



11c11 Outer Leven Estuary

(Technical report by Jacobs)

Policy area: 11c11 Outer Leven Estuary

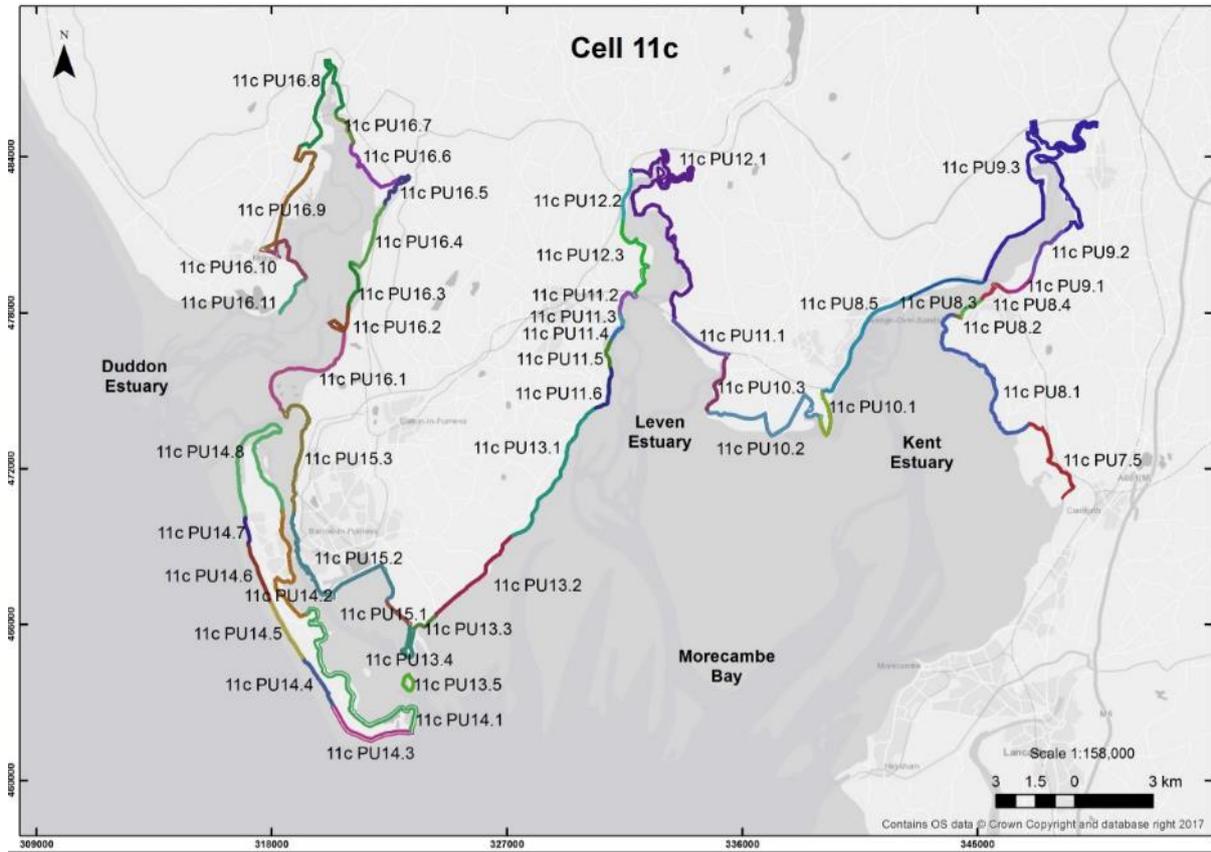


Figure 1 Sub Cell 11c Arnside to Hodbarrow Point Location Plan of policy units. Baseline mapping © Ordnance Survey; licence number 10026791.

