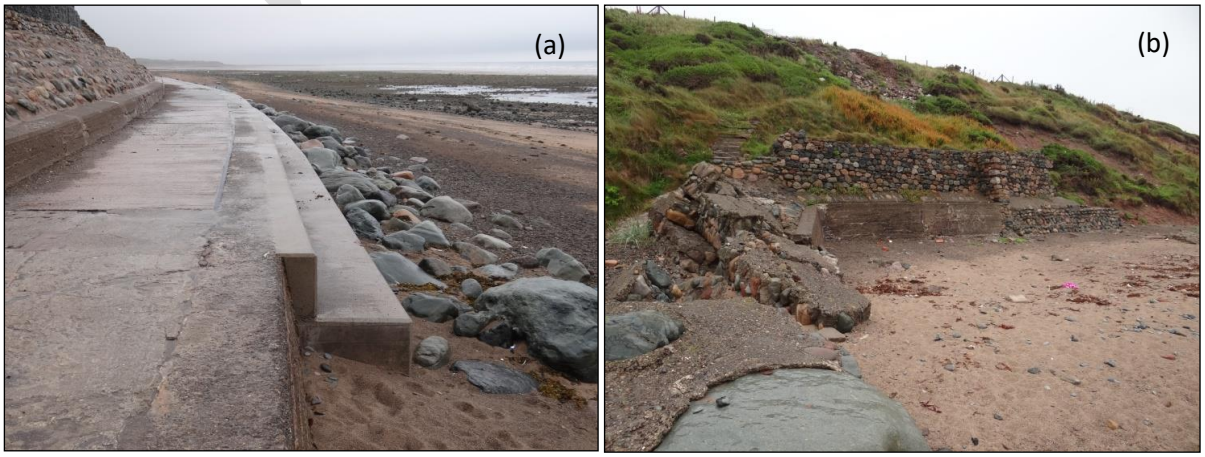

Figure 3 (a) Seascale concrete seawall (b) South of Seascale masonry wall (Site visit photo 2015; CEUK, 2016)

Figure 4 Seascale Shore car park defences looking south (Site visit photo 2015; CEUK, 2016)

Policy unit 11d5.2 (Seascale to Sellafield)

The beach is backed by low sand dunes and the railway embankment. The dunes are well vegetated and show little sign of change (CH2M, 2017b).

Figure 5 Seascale to Sellafield (11d5.2)

Policy unit 11d5.3 (Sellafield)

A large rock revetment defends the nuclear plant and railway line to the north of the Calder and Ehen outlet; there is some evidence that toe blocks have been displaced over time but overall condition of the structure is Fair (Figure 6). Network Rail have work planned for the southern end of the frontage towards the River Calder.

Figure 6 Sellafield (11d5.3)

The outlet channel of the River Ehen is diverted southwards, parallel to the coast, by a dune capped shingle spit which runs along the shoreline for over two kilometres forcing the channel to outlet where it meets the discharge from the River Calder at Sellafield (11d5.3). The spit was subject to manmade modifications in 1949 when two pipe lines were installed (Coastal Engineering UK, 2016a). In 2010 a notch was cut in the spit to form an access route for the beach import of the Evaporator D unit to the Sellafield site, which revealed that the top of the spit was artificial, probably consisting of excess fill from excavations associated with the pipeline installations. The notch was subsequently remediated. Repairs were also made to the southern end of the spit following damage during the 2014 storms.

Figure 7 Sellafield nuclear facility, fronted by the Ehen and Calder river mouth (11d5.3) © North West Regional Monitoring Programme, 2015

Policy unit 11d5.4 (Sellafield to Braystones)

There are coastal defences at Braystones station in the north of the policy unit. Here there is a defended embankment with the railway to the rear, elsewhere there are isolated rock armour, gabion baskets but much of the remaining frontage is undefended. A shingle beach and non continuous terrace supports beach huts and properties at the seaward toe of the railway embankment to the north of the policy unit. In 2016 Network Rail extended a section of the rock armour revetment along the railway embankment immediately south of Braystones station across sections previously occupied by properties which were taken down in 2015. New gabion defences were constructed at the first property south of Braystones station, filled with beach shingle rather than single sized stone, therefore it is likely the fines will be washed out and the gabion structure will settle (see Figure 8).

Figure 8 Braystones – rock revetment and gabions

Policy unit 11d5.5 (Braystones, Nethertown and Coulderton)

Between Braystones and Nethertown, there are various defences (Figure 9) including sections of revetment protecting the railway, which are in good condition, and informal defences along the beach properties comprising of gabion baskets and reprofiled shingle berms in various states of condition. At Nethertown car park, the concrete slabbing has failed and overall condition is Poor.

Figure 9 Nethertown 2 – Natural Cliff and Slipway at Nethertown shore car park (11d5.5)

Figure 10 Coulderton – beach properties (11d5.5 and 11d5.6) © North West Regional Monitoring Programme, 2015

Across the Coulderton frontage (Figure 10) there are a range of defences that have been placed in an attempt to reinforce the crest of the shingle bank north of the railway arch. There are gabions, random blocks and vertical stone and timber construction and a number of properties at the railway embankment seaward toe.

Winter storms in 2013 and 2014 caused movement in the shingle beach and damage to some properties. Local property owners built up the shingle fronting their properties to try and improve the standard of protection. Along this frontage monitoring has indicated an increase in beach reprofiling, increasing the shingle crest height and width fronting the properties (see Figure 11).

Figure 11 Braystones to Coulderton – shingle beach reprofiling

Figure 12 11d5.5 to 11d5.6 random tipped protection to the railway embankment. Rock shown in right photo appears to act as a spillway to a minor culvert.

Policy unit 11d5.6 (Coulderton to Sea Mill)

Various types of slope protection have been used in front of the railway line, which are the responsibility of Network Rail. There are two sections of revetment protecting the railway; these are in reasonable condition, with shorter sections of rock protection. Further north near Ancient Fishgarth, the stepped revetment is fronted by a revetment which is missing in several places. The cliffs behind appear fairly stable but there is outflanking at the southern end.

Figure 13 11d5.6 (Coulderton to Sea Mill) - various defences

Policy unit 11d5.7 (Sea Mill)

At Sea Mill (11d5.7), there is a linear gabion and rock revetment in a poor condition: the gabion baskets have failed and parts of the rock revetment are also displaced (Figure 14, Figure 15 and Figure 16).

A coastal protection options appraisal was undertaken for this frontage in 2012 and provided additional details of the existing defences, summarised in Table 4. The Capita report (Capita Symonds, 2012) examined the effectiveness of the existing defences, clarifying their ownership and maintenance responsibilities, and examined options for the future management, this is discussed further in Section 2.10.

Figure 14 Sea Mill defences (Capita, 2012)

Table 4 Sea Mill Additional Existing Defence Details, taken from Sea Mill Coast Protection Options Appraisal, Capita Symonds (2012).

Location		Structure Type	Length (m)	Condition	Maintainer
11d5.7	Ancient Fishgarth Section 1	Stone and precast concrete revetment to face of clay cliff	68	3	Network Rail
	Section 2	Stepped concrete revetment to clay cliff with rock armour revetment from northern end to approximately the midpoint and around half the height of the concrete revetment. The rock armour overlaps onto section 3.	33	2	Network Rail
	Section 3	Rock armour revetment (continued from Section 2) with random quarried stone on the upper section of the cliff face.	23	2	Network Rail
	Section 4	Stepped concrete revetment with rock armour toe protection. Terminates at a drainage outfall immediately adjacent to the southern end of the Sea Mill defences.	26	3	Network Rail
	Sea Mill	Rock armour revetment to the front and rear of a gabion basket wall. The southern end of the gabion basket has rotated forwards.	116	3	Copeland BC

Figure 15 Sea Mill (North of Ancient Fishgarth) - Rock revetment and gabions

Figure 16 Ancient Fishgarth

2.1.3 Shoreline change

This unit encompasses the villages and smaller communities of Seascale, Braystones, Nethertown, Coulderton and Sea Mill beach, as well as the Sellafield nuclear site.

Along the Seascale frontage (11d5.1), there are low till cliffs which are susceptible to erosion due to wave overtopping of defences (CH2M, 2017b). The shingle cover along the beaches is sparser than further north, particularly along the southern section of this frontage, and in places sandstone crops out at the back of the beach, particularly where the defences have held the shoreline position seawards of where it may have moved to naturally, creating a slight promontory (Halcrow, 2011).

The long term picture of change from the regional coastal monitoring data shows less extensive change than the short term, indicating that the interannual change can be greater than the long term net change at this location. The data also show that despite experiencing a net lowering between 2015 and 2016, the upper beach fronting the main Seascale car park is currently higher than recorded in 2009 (CH2M, 2017b).

There are seasonal changes in beach levels, with up to 1 m change evident from the monitoring data, but these tend to be cyclical and relate to the natural redistribution of sand in response to prevailing conditions, with no net trend observed and overall the beach can be considered stable (Coastal Engineering UK, 2016a; CH2M, 2017b).

Between Seascale and Braystones, the net littoral drift is small and variable as the shore is aligned almost perpendicular to the predominant wave direction, whilst further north, towards St Bees Head, the sediment transport becomes northwards (Halcrow, 2011). This coast is not believed to receive significant amounts of sediment from the south, i.e. Morecambe Bay, the offshore or rivers (Halcrow, 2011). Erosion of the beach, nearshore profile and cliff deposits is therefore the key contemporary source of sediment and contributes a wide range of sediments to the beach systems, from muds to boulders (Halcrow, 2002). There is limited net transport of the upper shingle beach, with this predominantly taking place during storms, whilst the lower sandy foreshore is more mobile (Coastal Engineering UK, 2016; CH2M, 2017b).

Between Seascale and Sellafield (11d5.2), the beach is backed by low sand dunes and the railway embankment. The dunes are well vegetated and generally show little signs of ongoing change, apart from some fluctuation in both beach height and frontal dunes (both accretion and erosion) over time, in response to prevailing conditions (CH2M, 2017b). There is a shingle upper beach and sandy lower beach and as to the north, the shingle cover is quite sporadic and is intermixed with sand. The sand cover on the lower beach appears to be slightly greater along this stretch. As elsewhere along this frontage, net littoral sediment transport of shingle is low along this stretch due to the orientation of the coastline relative to the predominant wave direction. The outlet of the Calder and Ehen also interrupts any littoral drift from the north. The sand across the lower foreshore is more mobile than the upper shingle beach and cyclical changes can be observed, but overall the beach can be considered generally stable (Coastal Engineering UK, 2016a; CH2M, 2017b).

The outlet channel of the River Ehen is diverted southwards, parallel to the coast, by a dune capped shingle spit which runs along the shoreline for over two kilometres forcing the channel to outlet where it meets the discharge from the River Calder at Sellafield (11d5.3). Longshore drift is bi-directional, but the net magnitude is southwards albeit at a low rate of sediment transport (Coastal Engineering UK, 2016a). There is a drift divide at the northern end of the spit. Data indicate that there has been very little net change in recent years, but like elsewhere along the frontage, fluctuations in beach levels do occur, relating to the redistribution of the more mobile sand component of the lower beach (Coastal Engineering UK, 2016a; CH2M, 2017).

Till cliffs back the shoreline between Sellafield and St. Bees (11d5.4 to 11d5.7). Although the cliffs are composed of till, there are variations in the lithology along this coastline, which affects both the primary mechanism of cliff failure and the local composition of the beaches (Halcrow, 2011). The sand cover along the foreshore is thinner along this stretch, with scars a more dominant feature. The upper shingle beach is also less continuous than to the north and forms more of a fringing beach, particularly north of Nethertown, overlying sand, and in places sandstone beds outcrop, e.g. Nethertown Station (Brig Stones) (Halcrow, 2011). There is little net drift of sediment and the coarser upper beach sediment also tends to be only mobilised during storm conditions, when the main mechanism of transport seems to be cross shore drawdown. The small headlands along this coast may also act as partial barriers to alongshore movement of the upper beach sediments. The sand on the lower beach is more mobile, but along this stretch is sparse and forms a thin, transient veneer on top of the scars (Halcrow, 2011).

Seaward of the railway line there are several permanent and seasonally occupied beach dwellings which have been constructed on the crest of the gravel and rely on the beach for protection. The winter storms of 2013 and 2014 caused some localised damage to beach front properties and movement of the beach; subsequent beach management was carried out (Coastal Engineering UK, 2016a). Data suggests that there is general stability in the upper beach with more movement of lower sandy beach (Coastal Engineering UK, 2016a), although at a local level the most recent data indicates that in places the upper foreshore is currently at its lowest level on record, around Braystones and Sea Mill beach (CH2M, 2017). The coarse upper beach can be mobilised and

transported by waves, although this tends to be mainly during storms, such as observed during the winter storms of 2013 and 2014.

Erosion of the till cliffs is understood also to be predominately during storms, for example as observed along the cliffs at Ancient Fishgarth (11d5.7) during the 2013 and 2014 winter storms (Coastal Engineering UK, 2016a) but at other times the beach provides adequate protection along most of this frontage (Halcrow, 2011).

The longer term data shows that there has been little change in the cliff top position south of Sea Mill beach car park, however there has been recession of the face and toe, which will eventually lead to recession of the cliff top, although changes to the cliff top position are unlikely to be dramatic in the short term (CH2M, 2017b).

Predictions of future erosion from NCERM suggest the following bands of change, under a scenario of No active intervention:

Table 5 Estimated erosion risk extents from NCERM

	By year 20	By year 50	By year 100
11d5.1 Seascale	0 to 8 m	0 to 20 m	0 to 40 m
11d5.2 Seascale to Sellafield	0 to 20 m	0 to 48.5 m	0 to 97 m
11d5.3 Sellafield	0 to 20 m	0 to 48.5 m	0 to 97 m
11d5.4 Sellafield to Braystones	0 to 20 m	0 to 48.5 m	20 to 97 m
11d5.5 Braystones, Nethertown, Coulderton	0 to 8 m	1 to 20 m	3 to 40 m
11d5.6 Coulderton to Sea Mill	0 to 8 m	0 to 20 m	0 to 40 m
11d5.7 Sea Mill to Pow Beck	0 to 8 m	0 to 20 m	0 to 40 m

Erosion predicted for the frontages is slightly lower than erosion predicted by the SMP2, which suggested that between 50 and 100 m erosion could occur by year 100 along undefended cliffs and 40 to 80 m along currently defended sections (Halcrow, 2011). These erosion bands were considered broad enough to incorporate any effects of sea level rise.