1 Introduction

1.1 Location and site description

Policy units:	<p>11c11.1 Cark to Leven Viaduct</p> <p>11c11.2 Leven Viaduct to Canal Foot cottages</p> <p>11c11.3 Canal Foot</p> <p>11c11.4 Glaxo Factory Site (south) (priority unit)</p> <p>11c11.5 Sandhall to Conishead Priory</p> <p>11c11.6 Conishead Priory to Bardsea</p>
Responsibility:	<p>Network Rail</p> <p>South Lakeland District Council</p> <p>Environment Agency</p> <p>Private</p> <p>GlaxoSmithKline</p>
Location:	<p>The policy area falls within Sub cell 11c (part) Arnside to Hodbarrow Point and covers both the east and west banks of the Leven Estuary, up to the viaduct. It extends from Cark Village in the east to Bardsea in the west.</p>
Site overview:	<p>The Outer Leven Estuary comprises of a small area of saltmarsh on the eastern bank and an easterly facing shoreline characterised by low glacial till cliffs on the western bank.</p> <p>The Leven Estuary is macrotidal and flood dominant, and despite local changes through erosion and accretion, the estuary presently appears to be in a state of relative equilibrium in terms of the extent of mudflat and saltmarsh area.</p> <p>High ground fronted by saltmarsh and mudflats extends between the Leven Viaduct and Canal Foot (11c11.2). A section of defended frontage continues south in 11c11.3 protecting a small number of properties extending until the frontage meets the Sealed Lock Gate at Canal Foot. Another defended frontage around the rock outcrop at Hammerside Point protects the part of the Glaxo Site located landward. The remainder of frontage in 11c11.4 consists of high ground and reclaimed land comprising of waste material from when the site was used as a metal works.</p> <p>National and international nature conservation designations cover the foreshore area, namely Morecambe Bay Ramsar, SAC and SSSI and Morecambe Bay and Duddon Estuary SPA. The frontage also includes part of Bardsea County Park.</p> <p>Whilst there are no Scheduled Monuments within the area, there are a number of listed building potentially at risk. There is also potential for buried archaeology.</p> <p>Natural England is working on proposals to improve public access to the coast between Silecroft and Silverdale, which includes this section (see https://www.gov.uk/government/publications/england-coast-path-in-the-north-west-of-england).</p>

1.2 Current SMP policy

The policy details for the whole policy area are shown here taken directly from the SMP2 (Halcrow, 2011), but non priority units have been greyed out.

Overview: *The long term vision here is to manage risks to the railway and agricultural land where economically justifiable, but to generally allow the shoreline to set back from the present alignment and respond to coastal change, by allowing additional saltmarsh development and habitat creation. By maintaining defence to the major assets and population whilst also allowing sections of the frontage to behave naturally and erode, most of the SMP objectives are met. However, there are locations where the potential erosion resulting from a naturally functioning shoreline could have negative impacts, such as the release of contaminants into the estuary; in these locations the impacts will need careful monitoring or investigation in order to inform future defence policy.*

Location		Policy and Approach (from 2010)		
		0-20 years	20-50 years	50-100 years
11c11.1	Cark to Leven Viaduct	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. Consider regulated tidal exchange habitat scheme to offset future coastal squeeze losses due to railway.	No active intervention – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.
11c11.2	Leven Viaduct to Canal Foot cottages	No active intervention – Allow shoreline to continue to evolve naturally while investigating contamination risks.	No active intervention – Allow shoreline to continue to evolve under natural processes unless contamination risk identified.	No active intervention – Allow shoreline to continue to evolve under natural processes unless contamination risk identified.
11c11.3	Canal Foot	Hold the line – Manage flood and erosion risk by maintaining existing defences.	Hold the line – Manage flood and erosion risk by maintaining or improving defences.	Hold the line – Manage flood and erosion risk by maintaining existing defences.
11c11.4	Glaxo Factory Site (south)	No active intervention – No defences present, allow natural processes to continue. Hold the line if eroding material presents pollution risk.	No active intervention – No defences present, allow natural processes to continue. Hold the line if eroding material presents pollution risk.	No active intervention – No defences present, allow natural processes to continue. Hold the line if eroding material presents pollution risk.
11c11.5	Sandhall to Conishead Priory	Hold the line – Manage flood risk by maintaining existing defences. Investigate opportunities to set back defences in the medium term.	Managed realignment – Depending on studies, manage flood risk by setting back defences if appropriate.	Managed realignment – Manage flood risk by maintaining existing or set back defences to an adequate standard.
11c11.6	Conishead Priory to Bardsea	No active intervention – Limited defences present, allow natural processes to continue. However private defences may be permitted subject to consent.	No active intervention – Allow natural processes to continue. However private defences may be managed subject to consent. Investigate long term flood risk to coast road.	No active intervention – Allow natural processes to continue. However private defences may be managed subject to consent.

2 Appraisal of priority units

One policy unit within this area has been defined as a priority unit:

- 11c11.4 Glaxo Factory Site (south)

2.1 Existing approach to flood and coastal erosion risk management

2.1.1 Justification of current SMP policy

Section 0 sets out the SMP policies for this priority unit. The primary justifications for the policies at the SMP level were:

- Social: limited assets at risk.
- Environmental: No active intervention will help to result in a more naturally functioning coastline. However other actions are required if the eroding material poses a pollution risk.
- Economic: Defences cannot be justified due to lack of risk to assets in this policy unit.

2.1.2 Current defences

Along this frontage the defences comprise a mixture of defence types (see Figure 2 and Table 1); they are commonly set back from the estuary shoreline, fronted by fringing marsh or reclaimed land, for example see Figure 3 (policy unit 11c11.4), where a slag (spoil) bank fronting the existing defences provides protection. Wave overtopping is known to occur at the lowest section of that slag bank at the south east end (ARUP, 2014).

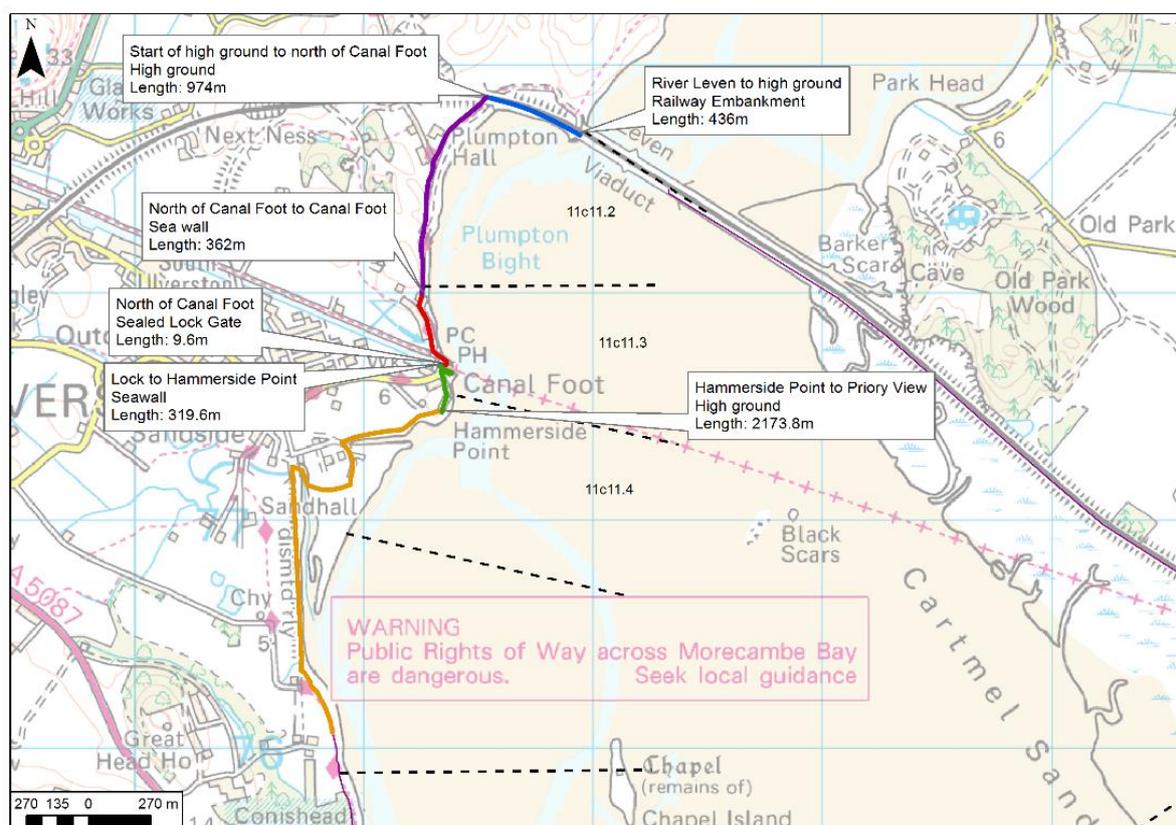


Figure 2 Policy unit location plan and defence overview. Baseline mapping © Ordnance Survey: licence number 100026791.



Figure 3 11c11.4 reclaimed land fronting the Glaxo Factory Site © North West Regional Monitoring Programme, 2015

Table 1 Existing Defence Details, taken from the latest asset inspection report (CH2M, 2018b).

Unit	Location	Structure Type	Length (m)	Crest Level (mOD)	Responsibility	Condition	Residual Life (years)
11c11.3/ 11c11.4	Lock to Hammerside Point	Sea wall	320	-	Private	Fair	10-20
11c11.4/ 11c11.5	Hammerside Point to Priory View	High ground	463	-	Private	Fair	20-50

Lock to Hammerside Point (11c11.3 and 11c11.4) - Along this frontage a sea wall is present; this is currently in good condition, fronted by a sloped revetment in fair condition with vegetation covering most of the element (Figure 4). Gabions are located at the western end of the asset, which are in good condition (Figure 5). Vegetated saltmarsh with numerous creeks and drainage depressions are visible along the length of the asset and cliffing of saltmarsh is visible at the seaward extent (CH2M, 2017). For the purpose of this assessment it is assumed that the 11c11.3 and 11c11.4 boundary is located at the south end of the defences at Hammerside Point.



Figure 4 Policy unit 11c11.3 and 11c11.4 Lock to Hammerside Point - Seawall