2.2 Outline of the problem

2.2.1 Background

The key risk to this frontage is storm erosion of the beach and backing cliffs. There are localised tidal flood risks beneath the railway bridges and within the River Ehen floodplain. The properties on the beach and access road (B5344) are also susceptible to erosion of the beach, wave action and tidal flooding.

The railway embankment currently plays a key role as the frontline defence for the northern part of the policy unit and is showing signs of erosion. Network Rail recognise the need for options and solutions to enhance the resilience of the defence along various sections.

The SMP2 advised that Seascale (11d5.1) required a scheme to address erosion issues. This has become more urgent following damage caused in 2013 and 2014. Seascale suffered from flooding on 30th August 2012, when 23 properties were reported to have suffered internal flooding. Very intense rainfall was the ultimate cause and the performance of culverts within drainage systems has contributed to the flooding impacts (Cumbria CC, 2014). Cumbria County Council (Cumbria CC, 2014) identified measures to reduce the risk of future flooding that ranged from cleaning drainage systems, installing property level protection, to longer term solutions. There are currently three fluvial flood defence schemes in development to improve water quality and reduce fluvial flood risk to the properties and United Utilities (UU) waste water treatment works (WWTW).

Between Seascale and Sellafield (11d5.2), the beach is backed by low sand dunes and the railway embankment. The Cumbrian Coast Line runs along the top of, or in front of, the till cliffs between Sellafield and St. Bees (11d5.4 to 11d5.7). On much of this frontage the railway embankment currently plays a key role as the frontline defence and is showing signs of erosion. Network Rail recognise the need for options and solutions to enhance the resilience of the defence along various sections.

There is a risk of erosion to properties located on beach seawards of railway at Braystones, Nethertown and Coulderton. Currently Limited assets at risk within the River Ehen floodplain, but farmsteads, agricultural land and caravan park potentially impacted. The site for the proposed Moorside development includes part of the Ehen floodplain.

Issues, constraints and opportunities

There are no statutory land based environmental designations along this frontage, but Drigg Dune system lies approximately 400 m to the south of the frontage, which is part of the Drigg Coast SAC and SSSI. Since the SMP2 was developed, the Cumbria Coast Marine Conservation Zone (MCZ) was designated in 2013 to protect habitats and a diverse range of supported plant and animal communities; this includes intertidal and shallow subtidal zones along this and adjacent frontages north and south. Potential impacts of any works on these designations therefore needs to be considered.

The SMP policies along this frontage assume that the railway will continue to operate for decades to come. Consideration of a strategic approach to managing risks to the railway could provide potential efficiencies in future management.

The Sellafield nuclear site is a large facility immediately adjacent to the coastline within 11d5.3. NuGen has been developing proposals for the Moorside project which involves the construction, operation and maintenance of a nuclear power station, together with railway works between Corkickle and Mirehouse, St Bees and at the Moorside Site, amongst other development (which includes a marine off loading facility at the Moorside Site, highway improvements and worker accommodation) (see Figure 17). The business case on which the final investment decision will be taken is being developed and was originally planned to be complete by the end of 2018, but work on the Development Consent Order was paused in 2017 whilst Toshiba, the parent company undertook a strategic review and sought an alternative investor to take the project forward. In December 2017 a preferred bidder, KEPCO was announced (http://www.nugeneration.com/timeline.html). Relating to this frontage, concern has been raised regarding the possible natural extension of the Calder and Ehen spit and potential impacts on the River Ehen flood plain.

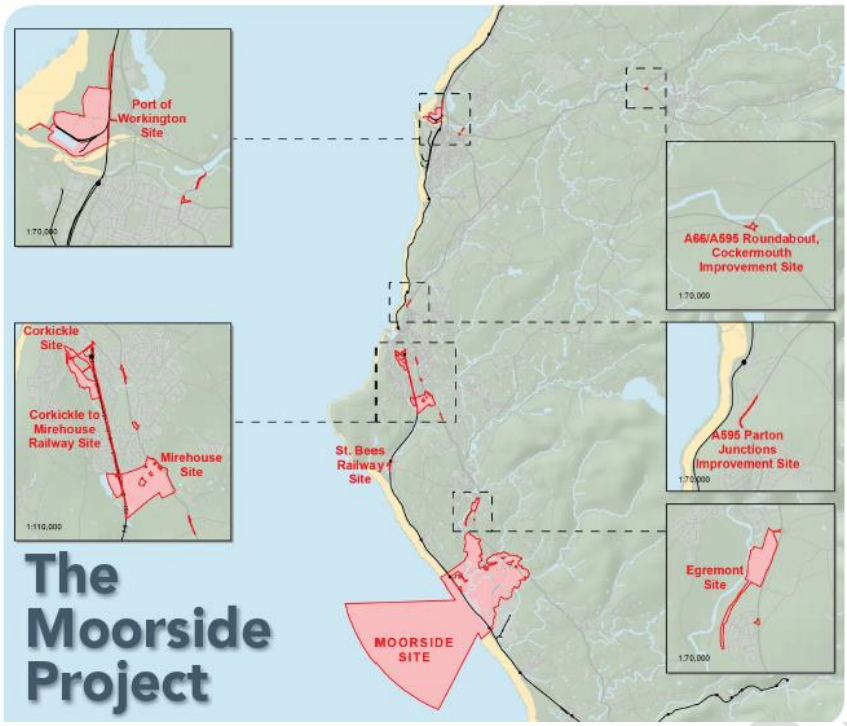

Figure 17 Moorside Project Overview (https://nugenconsultation.com/wp-content/uploads/2016/05/Proposed-Scheme-Overview.pdf)

Plans to extend the national cycleway are underway and consideration needs to be given to future erosion risk to the proposed cycleway route.

It is understood responsibility for the defences at Seascale Shore car park gabion wall lies with Copeland Borough Council (CBC), who carried out the works to bolster the gabions following the winter storms of 2013 and 2014. Copeland Borough Council's responsibility extends almost to the slipway. However, land ownership of the foreshore rests with the Nuclear Decommissioning Authority (NDA) and should major works be required in the future it would be appropriate for contributions to be sought from them (CH2M, 2017a). To the north of the village the railway embankment provides the primary line of defence.

There is also a need to consider a strategic approach to managing risks to beach properties. Copeland BC commissioned Capita Symonds to prepare a report for the Sea Mill frontage (11d5.7), produced in May 2012, to: aid the process of planning investment in future coastal defence improvements across Sea Mill and the Ancient Fishgarth frontage to the south, clarify defence ownership and maintenance responsibility and investigate the long term effectiveness of the defences as well as exploring several options for future management. Information from this report has been reviewed and summarised here.

Strategy considerations and general approach

Key considerations

Since the strategy was produced further monitoring data has been collated. The strategy has considered this more recent data to appraise:

- current defence conditions and risks
- recent shoreline change
- Impacts of the proposed Moorside Project – SMP policy or unit boundary needs to be considered to take account of Moorside proposal for policy units 11d5.3 Sellafield and 11d5.4 Sellafield to Braystones.

A review of the potential frontage effected by the proposed Moorside Project shows it extends just south of policy unit 11d5.4 to just north of policy unit 11d5.5, Figure 18. The SMP2 management policy for 11d5.4 is No active intervention – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk. At 11d5.3 the SMP2 policy is Hold the line – Maintain linear revetment and rock armour defences.

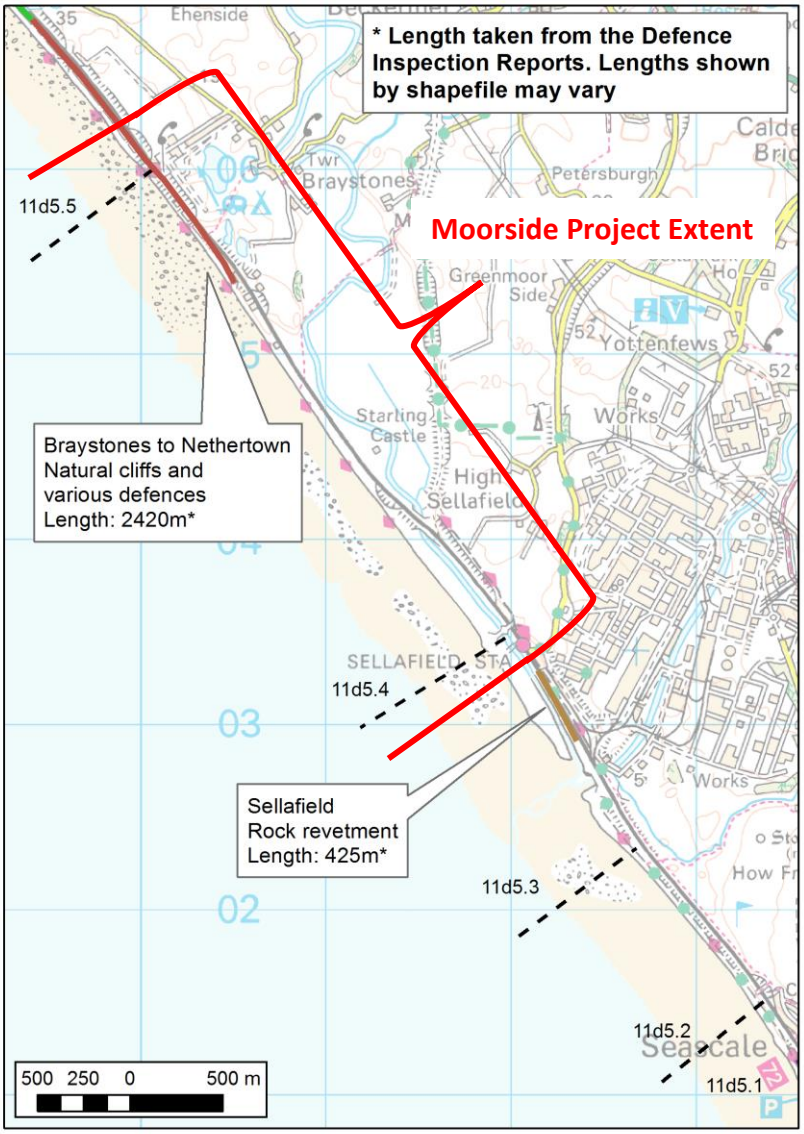

Figure 18 Approximate extent of Moorside Project and proposed policy unit change

Consideration needs to be given to the SMP2 policy of 11d5.4 and if the Moorside development could justify a change to a Hold the line approach. The SMP2 was prepared before the Moorside development was first proposed and concluded at the time that there was no justification for intervention until the railway is at risk, when viability of options would depend on overall case for railway.

- Consideration of options at policy unit 11d5.7 (Sea Mill) has been undertaken for the Coast Protection Options Appraisal, Capita Symonds (2012). For this strategy, a review of that document has been undertaken, taking into account latest observations from the asset inspections and monitoring data collated as part of the North West Regional Monitoring Programme.

Strategy approach

The following situations arise along this frontage, and will be addressed as following:

- SMP appropriate - the SMP2 policy does not need review so the aim of the strategy is to develop measures to implement the policy. Future works to manage flood and erosion risk may be eligible for a proportion of FDGiA funding and the economic appraisal will consider costs and benefits, following FCERM-AG guidance.
- Privately owned or funded defences – these are locations where the SMP policy may allow Hold the line subject to private funding and investment. The strategy will investigate the performance and impact of the defences and make recommendations on measures to ensure a strategic solution along the frontage. It is unlikely that these locations will attract significant FDGiA funding – here the focus will be on considering varying costs of approaches, environmental impacts on the wider coast and making recommendations accordingly.
- Proposed future developments – these are locations where the SMP policy may still be appropriate for current hinterland assets but where future developments are proposed. Here the strategy will consider possible measures taking account of a possible change to policy. Future or proposed developments cannot be included in economic assessment to justify FDGiA - here the focus will be on considering varying costs of approaches, environmental impacts on the wider coast and making recommendations accordingly.

2.3 Options development and appraisal

The main options report defined the long list options, each of these has been screened at a high level against technical, economic and environmental criteria to develop a list for final detailed appraisal.

The table below summarises the long list options for each policy unit covered in this section, in addition to the baseline options of:

- Do Nothing,
- Do minimum.

Table 6 Long list options considered for the priority units

Priority unit	Hold the line								Managed realignment				Other considerations
	***Maintain*: proactive maintenance**	***Maintain*: reinforce existing defences**	***Sustain*: reinforce existing defences**	***Improve*: improve existing defences**	***Improve*: construct new shore control structures**	***Improve*: construct new revetments or seawalls**	***Improve*: beach recharge**	***Improve*: cliff or slope stabilisation measure**	**Construct erosion slowing defences**	**Construct defences once set back**	**Construct secondary embankments**	**Remove existing defences**	**Adaptive management of assets**
11d5.1 Seascale	✓	✓		✓	✓	✓	✓	✓					
11d5.2 Seascale to Sellafield	✓	✓		✓	✓	✓	✓	✓	✓				
11d5.3 Sellafield	✓	✓	✓	✓	✓	✓	✓						
11d5.4 Sellafield to Braystones	✓	✓		✓	✓	✓	✓	✓	✓				✓
11d5.5 Braystones, Nethertown, Coulderton	✓	✓		✓	✓	✓	✓	✓	✓				✓
11d5.6 Coulderton to Sea Mill	✓	✓		✓	✓	✓	✓	✓	✓				
11d5.7 Sea Mill to Pow Beck	✓	✓		✓		✓							✓

The second stage has been to appraise the short listed options. Each of the sections below outline for each frontage the shortlisted options and approaches (measures) that could be adopted to achieve these.

Do nothing has been appraised as a baseline in all frontages. This option assumes that no further works would be undertaken and the existing defences would deteriorate over time, resulting in failure.

Additional information on environmental impacts will be provided in a **Strategic Environmental Assessment: Environmental Report** which systematically appraises the potential environmental consequences of the proposed strategy and recommends any actions needed to mitigate and monitor identified adverse effects.