Figure 5 Policy unit 11c11.3 and 11c11.4 Lock to Hammerside Point – Gabions

Hammerside Point to Priory View (11c11.4 and 11c11.5) - All the elements along this section of the frontage are in poor condition (Figure 6). High ground¹ consisting of made ground at Ainslie Pier is in poor condition and nearly vertical in places, (Figure 7). The steep slope is unstable in places and cliffing visible along the length of this section.

The sloped revetment along the dismantled railway is in good condition, though the exposed face, crest and landward face of the vertical wall is in very poor condition with missing blockwork at numerous locations (Figure 8).



Figure 6 Hammerside Point to Priory View (11c11.4 and 11c11.5) - mixture of rock armour revetment and sloped revetment

¹ In accordance with the Environment Agency's "FRCM Asset Templates & Weightings Guidance": Small wall structures found along channels that offer no flood defence or questionable erosion protection are defined as Defence - High Ground.



Figure 7 Hammerside Point to Priory View (11c11.4 and 11c11.5) - Ainslie Pier



Figure 8 Hammerside Point to Priory View (11c11.4 and 11c11.5) - revetment along the dismantled railway

2.1.3 Shoreline change

The stability of the Outer Leven shoreline is largely controlled by the mobility of the low water channel of the Leven (CH2M, 2017). The main source of sediment to the estuary is provided by Morecambe Bay and is not deemed to be sediment limited (Halcrow, 2013). Channel migration within the outer estuary is generally facilitated by strong tidal currents but the flow of the Leven has been restricted by the construction of the railway viaduct and breakwater and redirected westwards through the viaduct (Shoreline Management Partnership, 1999). At the large scale, the estuary presently appears to be in a state of relative equilibrium in terms of the extent of mudflat and saltmarsh area (Halcrow, 2011), but locally there are trends of erosion and accretion.

Since the early 1900s there has been little change in the plan form of the outer estuary where defences exist, but both erosion and accretion of the backshore has occurred along the undefended sections (Halcrow, 2013). The most recent data (reported in CH2M, 2017) shows that although steady vertical accretion of the saltmarsh occurred between 2006 and 2016, there was up to 450 m landward retreat of the saltmarsh edge between 2012 and 2016, with the greatest retreat towards the northwest of the marsh, where the main Leven channel lies close to the shoreline.