The economic feasibility of implementing a particular option has been appraised through considering the packages of measures required for its implementation which have then been costed and the benefits of the strategic options identified and evaluated. The No active intervention option provides the baseline for the economic appraisal. This is reported in the **Economic assessment** report.

2.4 11d5.1 Seascale

Seascale is a small seaside resort, which originally developed in Victorian times when the Furness Railway was constructed. It remains a popular tourism destination, supporting fishing, walking, wind surfing and water skiing. There are also listed buildings located within the village centre.

Seascale village frontage consists of low till cliffs which are slowly eroding despite defences at the toe of the cliffs. These cliffs are fronted by a wide sandy beach interspersed by scars (or skears). Seascale village itself is mainly located on higher ground and the key risk is from erosion, although there is a small area at risk from flooding south of the station, which is presumably where Whitriggs Beck originally discharged to the sea (discharge is now via an outfall).

The Cumbrian railway line is a significant feature along a large stretch of this coast between Seascale and St Bees and provides an important link to adjacent villages as well as a regional link to other areas.

A series of short sections of defences consisting of gabions and concrete revetments currently protect the frontage. The cliffs to the south are undefended and railway embankments provide a line of defence in the north of the village.

2.4.1 11d5.1 - Initial screening of options

Table 7 Screening of long list options

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail	Baseline only	This option would not manage the erosion risk to properties and access road (B5344). It has been assessed for comparative purposes only.
Do minimum	Reactive patch and repair of defences only	Baseline only	Option would delay damages but does not completely reduce erosion risk. Option to be considered if funding cannot be justified.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	Yes	Utilises the existing defences and reduces breach risk.
Hold the line: maintain through reinforcing existing defences	For this frontage, the measures involved are likely to be the same as those considered above, so this has not been considered further as a separate option.		

Hold the line: improve existing defences	Measures to strengthen existing structures. Such as strengthen, widening existing defences, incorporating additional toe works to mitigate storm erosion and manage risk of outflanking to the south.	Yes	Strengthen existing structures to improve resilience against storm erosion. Would reduce risk of undermining and the potential to provide a consistent approach along the frontage.
Hold the line: improve through constructing new shore control structures	Construction of new shore control structures, such as groynes, reefs, breakwaters to manage the ongoing erosion.	No	Any control structures would require careful design and consideration of any negative implications along the coastline. Due to the erosion occurring under storm events technically a difficult option to achieve. It would be an imposing structure along the frontage, requiring detailed studies to confirm no adverse implications along the coast or to the MCZ designation. This option would also require a large capital investment.
Hold the line: improve through constructing revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	This option would require a large capital investment, possibly not justified in the short to medium term. Option would allow a consistent approach along the frontage, part of which would be the inclusion of cliff or slope stabilisation measures in the south to mitigate the risk of outflanking.
Hold the line: improve through beach recharge	Recharge beach through either nourishment or recycling, which could include a range of different sediments.	No	This option would require ongoing costs to maintain a 'recharge' beach profile and does not offer a resilient solution to the storm erosion problem. This option would also require the construction of shore control structures to retain the placed beach material. Detailed studies to confirm no adverse implications along the coast or to the MCZ designation. This would need significant capital investment and has therefore not been considered further.
Hold the line: improve through cliff or slope stabilisation	Introduce cliff or slope stabilisation measures, such as rock toe works, netting, rock bolting, drainage schemes.	No	Not considered as a separate option for undefended cliffs to the south of the policy unit. This option would need to be considered with other options for the defended Seascale frontage to the north and has therefore been combined with Hold the line: improve – construction of new revetments or seawalls for a whole frontage solution.

2.4.2 11d5.1 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	Under a Do nothing approach, the defences would deteriorate leading to eventual failure and leaving the railway, residential assets and infrastructure exposed. Based on the defences existing conditions this could occur within 5 to 10 years. The failure is likely to be an initial breach in the defence, leading to further flooding and outflanking of the defences. Increasing health and safety risk to community as defences erode.
Environmental	This option would result in continued erosion of defences and lowering of beach levels leading to a loss of properties, and severance of the B5344 and National Cycle Route 72. This would increase the isolation of the local community and prevent access to emergency services, as well as decreasing the recreational value of the area including a reduction in area of amenity beach and potential impacts on the designated bathing waters at Seascale. There would be an increasing risk of loss to erosion of the Cumbrian Coast railway line and the Seascale railway station. An uncontrolled risk of erosion and deteriorating defences would also result in an unsightly coastal frontage.

	This option would allow for the reinstatement of more natural coastal processes, which would support WFD objectives and may enhance the SSSI, MCZ and SAC to the south of the unit. Further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects (e.g. through changes in coastal processes) on the integrity of the SAC to the south of the site. Additionally, further assessment may be required to consider any changes to the MCZ (under the Marine and Coastal Access Act 2009) and SSSI (Countryside and Rights of Way Act 2000).
Cost	There are no costs associated with the Do nothing option.
Damages	Damages would include loss of property, car park and access road B5344. The cost of damages is estimated to be £1,180 k.

Do minimum (Option 2)

This is also considered as a baseline against which other options can be appraised. Under this option only reactive patch and repair maintenance would be undertaken, with no works to address any increase in risk due to sea level rise.	
Technical	The works under this option are low cost and reactive. They would address storm damage and would therefore prolong the lifespan of the defences for a short period of time (approximately 10 – 20 years). The defences along the frontage are a series of types that require a variety of repair methods. Existing gabion structures are not typically suited to such an exposed location and could present a weak point and be potentially be damaged in storm events.
Environmental	This option would maintain SOP in the short term, however impacts would be the same as Option 1 once the defences fail.
Costs	There is no Present Value Capital Cost, since costs are restricted to patch and repair works of the existing defences only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £250 k.
Benefits	Provides protection to the properties at erosion risk along the frontage for the short term. Damages would be limited but in the longer term there would be economic impacts similar to the Do nothing option. Due to delay of onset of Do nothing, the benefits are estimated to be £1,170 k.

Hold the line: maintain through proactive maintenance (Option 3)

Measures to maintain the existing defences. **This would be a continuation of current activities involving the addition of rock to the existing defences to prevent it from being undercut.**	
Technical	To reduce the risk of a breach developing in the existing defences, placement of a designed rock toe, including use of geotextile (as used when rock armour was placed in front of gabions) would improve the structures resilience to storm erosion. This utilises the existing defences and reduces breach risk. This option could prolong the life of the existing structures by approximately a further 10 to 15 years over the do minimum. However, the existing gabion structures are likely to be damaged during storm events. The gabions would need to be removed and replaced with rock armour in about 20 to 25 years (delayed intervention compared to Option 4). There are no measures within this option to address the increased risk of overtopping in the long term.
Environmental	The existing approach would be maintained and the flood and erosion risk to properties, infrastructure, and recreational features would continue. However, this option would not defend against any increase in overtopping risk that might arise as a result of sea level rise or climate change factors. The origin of the rock material used in the rock toe would have to be considered to ensure it blends in with the surrounding visual amenity of the frontage. Recycled material is preferred wherever possible. Additional rock toe protection to the existing defence may result in the loss of intertidal habitats, which are a part of the MCZ. This may result in direct encroachment in the larger footprint of the defence or indirectly through future coastal squeeze losses. Impacts should be monitored to ensure that the increased footprint would not be detrimental to the condition of the mudflats, which are a priority habitat. Impacts on the SSSI, MCZ and SAC should be reassessed when the strategy is reviewed in future. Further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the SAC to the south of the site. Additionally, further assessment may be required to consider any changes to the MCZ (under the Marine and Coastal Access Act 2009) and SSSI (Countryside and Rights of Way Act 2000). Additionally, further consideration would need to be given to ensure that holding the line is implemented in a manner that does not compromise the WFD objectives for the Cumbria coastal water body.

Costs	Regular monitoring, post storm events and repair or replacement of rock toe structure involves ongoing costs. The Present Value Capital Cost is estimated to be £620 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,340 k.
Benefits	Provide ongoing protection to the properties at erosion risk along the frontage. Damages would be limited but in the longer term there could be economic impacts of any increase in overtopping flooding, due to any increase in sea level. Due to delay of onset of Do nothing, the benefits are estimated to be £1,180 k compared to Do nothing option.

Hold the line: improve existing defences (Option 4)

This would involve measures to improve the existing standard of protection. **This would be a continuation of existing works involving the addition of rock to the revetment toe to prevent it from being undercut, but would also include works to remove the existing gabions at Shore car park and reconstruction of the seawall fronting the B5344.**	
Technical	This option would involve removal of the existing gabions and the repair and reconstruction of the seawall to provide tidal flood protection. Extension of the rock armour toe is likely to be required to reduce the risk of undermining. This option would provide a consistent approach along the frontage. Replacement of the existing gabions is recommended in order to provide a more robust and resilient defence in this exposed location; a suitable replacement could be an extended rock toe.
Environmental	The existing standard of protection would be maintained and the flood and erosion risk to properties, infrastructure, and recreational features would be managed. In addition to this, this option would defend against increased risk of overtopping in the future that might result from sea level rise or climate change. Consideration as to the origin of any rock material used as part of this option must be considered, see option 3. The additional rock toe protection to the existing defence may result in the loss of intertidal habitats which are a part of the MCZ. This may result in direct encroachment in the larger footprint of the defence or indirectly through future coastal squeeze losses. Impacts should be monitored to ensure that the increased footprint would not be detrimental to the condition of the mudflats which are a priority habitat. Impacts on the SSSI, MCZ and SAC should be reassessed when the strategy is reassessed in future. Further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the SAC to the south of the site. Additionally, further assessment may be required to consider any changes to the MCZ (under the Marine and Coastal Access Act 2009) and SSSI (Countryside and Rights of Way Act 2000). Additionally, further consideration would need to be given to ensure that holding the line is implemented in a manner that does not compromise the WFD objectives for the Cumbria coastal water body.
Costs	It may be necessary to monitor and replace any displaced rock after storm events, therefore substantial costs could be involved. Raising the crest would also incur additional costs. The Present Value Capital Cost is estimated to be £1,830 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,990 k.
Benefits	Provide improved protection to the properties and community from coastal flood and erosion risk along the frontage. The benefits are £1,180 k compared to Do nothing option.

Hold the line: improve through constructing new revetments or seawalls (Option 5)

This would involve measures to improve the existing standard of protection. **The removal of the existing defences and construction of a continuous revetment and seawall along the frontage. Consideration of the tie in at the base of the cliff to ensure a whole frontage option and mitigate potential outflanking risk.**	
Technical	The demolition of the existing defences and replacement with a consistent defence along the frontage would reduce the erosion and flooding risk by introducing a consistent and resilient solution for the length of the frontage. A suitable structure at this location would be a rock revetment with the inclusion of a seawall along the existing alignment. Cliff or slope stabilisation measures would be included for the undefended cliffs immediately to the south of the policy unit, ensuring a suitable tie in detail to ensure the risk of potential outflanking is addressed.

Environmental	The flood and erosion risk to properties, infrastructure, and recreational features would be reduced. Additionally, this option would mitigate future increasing risk arising from sea level rise or other climate change factors. This option would result in changes to the existing landscape and visual amenity through the introduction of new hard structures. The additional rock toe protection to the existing defence may encroach on intertidal habitats which are a part of multiple designations. This may result in direct loss of these habitats to the larger footprint of the defence or indirect loss through changes to the regimes of the coastline as a result of the changes. Impacts should be monitored to ensure that the increased footprint would not be detrimental to the condition of the mudflats which are a priority habitat and a named NCA feature. Impacts on the SSSI, MCZ and SAC should be reassessed when the strategy is reassessed in future. Further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the SAC to the south of the site. Additionally, further assessment may be required to consider any changes to the MCZ (under the Marine and Coastal Access Act 2009) and SSSI (Countryside and Rights of Way Act 2000). Additionally, further consideration would need to be given to ensure that holding the line is implemented in a manner that does not compromise the WFD objectives for the Cumbria coastal water body.
Costs	It may be necessary to monitor and replace any displaced rock after storm events, therefore substantial costs could be involved. Raising the crest would also incur additional costs. The Present Value Capital Cost is estimated to be £5,110 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £8,520 k.
Benefits	Protection to the properties at erosion risk and any localised flooding along the frontage. Provide protection to the properties at erosion risk along the frontage from outflanking due to erosion of the cliffs in the south. The benefits are £1,180 k compared to Do nothing option.

2.4.3 11d5.1 – Discussion of Options

Table 8 summaries the economic data

The SMP2 identifies a long term policy to Hold the line for this frontage (Halcrow, 2011), with a recommendation to replace the existing defences with a structure designed to withstand any further erosion over the remainder of the SMP period.

There are several alternative approaches to Hold the line in the long term, although the most suitable technical approach is to provide a formal rock revetment with a seawall (Option 5); other methods could be considered with further investigation. The defence may need to be higher than the current low bank level to prevent overtopping and flooding in the future.

An approach of Hold the line: maintain through proactive maintenance (Option 3) in the short time would allow funding options to be investigated and allow time to develop a long term solution (delayed implementation of new revetments as option 4). This will also allow the Investigation of potential cost efficiency gained by packaging elements of work across the strategy frontage. Ongoing monitoring can identify key risk areas for repair and allow a programme of works to be developed to ensure the defence is maintained.

Table 8 Policy unit 11d5.1 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (PVc)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
Option 1 Do nothing	0.00	0.00	0.00	-
Option 2 Do minimum	0.00	0.25	1.17	4.68
Option 3 Hold the line: maintain through proactive maintenance	0.62	1.34	1.18	0.88

Option 4 Hold the line: improve existing defences	1.83	2.99	1.18	0.40
Option 5 Hold the line: improve - construct new revetments or seawalls	5.11	8.52	1.18	0.14
**Present Value cost (PVc) inclusive of 60% optimism bias*				

2.5 11d5.2 Seascale to Sellafield

Between Seascale and Sellafield, the beach is backed by low sand dunes and the railway embankment. There is a shingle upper beach and sandy lower beach and to the north, the shingle cover is quite sporadic and is intermixed with sand. The dunes are well vegetated and generally show little signs of ongoing change, apart from some fluctuation in both beach height and frontal dunes (both accretion and erosion) over time, in response to prevailing conditions (CH2M, 2017b).

The sand dunes provide protection to the railway and there appear to be no formal defences along this frontage[2]. Overall the beach can be considered stable (CH2M, 2017b). Seaward of the railway is a cycle path, the current understanding is this is to be surfaced as part of the Moorside Project with an aim to reduce traffic on the Sellafield site. There are no other assets at risk along this policy unit.

The SMP2 management policy is No active intervention – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk. Options need to consider managing the risk to the railway and consideration of the proposed extension to the national cycleway.

2.5.1 11d5.2 - Initial screening of options

Table 9 Screening of long list options for 11d5.2

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option is feasible in the short term but would need further investigation to determine if it would manage the medium and long term erosion risk to the railway assets.
Do minimum	Reactive patch and repair of defences only.	No	It is assumed there are no formal defences along this frontage. Managed realignment: Construction erosion slowing defences with low technical solutions may be considered as an alternative to Do minimum for comparison purposes.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	No	There are no formal defences along this frontage, therefore this option is not considered.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to improve longevity of existing defences.	No	There are no formal defences along this frontage, therefore this option is not considered.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising defence crest.	No	There are no formal defences along this frontage, therefore this option is not considered.

[2] (Site visit undertaken 14.05.2018 by Copeland BC to check to see if gabions were present, – none seen, just evidence of old railway sleepers within embankment next to foot/cycle path.)

Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwater.	No	This an exposed location but with limited net alongshore drift so for this solution to be viable significant volume of beach material would need to be sourced to fill the groyne bays. This is not considered a viable option given the high capital cost and potential implications to the adjacent shoreline.
Hold the line: improve through constructing new revetments or seawalls	Construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide a resilient and ongoing protection to the railway. It does require a significant capital cost which may not be viable given the present risks.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conductive to artificial beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge to maintain the profile. These represent high capital and ongoing maintenance costs; therefore, this option is not considered further.
Hold the line: improve through cliff or slope stabilisation measures	This may include toe protection works, drainage or netting.	No	The key risk for this strategy is erosion and scour of the toe of the railway embankment, therefore provision of toe protection is likely to be the most effective solution. Where this is in front of the existing defences this is considered as part of "Hold the line: improve existing defences", where new defences are required it is considered as "Hold the line: improve through construction new revetments or seawalls". This has therefore not been taken forward as a separate option.
Managed realignment: construction of erosion slowing defences	Low tech measures such as rock armour toes and sand filled geotextile bags.	Yes	Low tech solutions may be appropriate in areas where there is no imminent risk to the railway. This option has therefore been considered further.

2.5.2 11d5.2 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and any defences would be allowed to fail.	
Technical	Currently the railway is protected by the low sand dunes and the railway embankment. There is a risk of increased erosion in future with sea level rise, see Table 5. This means that the railway is at risk in the medium to long term given the current stable nature along this frontage. In the short term a Do nothing approach is viable although consideration of the proposed cycleway seaward of the railway would be at risk sooner.
Environmental	The Do nothing option would not change the current risk of tidal flooding and allows coastal erosion to continue. This would allow the coastline to develop naturally, potentially enhancing the Cumbria Coast MCZ, and the intertidal mudflats and sand dunes present (BAP habitats). This option would continue to benefit the Cumbria coastal water body, allowing it to evolve naturally without hydromorphological constraints. There are currently no defences present protecting the railway other than the natural sand dunes which may be subject to erosion as a result of this option. In the long term, this would leave risk of damage and erosion or tidal inundation of the railway line. This railway line is important for both passenger and freight transport, and its erosion or inundation would impact on the

	connectivity of the communities on the coastline as well as the decommissioning works ongoing at the Sellafield site to the north. Additionally, there are potential erosion risks to the National Cycle Route 72 and the golf course which are significant recreational assets in this unit.
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the railway assets and infrastructure and associated impacts on rail transport of goods and passengers. No benefit values have been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Option 2)

This involves the construction of a formalised revetment to provide improved protection to the railway. Although no current defence management is undertaken, intervention may be required in the medium to long term.	
Technical	The construction of a new revetment would provide a consistent and formalised defence for the railway, providing the required protection in the long term. A vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment is preferred to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.
Environmental	The risk of damage from coastal erosion and frequent flooding to the railway, National Cycle Route 72, the long distance Coast to Coast Path and Seascale Links golf course would be reduced through this option. This would protect the connectivity of coastal communities, maintain current land uses in the hinterland and maintain access to the railway for ongoing activity at the Sellafield site. However, there are likely to be negative impacts on the environment as a result of HTL including the coastal squeeze of intertidal mud and sandflats against new fixed defences and the loss of established, vegetated sand dunes (BAP habitat). These habitats are a designated feature of the Cumbria Coast MCZ. The increased footprint of the new defences may also result in the direct loss of intertidal habitats within the MCZ designated area itself. Additionally, new defences have the potential to affect coastal processes and sediment transport, which could affect the Drigg Coast SAC and SSSI, which lie at a minimum distance of 1.5 km to the south. Further consideration would need to be given to the Habitats and Species Conservation Regulations (2017), to assess the potential for significant effects on the integrity of this Natura site. Additionally, further assessment may be required to consider any changes to the SSSI under the Countryside and Rights of Way Act 2000. The introduction of new defences will affect local landscape character and may affect views of the sea from Seascale Links golf course. This option may compromise the WFD objectives of the Cumbria coastal water body as new defences would increase hydromorphological pressure on the water body, and therefore WFD assessment would be required. Location of the new defences would have to take into consideration the route of the current proposed cycle route.
Costs	Larger capital cost to construct a new defence along frontage. The Present Value Capital Works are estimated to be £2,240 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £3,820 k.
Benefits	This option would provide benefits by protecting to the railway and future-proofing the infrastructure against potential increases in sea level, changes in wave climate and storminess. However, given the current beach stability it is not anticipated the future benefits would justify a large capital scheme in the short term. No benefit values have been calculated at this stage.

Managed realignment: construct erosion slowing defences (Option 3)

This would involve measures to slow the rate of erosion by considerations of introducing a rock toe, low tech solution at a set back location along the railway.	
Technical	This option would only provide temporary short term protection to the railway embankment and cycleway. Loose tipped rock could be considered at this set back alignment as a sacrificial defence with a life span of less than 10 years. Given there is no imminent risk to the railway this option this could be considered as a reactive measure, avoiding the need for large scale up-front capital costs whilst developing a design for the frontage such that as and when piecemeal repair works are undertaken they follow a consistent robust solution.

Environmental	In the short term, this option would reduce risk to the railway and thus the assets in the hinterland as outlined in option 2. This option maintains the current situation but with a small increase to the structure foot print due to the extension of toe protection. This increased footprint would encroach on the Cumbria Coast MCZ and would result in a small loss of vegetated sand dunes (BAP habitat). Similar impacts of coastal squeeze on the habitats present on the shoreline are a risk under this option as they are under the HTL option as ultimately, the railway line presents a hard defence which may constrain coastal processes in the long term. The Drigg Coast SAC and SSSI, lie at a minimum distance of 1.5 km to the south; therefore, further consideration would need to be given to the Habitats and Species Conservation Regulations (2017), to assess the potential for significant effects on the integrity of this Natura site. Additionally, further assessment may be required to consider any changes to the SSSI under the Countryside and Rights of Way Act 2000. Similarly, impacts on current WFD objectives of the relevant waterbodies must be considered.
Costs	Costs include the preparation of embankment toe and placement of rock toe. The Present Value Capital Works are estimated to be £460 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £790 k.
Benefits	The key damages are the risk to the railway should the defences breach, this option would provide benefits by delaying this. No benefit values have been calculated at this stage.

2.5.3 11d5.2 – Discussion of Options

Table 10 provides a summary of costs for the various options considered above: note that benefits relate primarily to the railway and have not been calculated at this stage.

The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail. The current SMP2 management policy is No active intervention. Due to the strategic link the railway provides, monitoring of the flood and erosion risk to railway and undertaking works if the railway is at risk are included within this SMP2 policy management approach. The options considered focus on managing the risk to the railway and consideration of the proposed extension to the national cycleway.

Under the current SMP2 management approach, in the short term the cycle path seaward of the railway appears feasible, although it could be susceptible to storm damage and wind blown sand. Beach monitoring data collated as part of the North West Regional Monitoring Programme indicate that there is a natural variation in the position of the dune toe over time, which may have implications for the cycle path. Further consideration of the route and potential exposure due to its proximity to the sea in the medium to long term will therefore be needed in the future.

There is a need to better understand the level of risk to the railway in the medium to long term and operations for continued safety and avoidance of unacceptable risk. An Asset Management Plan should be developed for the overall 11d5 frontage, alongside the other Network Rail coastal defences on this route. This would, include stability assessments, overtopping potential, identification of trigger levels, monitoring and responses. While Option 2 would provide the greatest benefits, it would also require the largest up front capital costs. Option 3 would be a more practical way forward, avoiding the need for large scale up front capital costs whilst developing a design for the frontage such that as and when piecemeal repair works are undertaken they follow a consistent robust solution.

The long term need to protect the railway at this location an option of Managed realignment: Construction erosion slowing defences (Option 3) is likely to provide the most cost effective and resilient solution for the strategy period. Given that the frontage is currently not imminently at risk, it can be considered as a low priority site.

Table 10 Policy unit 11d5.2 Summary of economics

Policy Unit	Option		Design Life	Capital Works year applied	Whole Life Cost (cash 2018)	Present Value (PV)			
						Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
			Year	Year	£m	£m	£m	£m	£m
11d5.2	Option 1	Do nothing	20	-	0.00	0.00	0.00	0.00	0.00
11d5.2	Option 2	Hold the line: Improve through constructing new revetments/seawalls	100	-	5.28	2.24	0.15	2.39	3.82
11d5.2	Option 3	Manged Realignment: Construction erosion slowing defences	30	5	0.60	0.46	0.03	0.49	0.79

2.6 11d5.3 Sellafield

A linear rock revetment (1 to 4t) at a crest level of 9.9 mOD currently provides protection to this stretch of coast. It is considered to be in a fair condition with a residual life of 20 to 50 years. The revetment is partially protected by the Ehen spit. The revetment provides protection to the railway and the Sellafield nuclear site which lies immediately adjacent to the coastline.

Network Rail coastal defences located along parts of the route between Seascale and Sellafield stations comprise of stone and concrete pitched revetment with square protruding concrete sections equally spaced and rock armour at the toe in some locations. Although the beach is considered to be generally stable, the revetment has suffered significant scour.

A dune capped shingle spit runs along the shoreline for over two kilometres forcing the River Ehen southwards until it meets the discharge from the River Calder at Sellafield Power station. Fronting the dunes is a generally stable beach although there are dynamic changes where the Calder and Ehen discharge crosses the beach.

The SMP2 management policy is to Hold the line by maintaining the existing revetment and rock armour defences in the short term and maintain or construct larger defences in the medium to long term. This avoids potential contamination risks and when the SMP2 was developed there were no known designated conservation sites or intertidal habitats to constrain a Hold the line policy.

Since the SMP2 was developed the Cumbria Coast Marine Conservation Zone (MCZ) protecting habitats on the beach was designated in 2013.

2.6.1 11d5.3 - Initial screening of options

Table 11 Screening of long list options for 11d5.3

Long list options	Description	Short-listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage the long term risk to the railway or other assets within the frontage. It has been assessed for comparative purposes.
Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage the long term risk to the assets and the railway. However, may become the default short term option if funding is not available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure in the short term until the defence meets the end of its residual life. It is understood that localised repairs have previously been undertaken to the end of the spit following storm damage by beach management with recycling of

			beach material. Similar maintenance work could be included under this and other options.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to improve longevity of existing defences.	Yes	Options to modify or adapt the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life attained. It is a viable option to be considered.
Hold the line: sustain through reinforcing and raising existing defences	Measures to retain the current standard of protection through the reinforcement of existing defences	No	This option is similar to Hold the line: Improve existing defences therefore has not been considered further. As erosion is the key risk, the difference between the two options is a small increase in the toe protection equating to a minimal increase in the cost to 'improve' the existing structure.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to reinforce the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life attained. It is a viable option to be considered.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwater.	No	This is an exposed location with protection provided by both the Ehen spit and the revetment on landward side of the channel. Shore control structures would need to be located on the seaward side of the spit. Evidence from monitoring suggests that the spit has been slowly growing and so there is no justification for intervention to modify the spit with control structures.
Hold the line: improve through constructing new revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide a resilient and ongoing protection to the railway. It does require a significant capital cost which may not be viable.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conductive to beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge to maintain the profile. These represent high capital and ongoing maintenance costs. There would also be potential issues with maintaining fluvial discharge from the Ehen and Calder. Therefore, this option is not considered further.

2.6.2 11d5.3 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	Without investment the defences will deteriorate further, leading to eventual failure and leave the railway exposed.

	The existing concrete and rock toe revetment has suffered significant scour with areas of missing and damaged concrete elements. Large voids along the rock armour sections means further scouring of these sections will lead to eventual breach in the defence. Based on current condition this could occur within 20 to 50 years.
Environmental	Do nothing may increase the frequency of tidal inundation to the site as well as risk of damage to current assets as a result of coastal erosion. The railway is a key strategic link and this option would lead to damage to the railway from coastal erosion and increased flood risk to the railway, disrupting service and potentially leading to loss of this asset completely in the long term. This would impact on the connectivity of the coastal communities and impact on the ongoing decommissioning works at Sellafield and the viability of the Moorside proposal as the railway and Sellafield Station is regularly used to transport material and personnel to and from the site. When current defences ultimately fail as a result of this option, the debris would be distributed along the frontage and may take many years to dissipate which could impact on visual amenity, the Cumbria Coast MCZ and possibly in the long term the SAC in the policy areas to the south as well as the WFD objectives of the Cumbria Coastal water body. Although it is expected that eventually, more natural processes would create a more natural coastline, this is outweighed by the high contamination risk of the site. Do nothing would likely result in more frequent inundation of the Sellafield site which is undergoing decommissioning, expected to last for up to 100 years. Due to the nature of the site as a nuclear site currently undergoing a long term decommissioning project, any erosion or flooding would present an unacceptable risk of contamination to the surrounding environment, potentially by nuclear material. Additionally, the site itself contains two landfill sites known as the Calder Tip and the Calder Tip Extension.
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the assets within this frontage and particularly the railway assets and infrastructure. No damage values have been calculated at this stage.