Cliff erosion has been relatively insignificant along the western frontage, due to the sheltered orientation of the shore (Halcrow, 2011). Beach profiles along 11c11.4, which comprises the industrial area of Canal Foot, have shown very little net change since monitoring began, despite large cyclical changes in response to channel movement (CH2M, 2017). The presence of Wadhead Scar, which juts out into the channel at Bardsea, is believed to shelter this shoreline from wave action (CH2M, 2017).

2.1.4 Flood risk

There are three main sources of flooding for the area protected by this frontage, fluvial, tidal and surface water. The fluvial flood risk is from the Dragley Beck and Ulverston Canal at either end of the policy unit. The tidal flood risk is from Morecambe Bay both due to extreme water levels and wave overtopping. Surface water flooding is caused by drains and sewers becoming overwhelmed by rainfall of runoff from the surrounding area. It is understood that the Environment Agency is currently appraising a South Ulverston Integrated Flood Risk Management Scheme to address surface water and fluvial risk in the short term and to allow for tidal flood risk management schemes in 20 to 30 years.

There is no record of flooding from drains or surface water within the policy unit (Royal HaskoningDHV, 2014). The Environment Agency flood zone maps indicate that the hinterland falls within a tidal flood zone 2, medium risk (assessed as having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year). The western half of the frontage is also at risk from fluvial flooding (Dragley Beck) and is located within EA Flood Zone 3, high risk (a 1 in 100 or greater annual probability of river flooding (>1%).

Further fluvial risk has been addressed through the Ulverston Town Beck Flood Alleviation Scheme (<http://www.townbeckfas.co.uk/>). In partnership with the Environment Agency, Cumbria County Council, Network Rail, South Lakeland District Council and United Utilities, work to reduce the risk of flooding to 407 residential and 118 commercial properties from Town Beck was completed in May 2018. The works have provided over £9 million of investment related to flood alleviation infrastructure in Ulverston.

Town Beck lies within a steep catchment and the watercourse is mainly underground through the town centre. Ulverston has a history of flooding from various sources, most recently flooding in 2009 and 2012 when Town Beck burst its banks and caused flooding through the town centre. The construction included:

- Raising existing flood defence walls,
- Installation of new floodgates,
- Repairing and refurbishing the underground watercourse (culvert),
- Building a swale in the natural flood plain to ensure that there is no increase to flood risk in South Ulverston.

The works have improved the standard of defence to a 1% Annual Exceedance Probability (AEP). This is a flood event that has a 1% probability of occurring in any given year or alternatively can be explained as having an average recurrence interval of 100 years. This is a significant increase on the previous level of protection in Ulverston which ranged from imminent risk to 1 in 50 (2%) AEP.

2.1.5 GlaxoSmithKline site

GlaxoSmithKline (GSK) are the landowner and potential developer of a 25 ha site comprising two areas within the existing GSK site in policy unit 11c11.4; the West Site and the South Site are shown in Figure 9. The West Site is bounded by North Lonsdale Road and the Ulverston Canal and the South Site is bounded by Pulman Road, South Road and Morecambe Bay.

Proposed development of the site as of 2014 included widespread construction of a number of buildings across the entire GSK site. Although planning for a development in the West of the Site was given permission in 2017, GSK postponed the development.

The GlaxoSmithKline (GSK) South Site, as shown in Figure 9, ground comprises thick deposits of made ground (material deposited or re worked by man): mainly ironworks slag which was historically used to reclaim this area from Morecambe Bay. The site investigations undertaken by GSK as part of their proposed site development confirmed no significant soil contaminations, although a trace of asbestos was encountered in one location and it is possible that further asbestos

exists. Pockets of water within the made ground were identified as containing heavy metal contamination, believed to be from the historical ironworks slag tipped from 1870s until the 1960s (Royal HaskoningDHV, 2014).

It is clear from satellite imagery that some of this material (slag) is already eroding into the estuary.