Do minimum (Option 2)

This is also considered as a baseline against which other options can be appraised. Under this option only reactive patch and repair maintenance would be undertaken, with no works to address any increase in risk due to sea level rise.	
Technical	As the works would be low cost and reactive only, as for the Do nothing the future life span of the existing defences depends on the future conditions, for example storm frequency and magnitude. If works are not carried out promptly, this could accelerate the time to failure of the defence. Given the ad hoc placement of sections this is not a resilient solution and will revert to a Do nothing once the defences fail, although providing a delay to that of Do nothing.
Environmental	Once defences fail, the impacts would be as for the Do nothing scenario.
Costs	There are no Present Value Capital Works, since costs are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £250 k.
Benefits	The key damages are to the railway assets and infrastructure, although timing would be delayed from the Do nothing option. No benefit values have been calculated at this stage.

Hold the line: maintain through proactive maintenance (Option 3)

Measures to maintain the existing defences. This would be a continuation of the current activities of patch and repair to the defences, based upon regular monitoring and as part of a scheduled programme of works.	
Technical	The timely undertaking of repair works to the existing structure can prolong the integrity of the structure. Works to prevent undermining and scour of the toe, with the proactive approach to patch and repair may extend the residual life (20 to 50 years) by approximately 10 years.
Environmental	If the defences ultimately fail, then potential risks will reflect those outlined in Option 1 after this 10 year delay period.
Costs	The Present Value Capital Works are estimated to be £870 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,630 k.

Benefits	The benefits of this option result from the delay, by approximately 10 years, of the key damages to assets and the railway should the defences breach. No benefit values have been calculated at this stage.

Hold the line: maintain through reinforcing existing defences (Option 4)

This would involve more low cost measures to reinforce the existing defences, but without improving, the existing standard of protection. The option could involve the infilling of the large voids currently present along the rock toe and replacing displaced rocks.	
Technical	Capital works to infill the current rock toe voids and reprofile the armour could delay failure of the defence by a few years. During severe storm events the ad hoc placed rock armour could become displaced and damage adjacent sections of the structure due to poor interlock. There would therefore may need to be regular repairs following storm damage. The approach would not include upgrading the defences and so is not sustainable in the long term.
Environmental	This option would maintain current protection to the assets mentioned previously. However, in the long term, this option would not defend against potential climatic factors such as rising sea level and more frequent and extreme weather events. Overtopping of current defences may lead to inundation of the railway assets. This option would continue to result in the coastal squeeze of intertidal habitat (predominantly sandy foreshore) within the Cumbria Coast MCZ. Potentially impacts on the Drigg Coast SAC and SSSI in policy area 11d4 to the south are considered minimal due to the distance from the site and the low net alongshore drift. Impacts on the WFD objectives of the Cumbrian coastal water body must be taken into consideration. If the defences ultimately fail after the expected 10 to 15 year delay then risks will reflect those under option 1.
Costs	Cost associated with the continual maintenance and filling the existing voids with rock armour. The Present Value Capital Works are estimated to be £110 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £470 k.
Benefits	The benefits of this option result from the delay, by approximately 10-15 years, of the key damages to the assets and the railway should the defences breach. No benefit values have been calculated at this stage.

Hold the line: improve existing defences (Option 5)

This would involve measures to improve defence resilience, such as rock toe works, raising crest levels to improve the standard of protection through the reinforcement of existing defences. The option could involve consideration of improvements to the toe of the existing structure and reprofiling of the main rock armour to provide a more resilient solution to scour and storm damage.	
Technical	The inclusion of a formal rock toe along the revetment, ensuring interlock and extent to allow for variations in the beach fronting the structure. This offers a viable solution to extend the life of the defences with ongoing investment as the railway is slightly set back.
Environmental	This option would reduce flood risk and protect against damage from coastal erosion as well as accounting for potential overtopping in the future as a result of sea level rise. As with the previous option, this option is HTL and so similar, continued impacts of coastal squeeze may occur in the long term potentially affecting the MCZ. The requirement to increase the footprint of the rock toe would result in loss of riparian habitat along the River Ehen, although there is no BAP habitat recorded to be present. Impacts of this option on the WFD objectives of the relevant waterbodies must be taken into consideration.
Costs	Capital cost associated providing a formalised toe and reprofiling of the rock armour to resist scour and storm damage with reduced regular maintenance compared to options 3 and 4. The Present Value Capital Works are estimated to be £760 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,500 k.
Benefits	The benefits of this option result from the delay, by approximately 20 to 25 years, of the key damages to the assets and the railway should the defences breach. No benefit values have been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Option 6)

This may involve the removal of the existing structure and construction of a formalised revetment to provide improved protection to the railway.	
Technical	The removal and reconstruction of a new revetment would provide a consistent and formalised defence. A vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment with a rough face is preferred to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.
Environmental	This option would result in very similar impact as option 5 – see above for details.
Costs	Larger capital cost to remove, dispose of existing structure and construction of new defence along frontage. Reduced costs for maintenance and repairs. The Present Value Capital Works are estimated to be £3,110 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5,400 k.
Benefits	This option would provide long term protection to the assets and the railway and future proof the infrastructure against potential increases in sea level, changes in wave climate and storminess. No benefit values have been calculated at this stage.

2.6.3 11d5.3 – Discussion of Options

Table 12 provides a summary of costs for the various options considered above: note that benefits relate primarily to the railway and have not been calculated at this stage.

The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail. There is a need to better understand the level of risk to the railway and operations for continued safety and avoidance of unacceptable risk. An Asset Management Plan should be developed for this frontage alongside the other Network Rail coastal defences on this route. This would include stability assessments, overtopping potential, identification of trigger levels, monitoring and prioritisation of responses.

Based on the current monitoring data the frontage is relatively stable, longshore drift is bi-directional and erosion is predominately storm driven, with little net change in recent years. Storm damage to the Calder and Ehen dune capped shingle spit in 2013 and 2014 required localised repairs to the end of the spit with recycling of beach material. This feature provides protection to the assets and if the spit is maintained this can prolong the protection.

There is a linear rock revetment which if proactively repaired and maintained (Option 3) could be sufficient to provide protection to the hinterland and the railway for in excess of 50 years. This would allow time for development of a long term solution of improving the defence by constructing a new revetment, rock armour likely to be most cost effective solution, in the long term (Option 6).

The presence of the spit and the existing defences means the railway is not at imminent risk from erosion or flooding, therefore can be considered a low risk frontage in the short and possibly medium term.

Table 12 Policy unit 11d5.3 Summary of economics

Policy Unit	Option		Design Life	Capital Works year applied	Whole Life Cost (cash 2018)	Present Value (PV)			
						Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
			Year	Year	£m	£m	£m	£m	£m
11d5.3	Option 1	Do Nothing	20	-	0.00	0.00	0.00	0.00	0.00
11d5.3	Option 2	Do minimum	25	-	0.23	0.00	0.15	0.15	0.25
11d5.3	Option 3	Hold the line: maintain through proactive maintenance	30	5	1.28	0.87	0.15	1.02	1.63
11d5.3	Option 4	Hold the line: maintain through reinforcing existing defences	35	5	0.45	0.11	0.19	0.29	0.47
11d5.3	Option 5	Hold the line: Improve existing defences	40	20	1.84	0.76	0.17	0.94	1.50
11d5.3	Option 6	Hold the line: improve - construct new revetments/seawalls	100	20	7.61	3.11	0.26	3.38	5.40

2.7 11d5.4 Sellafield to Braystones

The defences are centred at Braystones station, an embankment with the railway at the rear. There are isolated rock armour and gabion baskets but the majority of the frontage is undefended. Shingle beach and a non continuous terrace supports beach huts and properties at the seaward toe of the railway embankment.

The SMP2 management policy is No active intervention – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk. Options for the strategy need to consider managing the risk to the railway and the properties situated at the seaward toe of the railway embankment.

Monitoring data suggests that the upper beach is relatively stable with more movement of the lower sand beach (CH2M, 2016a). Although around Braystones the levels are presently at their lowest since the North West Regional Monitoring began. The erosion of the frontage is typically storm driven causing localised damage to the beach front properties.

A review of the potential frontage effected by the proposed Moorside Project shows it extends just south of policy unit 11d5.4 to just north of policy unit 11d5.5, Figure 18. Consideration needs to be given to the SMP2 policy of 11d5.4 and whether the Moorside Project could justify the change to a Hold the line approach. The SMP2 considered only present day land use in 2008 and concluded that there was no justification for intervention until the railway is at risk, when viability of options would depend on overall case for the railway. The Moorside project would clearly add justification to the case for intervention.

2.7.1 11d5.4 - Initial screening of options

Table 13 Screening of long list options for 11d5.4

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage the long term erosion risk to the railway or the beach properties located on the beach crest. It has been assessed for comparative purposes.
Do minimum	Reactive patch and repair of defences only.	Yes	This option would not manage the long term erosion risk to the railway assets or the beach front properties. However, may be become the default option if funding is not available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	Yes	The majority of the frontage is undefended with no formal coastal defences, therefore this would only

			apply where there are defences present, such as at Braystones station and the ad hoc defences – arguably as these are the areas deemed to be at greater risk in the short term this option has been considered further.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to improve longevity of existing defences.	No	The majority of the frontage is undefended with no formal coastal defences, therefore this would only apply where there are defences present, such as at Braystones station and the ad hoc. Given the informal nature of some of the defences and erosion being the predominant risk this option is better investigated under Hold the line: Improve existing defences and Hold the line: Improve through constructing new revetments or seawalls. Therefore, this option is not considered further.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	The majority of the frontage is undefended with no formal coastal defences, therefore this would only apply where there are defences present, such as at Braystones station and the ad hoc defences. Arguably as these are the areas deemed to be at greater risk in the short term, therefore this option has been considered further.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwater.	No	This an exposed location and for this solution to be viable significant volumes of beach material would need to be sourced. This is not considered a viable option given the high capital cost and potential implication to the adjacent shoreline. Furthermore, the beach is designated as an MCZ due to the rare honeycomb worm (Sabellaria alveolata) reefs. This option is therefore not considered further.
Hold the line: improve through constructing new revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide a resilient and ongoing protection. It does require a significant capital cost, but should be investigated further.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conducive to artificial sand beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge or recycling to maintain the profile. Importing large volumes of shingle or cobble material to significantly raise the beach is not considered viable as there are no suitable local sources. These represent high capital and ongoing maintenance costs. Furthermore, the beach is designated as an MCZ due to the rare honeycomb worm (Sabellaria alveolata) reefs. This option is therefore not considered further.

Hold the line: improve through cliff or slope stabilisation measures	This may include toe protection works, drainage or netting.	Not considered as a separate option	Undefended frontage to the south of the policy unit. This option would need to be considered with other options for the defended ad hoc and Braystones station frontage to the north. Therefore, has been combined with Hold the line: improve – construction of new revetments or seawalls for a whole frontage solution.
Managed realignment: construct erosion slowing defences	Low tech measures such as rock armour toes and sand filled geotextile bags.	No	The policy unit is exposed to waves and ongoing coastal processes such that a low tech solution will not offer the required resilience; therefore this option has not been considered further.
Other considerations: adaptive management of assets	Reprofiling of existing beach material.	Yes	There may be benefit in reprofiling the shingle beach to provide protection along the frontage, therefore this option has been considered further.

2.7.2 11d5.4 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	The various defences along this frontage range in condition from good to poor. Without investment the defences will deteriorate further, leading to eventual failure and increased exposure to the beach crest properties and the railway.
Environmental	This option would not reduce risk of flooding or damage by coastal erosion to various assets. Principally, the railway line would remain at risk of damage or loss to erosion. This would reduce operation of this railway, limiting the connectivity of Braystones to the wider area. Reduced accessibility due to the severance of the railway, would also affect the Sellafield site due. Beachfront properties would also remain at risk of damage or loss to coastal erosion. The wastewater treatment works in this frontage would be at risk of flooding or damage from erosion, which would impact on wider water resources and presents a risk of pollution should the material within the treatment works enter the wider environment. There are two caravan parks that appear to be directly at risk of damage from coastal erosion. This would impact on the recreational and tourist value of the area of Braystones. Additionally, increased frequency of inundation of the hinterland would likely reduce its viability as agricultural land. As tourism and agriculture are currently the two key economic impacts into the area, loss of these areas would lead to wider economic impacts. Although the Do nothing option would potentially result in the loss of terrestrial and freshwater habitats with an associated change in landscape character, this option could, in the long term, allow a more natural evolution of the coastline along the frontage, benefitting the maritime cliffs and slopes, and the Cumbrian Coast MCZ. This option may also enhance the geological value of the frontage through establishment of more natural erosion rates of the cliffs and slopes present around the Braystones station. Implementation of the Do nothing option may benefit the Cumbria coastal water body, reducing the existing hydromorphological pressures but consideration would need to be given to potential deterioration in water quality of the water body due to pollution risks. The Moorside proposal must be taken into consideration as this option would likely reduce the viability of this proposal due to risk of flooding of the proposed site.
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the railway assets and infrastructure and the beach crest properties. The property damages are estimated to be £610 k. Damages relate primarily to the railway but have not been monetised at this stage.