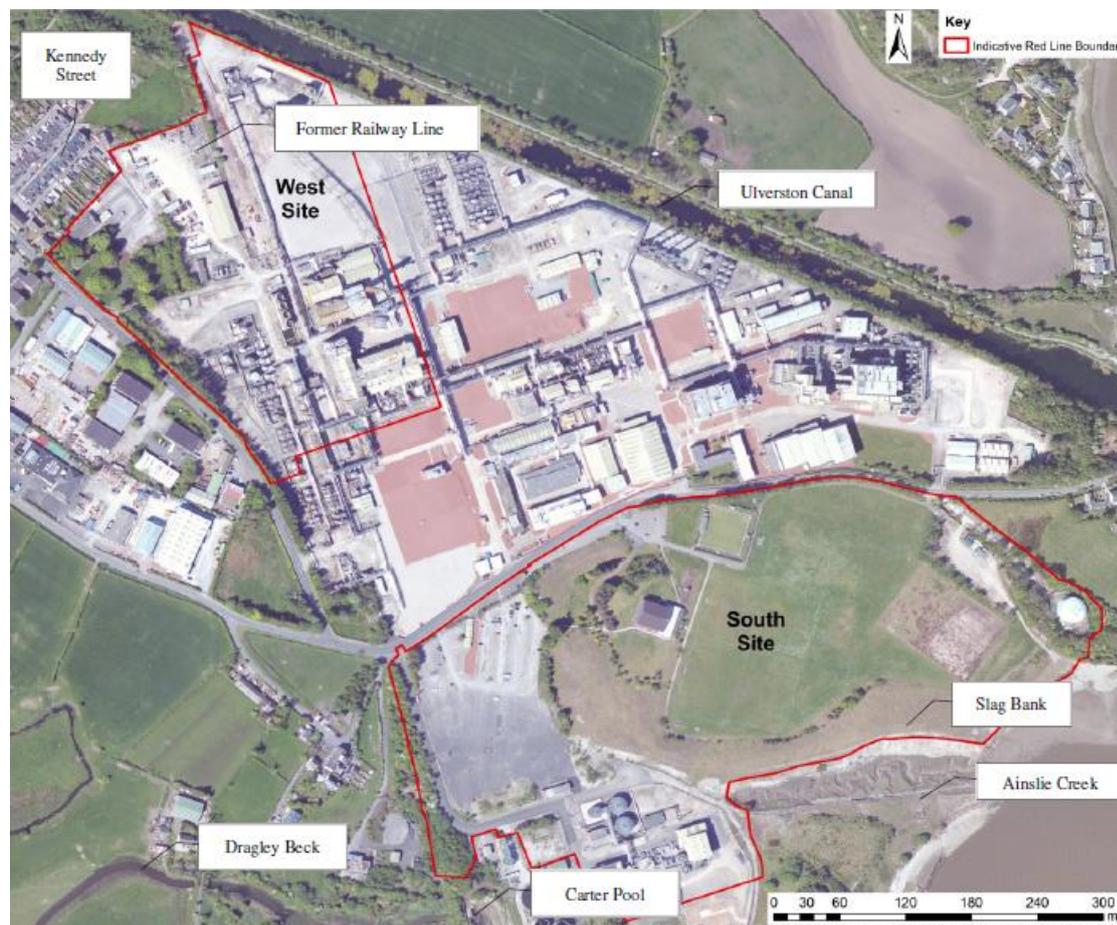


Figure 9 GSK Development Site Overview, with indicative red line boundary (ARUP, 2014)

2.2 Outline of the problem

2.2.1 Background

The frontage has limited assets are at risk of coastal erosion, but there is potential contamination risk due to the reclaimed land fronting the GSK Factory Site. Although the latest monitoring has shown little net change since monitoring began, satellite imagery indicates some of this material (slag) is already eroding into the estuary.

Assets at risk of flooding include properties and amenities within Ulverston and transport links including major roads A5087 and A590 and the railway. Large tracts of agricultural land and farmsteads are also at risk of flooding.

The GSK site expansion that was planned has been put on hold at present, but it is assumed here that it may go ahead in future under different owners or developers.