Do minimum (Option 2)

This is also considered as a baseline against which other options can be appraised. Under this option only reactive patch and repair maintenance would be undertaken, with no works to address any increase in risk due to sea level rise.	
Technical	As the works would be low cost and reactive only, as for the Do nothing the future life span of the existing defences depends on the future conditions, for example storm frequency and magnitude. If works are not carried out promptly, this could accelerate the time to failure of the defence. Given the ad hoc variety of defences, with no consistency and range of conditions this is not a resilient solution and will revert to a Do nothing once the defences fail.
Environmental	Once defences fail, the impacts would be as for option 1 – see above for details.
Costs	There is no Present Value Capital Cost, since costs are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £410 k.
Damages	The key damages are to the railway assets and infrastructure and the beach crest properties, although timing would be delayed from the Do nothing option. The property related damages are estimated to be £510 k. Damages relate primarily to the railway and have not been calculated at this stage

Hold the line: maintain through proactive maintenance (Option 3)

Measures to maintain the existing defences. This would be a continuation of the current activities of patch and repair to the defences, based upon regular monitoring and as part of a scheduled programme of works.	
Technical	The timely undertaking of repair works to the existing structures can prolong the integrity of the structure. Works to prevent undermining and scour of the toe, with the proactive approach to patch and repair the existing defences may extend the residual life by approximately 10 years. Although it could be costly, given the range of defences along this frontage. Network Rail have remedial works for some of the defences planned already.
Environmental	This option would maintain the current situation. Once the defences failed following the 10 year delay, the impacts would be as in option 1 – see option 1 for details.
Costs	Cost of patch and repair on an annual basis. The Present Value Capital Works are estimated to be £240 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £790 k.
Benefits	The key damages are the increased risk to the railway and the beach crest properties should the defences breach, this option would delay this by approximately 5 to 10 years. The property related benefits are estimated to be £100 k compared to Do nothing option. Benefits related to the railway have not been calculated at this stage.

Hold the line: improve existing defences (Option 4)

This would involve measures to improve defence resilience, such as rock toe works, raising crest levels to improve the standard of protection through the reinforcement of existing defences. The option could involve consideration of improvements to the toe of the existing structure to provide a more resilient solution to scour and storm damage.	
Technical	The inclusion of a formal rock toe along the revetment, ensuring interlock and extent to allow for variations in the beach fronting the structure. Although this would be incorporated along the existing defences, a separate detail would be required for each defence type and given this it would be difficult to provide a consistent defence along the frontage. It would also require significant refurbishment to the existing structures to ensure they would be able to maintain the required standard of protection. This also raises questions on the sustainability of less suitable existing defences that have been placed along the frontage and how to refurbish them to a sufficient standard.
Environmental	Maintains the current situation with an increase to the structure foot print due to the extension of the toe protection. This option would maintain the current flood defence to the railway assets, caravan parks, homes, and land related to the Moorside development. However, this option may lead to coastal squeeze of the intertidal habitats which are a part of the MCZ designation. This option would also restrict the natural erosion of the maritime cliffs and slopes, potentially affecting the geological value of the area, and would increase hydromorphological pressure on the Cumbria coastal water body Increasing the crest of the defences may affect local landscape character and views afforded of the sea. Should the defences fail or be breached, the impacts would be as in option 1 – see option 1 for details.

Costs	Cost associated with the refurbishment of the existing defences to a suitable condition, the continual maintenance and construction of a rock toe. The Present Value Capital Works are estimated to be £3,010 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5,300 k.
Benefits	The key damages are the increased risk to the railway and beach properties should the defences breach, this option would delay this by approximately 20 to 25 years. The benefits are estimated to be £100 k compared to Do nothing option. Benefits related to the railway have not been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Option 5)

This may involve the removal of the existing structures and construction of a formalised revetment to provide improved protection. Consideration of the alignment as two options (a) protect the railway, therefore construct behind the beach crest properties or (b) to protect the beach crest properties.	
Technical	(a) The removal and reconstruction of a new revetment would provide a consistent and formalised defence for the railway. (b) The proposed alignment could be considered in line with the existing properties, although this is likely to result in a much larger structure, rather than being set back in line with the railway. For both alignments a vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment is preferred to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.
Environmental	**(a) To protect the railway:** This option would defend the railway and the land behind it, including caravan parks, wastewater treatment works, and land proposed as the new Moorside development. However, there is a risk that the beachfront properties which will be left undefended will be subject to increased inundation and damage from coastal erosion. There is potential for HTL impacts of coastal squeeze of the intertidal habitats designated as part of the MCZ, however these may be delayed due to the set back nature of the proposed defences. Ultimately though, the hard defence will constrain natural erosion and coastal processes. There may be requirement for construction on the MCZ and which may result in loss of habitat and therefore the value of the MCZ. Impacts on the WFD objectives of relevant waterbodies must be taken into consideration. **(b) To protect beach crest properties**: This option would defend the assets as in a) with the addition of protecting the beachfront properties. There is potential for HTL impacts of coastal squeeze without the delay that the set back nature of a) gives. The location of the proposed defence on the exposed shoreline would result in a significant visual change and may limit the recreational and amenity value of the beach present. This in turn may impact on the attractiveness of the area to residents of the beach front properties. This exposed shoreline is also a part of the MCZ and construction in this area may result in reduced natural value of the MCZ. Additionally, this hard engineering of a previously exposed frontage may impact on the coastal processes and sediment movements along the shoreline, with increased hydromorphological pressure on the Cumbria coastal water body. Impacts on the WFD objectives of the relevant waterbodies must be taken into consideration.
Costs	Larger capital cost to remove, dispose of existing structure and construction of new defence along frontage. Option (b) would be required sooner, potentially in the short to medium term and option (a) in the medium to long term. Cost would be significantly greater for alignment (b) due to the larger structure required as a result of the more exposed location. For option (a) The Present Value Capital Works are estimated to be £6,520 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £11,120 k. For option (b) the PV cost increases to ~£18,600 k.
Benefits	(a) This option would provide protection to the railway and future proof the infrastructure against potential increases in sea level, changes in wave climate and storminess. It will not provide protection to the beach crest properties.

	(b) As well as protecting the railway this option would also provide protection to the beach crest properties, given there are limited number of properties at risk the additional cost for this option may not be justifiable. The benefits for option b are estimated to be £610 k compared to Do nothing option (property damages. No allowance for railway benefits.

Other considerations: adaptive management of assets (Option 6)

This option would be the reprofiling of the existing beach material to provide protection to the beach front properties.	
Technical	This option is consistent with current practice observed further along the frontage (11d5.5) although potentially greater in scale and frequency. Reprofiling the shingle beach to provide a higher and wider beach crest replicates the action of more wave action that might naturally occur with the aim of increasing the standard of protection. The option is likely to be constrained by the volume of shingle currently available and is therefore unlikely to be suitable beyond the short term as additional material would be required to raise the beach in order to adapt to rising sea levels in the medium or long term. The removal of sediments from at or below the mean water line will expose underlying sediments that will typically contain a higher percentage of finer particles leading to potential problems of near vertical cliffs forming in the beach profile (CIRIA, 2010). The operation of reprofiling does not collect from the below the low water line, which is where the sediment removed during storm events is deposited – the artificially created beach profile will be unnaturally steep in the upper inter tidal zone allowing larger waves to travel further inshore. This may discourage onshore movement of the sediment below the low tide mark as well as leading to more rapid erosion of the beach crest (CIRIA, 2010).
Environmental	This option would continue to manage coastal risks to the variety of assets discussed in this assessment without a hard engineering solution. The proposed wider beach profile may increase the recreational value of the area and so lead to increased attractiveness to tourists. This may have positive economic benefits. However, the requirement for regular reprofiling of the beach is likely to impact on the MCZ designation that covers the area from mean high water to mean low water. This area is designated for its extensive intertidal soft sediments which will be directly impacted by this option. The regular removal and redistribution may make it difficult for intertidal species to establish and flourish, and there are many bird species that feed on these intertidal species. Additionally, this option may have impacts on the geological processes of this frontage and the wider area due to wider impacts of sediment transport along the coastline.
Costs	Ongoing maintenance costs post storms, likely an annual operation. It is assumed that the option is only viable for up to 20 years. There is no Present Value Capital Cost and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £0.600 k.
Benefits	Potentially provides a wider and higher shingle beach fronting the properties improving the standard of protection against flooding in the short term. Benefits estimated as approx. £100k Does not consider railway.

2.7.3 11d5.4 – Discussion of Options

Table 14 summaries the cost and benefit calculations for the various options presented above.

Given the SMP policy concluded that there was not sufficient justification for intervention until the railway is at risk, when viability of options would depend on overall case for railway a proactive maintenance approach could be suitable in the short term (Option 3), essentially continuing current practices. Monitoring data suggests that the upper beach is relatively stable with more movement of the lower sand beach (CH2M, 2016a). Although around Braystones the levels are presently at their lowest levels. The erosion of the frontage is typically storm driven causing localised damage to the beach front properties. The SMP2 approach is therefore still valid in the short to medium term. Allowing the development of a long term solution of improving the defence by constructing a new revetment, rock armour likely to be most cost effective solution, in the long term (Option 5a).

The defences are centred at Braystones station, an embankment with the railway at the rear. There are isolated rock armour and gabion baskets but the majority of the frontage is undefended. Shingle beach and a non continuous terrace supports beach huts and properties at the seaward toe of the

railway embankment. There is no economic justification to providing significant investment at the present time. Option 6, reprofiling the shingle beach to provide a higher and wider beach crest is consistent with current practice observed along some of the frontage (11d5.5) but does not provide a sustainable solution in the long term due to sea level rise but does provide some short term reduction in coastal risks to the beach front properties, however a more resilient and cost effective solution would be Option 4 the inclusion of a formal rock toe along the revetment, although this is a much higher capital cost. As per the SMP policy, no further development should be permitted along the beach.

The railway is currently not imminently at risk, therefore can be considered as a low priority site. The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail. An Asset Management Plan should be developed for this frontage alongside the other network rail coastal defences on this route. This would include stability assessments, overtopping potential, identification of trigger levels, monitoring and prioritisation of responses. This will allow any changes to the exposure and risk to the railway are monitored and allow planning of any works and operations for continued safety and avoidance of unacceptable risk.

With the Moorside Project it is proposed an adaptive strategy for this frontage, once the Moorside Project is in place the justification to Hold the line at this location is possible. As the Moorside Project also includes the construction of a marine off loading facility, consideration of protection to the shoreline either side could provide an opportunity at the same time. Although the structure is considered temporary, it may be present for 10 years. The changes to coastal risks and mitigation requirements due to the off loading facility breakwaters are not yet known but will need to be considered in the Moorside Project EIA.

Table 14 Policy unit 11d5.4 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (PVc)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
Option 1 Do nothing	0.00	0.00	0.00	-
Option 2 Do minimum	0.00	0.41		
Option 3 Hold the line: maintain through proactive maintenance	0.24	0.79		
Option 4 Hold the line: improve existing defences	3.01	5.30		
Option 5a Hold the line: improve through constructing new revetments or seawalls	6.52	11.12		
Option 5b Hold the line: improve through constructing new revetments or seawalls	6.52	18.60	0.6	<<1
Option 6 Other considerations: adaptive management of assets	0.00	0.60	~0.1	<<1

**Present Value cost (PVc) inclusive of 60% optimism bias*
Options 2 -5 do not protect the properties seaward of the railway, just the railway.

2.8 11d5.5 Braystones, Nethertown, Coulderton

Between Braystones and Nethertown there are various defences including sections of revetment protecting the railway, which are in good condition, and informal defences along the beach properties, comprising of gabion baskets and reprofiled shingle berms in various states of condition. At Nethertown car park, the concrete slabbing has failed and overall condition is Poor. At a local level the most recent data indicates that in places the beach upper foreshore is currently at its

lowest level on record, around Braystones and Sea Mill (CH2M, 2017). The coarse upper beach can be mobilised and transported by waves, although this tends to be mainly during storms, such as observed during the winter storms of 2013 and 2014.

Monitoring data suggests there is general stability in the upper beach, NCERM erosion risk predictions are slightly less along this frontage than toward Seascale in the south.

The short term SMP2 policy is Managed realignment with the monitoring of flood and erosion risk to the railway and to only carry out works if the railway is at risk. It identified the need to develop an adaptation strategy for properties on the beach, with advisement that no further development should be permitted along the beach. This policy changes to No active intervention in the medium to long term with monitoring of the flood and erosion risk to the railway, only carry out works if the railway is at risk.

The SMP policy unit boundary is mapped as centred on Coulderton but it is suggested that for policy consistency across frontage where beach properties are located the boundary should be moved north to include them in 11d5.5.

2.8.1 11d5.5 - Initial screening of options

Table 15 Screening of long list options for 11d5.5

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage the long term erosion risk to the railway assets or the beach properties located along the beach crest. It has been assessed for comparative purposes.
Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage the long term erosion risk to the railway assets or the properties located along the beach crest. However, it may become the default option if funding is no longer available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure. This would not provide a long term solution to the storm erosion along the frontage.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to improve longevity of existing defences.	No	The existing defences within this policy unit are a variety of structures and some are in poor condition or are not considered suitable for the exposed location. The defences would require significant refurbishment as well as incorporation of measures to maintain their current level of protection – which is not considered to be enough. This option is therefore not considered further.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to reinforce the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life attained. It is a viable option to be considered, although noted that significant refurbishment of the existing defences is required due to their poor condition.

Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwater.	No	This an exposed location and for this solution to be viable significant volumes of beach material would need to be sourced. This is not considered a viable option given the high capital cost and potential implication to the adjacent shoreline.
Hold the line: improve through constructing new revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide a resilient and ongoing protection. Consideration of the proposed alignment could be considered in line with the existing properties. It does require a significant capital cost which may not be viable.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conductive to beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge or recycling to maintain the profile. These represent high capital and ongoing maintenance costs; therefore, this option is not considered further.
Hold the line: improve through cliff or slope stabilisation measures	This may include toe protection works, drainage or netting.	Not considered as a separate option	The key risk for the coastal strategy is erosion and scour of the toe of the structure, therefore provision of toe protection is likely to be the most effective solution. Where this is in front of the existing defences this is considered as part of “Hold the line: improve existing defences”, where new defences are required it is considered as “Hold the line: improve through construction new revetments or seawalls”. This has therefore not been taken forward as a separate option.
Managed realignment: construct erosion slowing defences	Low tech measures such as rock armour toes and sand filled geotextile bags.	No	The policy unit is exposed to waves and ongoing coastal processes that a low tech solution will not offer the required resilience therefore has not been considered further.
Other considerations: adaptive management of assets	Reprofiling of existing beach material.	Yes	There may be some benefit in reprofiling the shingle beach for the properties built on the beach therefore this option has been considered further.

2.8.2 11d5.5 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	The railway is slightly set back from the beach along most of the frontage and is not considered to be at imminent risk. Beach front properties are exposed under storm events and are situated at the toe of the railway embankment. Without investment in the existing defences the beach front properties and railway are increasingly at risk throughout the appraisal period.

	The ad hoc beach front property defences will be lost with each storm event and eventual failure and loss of the defences and eventually the properties themselves. In the long term this option increases the potential exposure of the railway in the medium to long term.
Environmental	This option could result in potential coastal erosion and flooding of the beachfront properties, as well as the railway which is a key link for coastal communities and industrial sites such as Sellafield. There may be impacts on the recreational amenity of the area dependent on the impacts to the accessibility and profile of the beach which would likely change under a Do nothing option. This option would allow natural coastal processes, which may enhance the Cumbria Coast MCZ habitats and benefit the Cumbria coastal water body as the failure of defences would remove some of its hydromorphological pressure. Impacts on the WFD objectives should be considered as this option may alter the hydromorphology of the frontage. Potential impacts on the Silver Tarn, Hallas and Harnsey Mosses SSSI under the Countryside and Rights of Way Act should be undertaken.
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the railway assets in the long term and infrastructure and the beach crest properties in the short term. The property related cost is estimated to be £1,870 k. No allowance for railway benefits.

Do minimum (Option 2)

This is also considered as a baseline against which other options can be appraised. Under this option only reactive patch and repair maintenance would be undertaken, with no works to address any increase in risk due to sea level rise. This option would only apply where defences are present.	
Technical	As the works would be low cost and reactive only, as for the Do nothing the future life span of the existing defences depends on the future conditions, for example storm frequency and magnitude. If works are not carried out promptly, this could accelerate the time to failure of the defence. Given the ad hoc variety of defences, with no consistency and range of conditions this is not a resilient solution and will revert to a Do nothing once the defences fail.
Environmental	Once defences fail, the impacts would be as for option 1 after approximately a 10 year delay.
Costs	There are no Present Value Capital Works, since works are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £330 k.
Damages	The key damages are to the railway assets in the medium to long term and infrastructure and the beach crest properties, although timing would be delayed from the Do nothing option. The property damages are estimated to be £900 k. No allowance for railway benefits.

Hold the line: maintain through proactive maintenance (Option 3)

Measures to maintain the existing defences. This would be a continuation of the current activities of patch and repair to the railway defences, based upon regular monitoring and as part of a scheduled programme of works. This option would only apply where defences are present.	
Technical	The timely undertaking of repair works to the existing Network Rail structures can prolong the integrity of the structures. Works to prevent undermining and scour of the toe, with the proactive approach to patch and repair the existing defences may extend the residual life by approximately 10 years. For the beach front properties defences this could be costly, given the range of defences along this frontage and the suitability to the exposed location. It is suggested that where gabions are present the fill material be replaced with more suitable single sized rock fill to prolong the structures life, although this is still not a resilient solution.
Environmental	This option would maintain the current situation. Once the defences fail following the 10 year delay, impacts would be as in option 1.
Costs	Cost of patch and repair on an annual basis. Refurbishment of any gabion structures. The Present Value Capital Works are estimated to be £300 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £820 k.
Benefits	The key damages are the increased risk to the railway in the long term and the beach crest properties should the defences breach in the short term, this option would delay this by approximately 5 to 10

	years. The property benefits are estimated to be £970 k compared to Do nothing option. No allowance for railway benefits.

Hold the line: improve existing defences (Option 4)

This would involve measures to improve defence resilience, such as rock toe works, raising crest levels to improve the standard of protection through the reinforcement of existing defences. The option could involve consideration of improvements to the toe of the existing structure to provide a more resilient solution to scour and storm damage. This option would only apply where defences are present.	
Technical	The inclusion of a formal rock toe along the revetment, ensuring interlock and extent to allow for variations in the beach fronting the structure. Although this would be incorporated along the existing defences, a separate detail would be required for each defence type and given this it would be difficult to provide a consistent defence along the frontage. It would also require significant refurbishment to the existing structures to ensure they would be able to maintain the required standard of protection. This also raises questions on the sustainability of less suitable existing defences that have been placed along the frontage and how to refurbish them to a sufficient standard. For example, where gabions are present the fill material be replaced with more suitable single sized rock fill to prolong the structures life, although this is still not a resilient solution.
Environmental	This option would maintain the current coastal defence to the railway assets and homes. HTL options such as this may lead to coastal squeeze of the intertidal habitats (and potential encroachment through the increased footprint of defences), which are a part of the MCZ designations. This would also impact on the natural erosion of the cliffs and slopes, potentially affecting the geological value of the area. Raising crest levels to improve the standard of protection may affect local landscape character and views afforded of the sea. Should the defences fail or be breached, the impacts would be as in option 1 – see option 1 for details.
Costs	Cost associated with the refurbishment of the existing defences to a suitable condition, the continual maintenance and construction of a rock toe. The Present Value Capital Works are estimated to be £2,270 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £4,060 k.
Benefits	The key damages are the increased risk to the railway and beach properties should the defences breach, this option would delay this by approximately 20 to 25 years. The property benefits are estimated to be £970 k compared to Do nothing option. No allowance for railway benefits.

Hold the line: improve through constructing new revetments or seawalls (Option 5)

This may involve the removal of the existing structure and construction of a formalised revetment to provide improved protection. Consideration of the alignment as two options (a) protect the railway, therefore construct behind the beach crest properties or (b) to incorporate and protect the beach crest properties.	
Technical	Option (a) The removal and reconstruction of a new revetment would provide a consistent and formalised defence for the railway. This option could tie into adjacent frontages to provide a consistent approach along this coastline to protect the railway. Option (b) The proposed alignment could be considered in line with the existing properties, although this is likely to result in a much larger structure, rather than being set back in line with the railway. The alignment would need to change as it progresses along the frontage and would interfere with the natural coastal processes along the frontage. For both alignments a vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment is preferred to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.
Environmental	**(a) To protect the railway:** This option would defend the railway and the land behind it. However, there is a risk that the beachfront properties which will be left undefended will be subject to increased inundation and damage from coastal erosion. There is potential for HTL impacts of coastal squeeze on the intertidal habitats designated as part of the MCZ, however these may be delayed due to the set back nature of the proposed defences. Ultimately though, the hard defence will constrain natural erosion and coastal processes. There may be requirement for construction in the MCZ, which may result in the loss of intertidal habitat

	and therefore reduce the value of the MCZ. Impacts on the WFD objectives of relevant waterbodies must be taken into consideration. **(b) To protect beach crest properties**: This option would defend the assets as in a) with the addition of protecting the beachfront properties. There is potential for HTL impacts of coastal squeeze without the delay that the set back nature of a) gives. The location of the proposed defence on the exposed shoreline would result in a significant visual change and may limit the recreational and amenity value of the beach present. This in turn may impact on the attractiveness of the area to tourists. This exposed shoreline is also a part of the MCZ and construction in this area may result in reduced natural value of the MCZ. Additionally, this hard engineering in a previously exposed frontage may impact on the coastal processes and sediment movements along the shoreline. Impacts on the WFD objectives of the relevant waterbodies must be taken into consideration.
Costs	Larger capital cost to remove, dispose of existing structures and construction of new defence along frontage. Option (b) would be required sooner, potentially in the short to medium term and option (a) in the medium to long term. Cost would be significantly greater for alignment (b) due to the larger structure required as a result of a more exposed location. The Present Value Capital Works are estimated to be £6,880 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £11,930 k for option (a), assuming implementation of capital works in year 20. For option (b) the PV cost estimate increased to about £20 million.
Benefits	Option (a) This option would provide protection to the railway and future proof the infrastructure against potential increases in sea level, changes in wave climate and storminess. It will not provide protection to the beach crest properties. Option (b) As well as protecting the railway this option would also provide protection to the beach crest properties, given there are limited number of properties at risk the additional cost and earlier intervention for this option may not be justifiable. The property benefits for option (b) are estimated to be £970 k compared to Do nothing option. No allowance for railway benefits.

Other considerations: adaptive management of assets (Option 6)

This option would be the reprofiling of the existing beach material to provide protection to the beach front properties.	
Technical	This option is consistent with current practice observed, although potentially greater in scale and frequency. Reprofiling the shingle beach to provide a higher and wider beach crest replicates the action of more wave action that might naturally occur with the aim of increasing the standard of protection. The option is likely to be constrained by the volume of shingle currently available and is therefore unlikely to be suitable beyond the short term as additional material would be required to raise the beach in order to adapt to rising sea levels in the medium or long term. The removal of sediments from at or below the mean water line will expose underlying sediments that will typically contain a higher percentage of finer particles leading to potential problems of near vertical cliffs forming in the beach profile (CIRIA, 2010). The operation of reprofiling may be counterproductive if it does not collect material from the below the low water line, which is where the sediment removed during storm events is deposited. Reprofiling of the upper inter tidal zone tends to leave an unnaturally steep beach profile in the upper inter tidal zone allowing larger waves to travel further inshore. This may discourage onshore movement of the sediment from below the low tide mark during calm beach building conditions as well as leading to more rapid erosion of the beach crest in storms (CIRIA, 2010).
Environmental	This option would continue to defend the variety of assets discussed in this assessment without a hard engineering solution. The proposed wider beach profile may increase the recreational value of the area and so lead to increased attractiveness to tourists. This may have positive economic benefits. However, the requirement for regular reprofiling of the beach is likely to impact on the MCZ designation that covers the area from mean high water to mean low water. This area is designated for its extensive intertidal soft sediments which will be directly impacted by this option. The regular removal and redistribution may make it difficult for intertidal species to establish and flourish, and there are many bird species that feed on these intertidal species. Additionally, this option may have

	impacts on the geological processes of this frontage and the wider area due to wider impacts of sediment transport along the coastline.
Costs	Ongoing maintenance costs post storms, likely an annual operation. There are no Present Value Capital Works. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £670 k. (assumes option only viable for 20 years)
Benefits	Provides a wider and higher shingle beach fronting the properties improving the standard of protection against flooding in the short term. Property benefits not calculated at strategy stage. No allowance for railway benefits

2.8.3 11d5.5 – Discussion of Options

Table 16 summaries the cost and benefit calculations for the various options presented above.

There are various defences including sections of revetment protecting the railway, which are in good condition, and informal defences along the beach properties, comprising of gabion baskets and reprofiled shingle berms in various states of condition.

The short term SMP2 policy is Managed realignment with the monitoring of flood and erosion risk to railway and to only carry out works if the railway is at risk. It identified the need to develop an adaptation strategy for properties on the beach, with advisement that no further development should be permitted along the beach. This policy changes to No active intervention in the medium to long term with monitoring of the flood and erosion risk to the railway, only carry out works if the railway is at risk. Not technically viable or economically justified to defend properties on the beach in the medium or long term. It is noted that there are several replacement properties that have been constructed along the beach crest since the SMP2. The SMP2 approach is still valid in the short to medium term. Allowing the development of a long term solution of improving the defence by constructing a new revetment, rock armour likely to be most cost effective solution, in the long term (Option 5a).

Option 6, reprofiling the shingle beach to provide a higher and wider beach crest is consistent although potentially greater in scale and frequency with current practice observed along some of the frontage. It does not provide a sustainable solution in the long term due to sea level rise but does provide for short term coastal risk management to the beach front properties. A more resilient and cost effective solution for the railway would be Option 4 the inclusion of a formal rock toe, although this is a much higher capital cost. No further development should be permitted along the beach. This is also the strategy for the properties located near Coulderton, where properties are situated approximately 500m into policy unit 11d5.6.

The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail. An Asset Management Plan should be developed for this frontage alongside the other network rail coastal defences on this route. This would include stability assessments, overtopping potential, identification of trigger levels, monitoring and prioritisation of responses. This will allow any changes to the exposure and risk to the railway are monitored and allow planning of any works and overall prioritisation of operations for continued safety and avoidance of unacceptable risk. Monitoring data suggests there is general stability in the upper beach, NCERM erosion predictions are slightly less along this frontage than toward Seascale in the south. The railway is currently not imminently at risk, therefore can be considered as a low priority site.

Table 16 Policy unit 11d5.5 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (PVc)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
Option 1 Do nothing	0.00	0.00	0.00	-
Option 2 Do minimum	0.00	0.33		

Option 3 Hold the line: maintain through proactive maintenance	0.30	0.82		
Option 4 Hold the line: Improve existing defences	2.27	4.06		
Option 5a Hold the line: improve through constructing new revetments or seawalls	6.88	11.93		
Option 5b Hold the line: improve through constructing new revetments or seawalls	11.5	19.7	0.9	<<1
Option 6 Other considerations: adaptive management of assets	0.00	0.67	-	<<<1
**Present Value cost (PVc) inclusive of 60% optimism bias* *Options 2 -5 do not protect the properties seaward of railway, just the railway*				

2.9 11d5.6 Coulderton to Sea Mill

There are two sections of revetment protecting the railway, these are in reasonable condition (residual life of 20 to 50 years), with shorter sections of rock protection. The cliffs behind are stable but there is outflanking at the southern end. The erosion of the till cliffs is primarily during storms, at other times the beach provides adequate protection along much of the frontage (Halcrow, 2011).

Across the Coulderton frontage there are a variety of defences (gabions, random blocks, vertical stone or timber structure) in an attempt to reinforce the shingle beach crest. Refer to 11d5.5 for consideration of beach properties situated at Coulderton at the interface between 11d5.5 and 11d5.6 as the remaining 11d5.6 frontage has no properties on the beach.

The SMP2 management policy for the policy unit is No active intervention – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.

2.9.1 11d5.6 - Initial screening of options

Table 17 Screening of long list options for 11d5.6

Long list options	Description	Short-listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	There are limited assets at risk but this option would not manage the long term erosion risk to the railway assets. It has been assessed for comparative purposes.
Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage the long term erosion risk to the railway assets. However, may become the default option if funding is no longer available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure. This would not provide a long term solution to the storm erosion along the frontage.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to improve longevity of existing defences.	No	Options to reinforce the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life attained. This option is similar to Hold the line: Improve existing defences therefore has not been considered further. As erosion is the key risk, the difference between the two options is a

			small increase in the toe protection equating to a minimal increase in the cost to 'improve' the existing structure.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to reinforce the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life attained. It is a viable option to be considered.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwater.	No	This is an exposed location and for this solution to be viable significant volume of beach material would need to be sourced. This is not considered a viable option given the high capital cost and potential implication to the adjacent shoreline.
Hold the line: improve through constructing new revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide a resilient and ongoing protection. It does require a significant capital cost, but should be investigated further.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conductive to beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge to maintain the profile. These represent high capital and ongoing maintenance costs, therefore this option is not considered further.
Hold the line: improve cliff or slope stabilisation measures	This may include toe protection works, drainage or netting.	No	The key risk for the strategy is coastal erosion and scour of the toe of the structure, therefore provision of toe protection is likely to be the most effective solution. Where this is in front of the existing defences this is considered as part of "Hold the line: improve existing defences", where new defences are required it is considered as "Hold the line: improve through construction new revetments or seawalls". This has therefore not been taken forward as a separate option.
Managed realignment: construct erosion slowing defences	Low tech measures such as rock armour toes and sand filled geotextile bags.	No	The policy unit is exposed to waves and ongoing coastal processes that a low tech solution will not offer the required resilience therefore has not been considered further.

2.9.2 11d5.6 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	The existing defences are not along the full length of the policy unit. The undefended sections are typically set back so not are likely to be at risk in the medium to long term. The existing rock armour revetment is in a fair condition, but without investment the defences will deteriorate further, leading to eventual failure and increased exposure to the railway.
Environmental	This option would result in risk of damage from coastal erosion and flooding to the beachfront properties (see 11d5.5 for further consideration of these), as well as the Cumbrian Coastal Railway Line which is a key link for coastal communities and industrial sites such as Sellafield. There may be

	impacts on the recreational amenity of the area dependent on the impacts to the accessibility and profile of the beach which would likely change under NAI. Do nothing option may allow natural coastal processes to enhance the MCZ habitats. Impacts on the WFD objectives must be considered as this option may alter the hydromorphological pressures along the frontage. Assessment of potential impacts on the St Bees Head SSSI under the Countryside and Rights of Way Act should be undertaken.
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the railway assets and infrastructure. The property related damages are estimated to be £300 k. No allowance for railway damages.

Do minimum (Option 2)

This is also considered as a baseline against which other options can be appraised. Under this option only reactive patch and repair maintenance would be undertaken, with no works to address any increase in risk due to sea level rise.	
Technical	As the works would be low cost and reactive only, as for the Do nothing the future life span of the existing defences depends on the future conditions, for example storm frequency and magnitude. If works are not carried out promptly, this could accelerate the time to failure of the defence.
Environmental	Once defences fail, the impacts would be as for option 1 after approximately 10 year delay.
Costs	There are no Present Value Capital Works, since works are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £700 k.
Damages	The key damages are to the railway assets and infrastructure and the beach properties, although timing would be delayed from the Do nothing option. The property related damages are estimated to be £290 k. No allowance for railway damages.

Hold the line: maintain through proactive maintenance (Option 3)

Measures to maintain the existing defences. This would be a continuation of the current activities of patch and repair to the defences, based upon regular monitoring and as part of a scheduled programme of works. This would not include the undefended sections along the frontage.	
Technical	The timely undertaking of repair works to the existing structure can prolong the integrity of the structure. Works to prevent undermining and scour of the toe, with the proactive approach to patch and repair may extend the residual life by approximately 10 years. The undefended sections would not be included within this option, therefore risk to the railway still remains in the medium to long term.
Environmental	This option would maintain the current situation. Once the defences fail following the after the extension of the residual life the impacts will as in option 1 – see option 1 for details.
Costs	Cost of patch and repair on an annual basis. The Present Value Capital Works are estimated to be £550 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,490 k.
Benefits	The key benefits are the reduced risk to assets and the railway. This option would delay the Do nothing damages by approximately 5 to 10 years. The property related benefits compared to Do nothing option are estimated to be <£10 k. No allowance for railway benefits.

Hold the line: improve existing defences (Option 4)

This would involve measures to improve defence resilience, such as rock toe works, raising crest levels to improve the standard of protection through the reinforcement of existing defences. The option could involve consideration of improvements to the toe of the existing structure to provide a more resilient solution to scour and storm damage. This would not include the undefended sections along the frontage.	
Technical	The inclusion of a formal rock toe along the revetment, ensuring interlock and extent to allow for variations in the beach fronting the structure. This offers a viable solution to extend the life of the defences with ongoing investment as the railway is slightly set back. The undefended sections would not be included within this option, therefore risk to the railway still remains in the medium to long term.

Environmental	This option would maintain the current flood defence to the Cumbrian Coastal Railway Line and homes present in the frontage as outlined in Option 1. HTL options such as this may lead to coastal squeeze, impacting on the intertidal habitats which are a part of the MCZ designations and the St Bees Head SSSI. Potential impacts on the latter will require further assessment under the Countryside and Rights of Way Act. This option would also impact on the natural erosion of the cliffs and slopes, potentially affecting the geological value of the area. Impacts on the WFD objectives of the relevant waterbodies must be considered. Should the defences fail or be breached, the impacts would be as in option 1 – see above for details.
Costs	Cost associated with the continually maintenance and improvement to the toe by filling the existing voids and providing a formalised toe to resist scour and storm damage. The Present Value Capital Works are estimated to be £1,270 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,590 k.
Benefits	The key damages are the increased risk to the assets and the railway should the defences breach, this option would delay this by approximately 20 to 25 years. The benefits compared to Do nothing option are estimated to be ~£10 k. No allowance for railway benefits.

Hold the line: improve through constructing new revetments or seawalls (Option 5)

This may involve the removal of the existing structure and construction of a formalised revetment to provide improved protection to the railway. This would include the currently undefended sections of the frontage.	
Technical	The removal and reconstruction of a new revetment would provide a consistent and formalised defence for the railway. A vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment is preferred to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.
Environmental	This option would defend the assets present in the frontage as in option 4. As in option 4, there is potential for HTL impacts of coastal squeeze. The location of the proposed defence on the exposed shoreline would result in a significant visual change and may limit the recreational and amenity value of the beach present. This in turn may impact on the attractiveness of the area to tourists. This exposed shoreline is also a part of the MCZ and construction in this area may result in reduced natural value of the MCZ. Additionally, this hard engineering in a previously exposed frontage may impact on the coastal processes and sediment movements along the shoreline. This may also impact on the St Bees Head SSSI which has geological features as part of its designations. Impacts will require assessment under the Countryside and Rights of Way Act. Impacts on the WFD objectives of the relevant waterbodies must be taken into consideration.
Costs	Larger capital cost to remove, dispose of existing structure and construction of new defence along frontage. The Present Value Capital Works are estimated to be £4,540 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £7,740 k.
Benefits	This option would provide protection to the assets and the railway and future proof the infrastructure against potential increases in sea level, changes in wave climate and storminess. The property protection benefits compared to Do nothing option are estimated to be £300 k. No allowance for railway benefits.

2.9.3 11d5.6 – Discussion of Options

Table 18 summaries the cost and benefit calculations for the various options presented above.

There are two sections of revetment protecting the railway, these are in reasonable condition (residual life of 20 to 50 years), if proactively maintained (Option 3) could be sufficient to provide protection to the hinterland and the railway for in excess of 50 years. Option 3 would only apply to the currently defended sections, as these areas are not at risk in the short term it would allow time for development of a long term solution of improving the defence by constructing a new revetment, rock armour likely to be most cost effective solution, in the long term (Option 6).

The undefended sections of the frontage are not considered to be imminently at risk however, there is a need to better understand the level of risk to the railway and operations for continued safety and avoidance of unacceptable risk. An Asset Management Plan should be developed for this

frontage, alongside the other network rail coastal defences on this route. This would include stability assessments, overtopping potential, identification of trigger levels, monitoring and prioritisation of responses. This would allow for ensuring the areas currently undefended are captured and protected when the risk increases. The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail.

The properties located at Coulderton are considered within policy unit 11d5.5, Section 2.8.

Table 18 Policy unit 11d5.6 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (PVc)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
Option 1 Do nothing	0.00	0.00	0.00	-
Option 2 Do minimum	0.00	0.70		
Option 3 Hold the line: maintain through proactive maintenance	0.55	1.49		
Option 4 Hold the line: improve existing defences	1.27	2.59		
Option 5 Hold the line: improve through constructing new revetments or seawalls	4.54	7.74		

**Present Value cost (PVc) inclusive of 60% optimism bias*
Options 2 -5 do not protect the properties seaward of the railway, just the railway. The strategy for properties located at Coulderton are considered within policy unit 11d5.5.
Benefits related to protection of railway not calculated at this stage.

2.10 11d5.7 Sea Mill to Pow Beck

The SMP2 management policy is to Hold the line by maintaining the existing revetment and rock armour defences in the short term and maintain or construct larger defences in the medium to long term. Where the railway turns away from the shoreline at Sea Mill there are several properties located between the coastal defences and the railway embankment.

At Sea Mill (11d5.7), the gabion baskets have failed and parts of the rock revetment are also displaced, such that the overall condition of the defence is Poor. Erosion of the till cliffs is understood to be predominately during storms, for example as observed along the cliffs at Ancient Fishgarth (11d5.7) during the 2013 and 2014 winter storms (Coastal Engineering UK, 2016a) but at other times the beach provides adequate protection along most of this frontage (Halcrow, 2011).

2.10.1 11d5.7 - Initial screening of options

Table 19 summarises the options considered by the Capita Symonds (2012) report and the equivalent strategy options considered elsewhere. All options that would have been considered as part of this strategy have been included in the short list of options by Capita Symonds.

Table 19 Options considered in the Capita Symonds (2012) report.

Capita Symonds short list options	Equivalent options considered elsewhere by this strategy
1. Do nothing	Do nothing
2. Do minimum	Do minimum
3A. Do Something: Upgrade existing defences at current location, extending the life of the existing defences by improving their condition.	Hold the line: maintain through reinforcing existing defences.

3B. Do Something: Continue maintaining the existing defences until they reach the end of their effective life span then replace them in their current locations. This option is similar to Option 2, but would replace the Sea Mill defences in front of the car park rather than constructing new defences adjacent to the railway.	Hold the line: maintain through proactive maintenance
3C: As Option 3B, but allowing the car park to erode and only providing new defences when properties come under threat from erosion.	Hold the line: maintain through reactive maintenance
3D: Reconstruction of the existing defences in their current positions in 2024. This option tests whether it may be advantages to replace all of the same time with a single structure rather than on a piecemeal basis. As for option 3A this would allow time for seeking funding, planning and designing the new structure before construction.	Hold the line: Improve through constructing new revetments or seawalls.
3E: As Option 3E by upgrading the defences when they reach condition 4 rather than in 2015.	Hold the line: Improve existing defences

2.10.2 11d5.7 - Development and appraisal of short listed options

Capita Symonds (2012) explored and assessed a range of implementation options for the frontage at Sea Mill, south of St Bees, from Pow Beck in the North to Ancient Fishgarth in the south. These have been considered from a technical, environmental and economic perspective.

The assessment concluded that the defences were in a generally reasonable condition, however decisions need to be made by Copeland BC and Network Rail on future management options for the defences, not least whether the properties and the car park can continue to be defended (Capita, 2012).

A number of options were considered (Capita, 2012), including:

- Continuing present maintenance until the defences fail at which point the Ancient Fishgarth defences would be replaced at their current location and new Sea Mill defences would be constructed to protect the railway line only rather than at the current location (Option 2)
- Upgrade the defences at differing times to extend the effective lifespan (Options 3A and 3E)
- Replacement of the defences at their present locations (Options 3B and 3D)
- Replacement of Ancient Fishgarth defences at their present locations and construction of setback defences at Sea Mill to protect the properties and railway line, but not the car park (Option 3C).

Following the screening of the options presented by Capita against technical, environmental and economic criteria Options 3A and 3E to be the most sustainable.

2.10.3 11d5.7 – Discussion of Options

Options proposed by Capita Symonds are considered to be reasonable and no additional relevant options have been identified as part of this strategy. Table 20 summaries the cost and benefit calculations. Proactive maintenance (Option 3B) could be sufficient to provide protection to the hinterland and the railway for in excess of 50 years; this would allow time for development of a long term solution of improving the defence by constructing a new revetment, with rock armour likely to be most cost effective solution, in the long term (Options 3A or 3E).

There are several recommendations made in the Capita Symonds 2012 appraisal report and it is important that these are taken forward, such as seeking contributions toward the cost of the works from benefitting parties. In this case that would include the property owners whose properties would be directly protected and Network Rail (Capita, 2012). Capita concluded that Copeland BC should consult with Network Rail, property owners and the Environment Agency to discuss the options identified and how they can be funded.

Table 20 Policy unit 11d5.7 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (PVc)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
Option 1 Do nothing	-	0.00	0.00	-
Option 2 Do minimum	-	0.45	0.17	0.38
Option 3A Do Something: upgrade existing defences at current location, extending the life of the existing defences by improving their condition.	0	0.26	0.17	0.65
Option 3B Do Something: continue maintaining the existing defences until they reach the end of their effective life span then replace them in their current locations.	20	0.77	0.17	0.22
Option 3C Providing setback defences to protect properties and the railway.	20	0.67	0.17	0.25
Option 3D Reconstruction of the existing defences in 2014.	20	1.01	0.17	0.17
Option 3E Phased upgrading of defences when they reach condition 4.	20	0.32	0.17	0.53

**Present Value cost (PVc) inclusive of 60% optimism bias*
Costs are updated from Capita (2012); Property related Benefits derived under this study. No allowance for railway benefits.

3 References

Capita Symonds (2012). Copeland borough Council Sea Mill Coast Protection Options Appraisal.

CIRIA (2010) Beach Management Manual (second edition). Environment Agency. CIRIA C685

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CH2M (2017b) Copeland Analytical Report 2016. Sefton Borough Council.

Coastal Engineering UK (2016a) Copeland Annual Local Monitoring Report 2015. Produced for Copeland Borough Council. Final Report. September 2015.

Cumbria County Council (2014). Seascale Flood Investigation Report 31. Flood Event 30/8/2012. (Version: 2nd April 2014)

Halcrow (2011). North West England and North Wales Shoreline Management Plan SMP2: main report and supporting appendices. North West & North Wales Coastal Group.