2.2.2 Issues, constraints and opportunities

Since the SMP2 there have been proposals for development of Ulverston and its infrastructure, which would have implications for the areas at risk. This includes the potential construction of an Ulverston bypass (beyond 2015); a possible southern route could pass through Cross Moor to Nook Farm and Gascow Farm.

The proposed expansion of the Glaxo (GSK) site has been put on hold but any future proposals for the site need to be taken into account.

National and international nature conservation designations cover the foreshore area, namely Morecambe Bay Ramsar, SAC and SSSI and Morecambe Bay and Duddon Estuary SPA. There are potential environmental opportunities, if Managed realignment is viable. This could offset losses due to coastal squeeze, however would have an impact on adjacent agricultural land. Currently the SSSI units covered by this policy area are in favourable condition, although the impact of defences is noted within the most recent assessments (2010), which recognises that these represent a constraint on the transition between lower saltmarsh and upper saltmarsh or terrestrial habitats.

The eroding slag bank includes a historic licensed landfill site managed by GSK although the waste is classified as inert.

2.2.3 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
- Contaminated land and flood risk study available for the cancelled GSK expansion site
- Consider the viability, including potential impacts on the wider estuary of implementing Managed realignment.
- Since the SMP there have been proposals for both the area surrounding Ulverston and the former GSK site. Options need to be flexible to take account of future changes in land use. Highlighted as a possible development site so measures to Hold the line to be considered.

Strategy approach

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

- Possible change to SMP2 policy – issues have been raised regarding the current policy. The strategy will consider possible measures taking account of a possible change to 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.
- 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 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 Development 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.

For the single priority unit of 11c11.4, the following long listed options have been considered:

- Do nothing
- Do minimum
- Hold the line: improve existing defences
- Hold the line: improve through constructing new revetments or seawalls

- Managed realignment: construct erosion slowing defences
- Managed realignment: construct secondary embankments

The second stage has been to appraise the short listed options, section 2.4 outlines 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 is provided in a **Strategic Environmental Assessment: Environmental Report** which systematically appraises the potential environmental consequences of the proposed strategy and recommend 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. These have been costed and the benefits of the strategic options identified and evaluated. The Do nothing option provides the baseline for the economic appraisal. This is reported in the **Economic assessment** report.

2.4 11c11.4 Glaxo Factory Site (south)

2.4.1 11c11.4 - Initial screening of options

Table 2 below summarises the rationale for taking long options forward to the short list stage.

Table 2 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 would not manage the increasing flood risk to the hinterland, but feasibility is dependent on any proposed development at the GSK site.
Do minimum	Reactive patch and repair of defences only	No	The frontage is undefended at present (the unit boundary is taken to be at the southerner end of the seawall), therefore this is the same as Do nothing.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	No	Would only apply to existing defended lengths until such time that they were outflanked. Existing defence remnants considered ineffective. Alone, does not accord with strategic approach.
Hold the line: improve through constructing new revetments or seawalls	New shore parallel defences replacing or extending existing defences	Yes	Does not accord with SMP2 policy or strategic approach of No active intervention, although consideration should be given if further developments within Ulverston are undertaken. Options would provide a consistent and resilient defence along the frontage.
Managed realignment: construct erosion slowing defences	Low tech measures such as gabion baskets to reduce erosion rates.	Yes	This option would include protection to the existing slag embankment, which is currently providing protection against tidal flooding and wave overtopping. Measures to slow erosion of this 'bank' have been considered further. Does not accord with SMP2 policy or strategic approach of No active intervention, although consideration should be given if further developments within Ulverston are undertaken.

Managed realignment: construct secondary embankments	Allow erosion to continue and then construct defences	No	Effectively this would allow the shoreline to retreat with the eventual loss of the existing reclaimed slag embankment and then works to the secondary alignment to provide protection to the hinterland. Consistent with the 'Hold the line: improve or construct new revetments or seawalls' therefore not considered as a separate option.
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2.4.2 11c11.4 - Development and appraisal of short listed options

The sections below outline for each frontage the shortlisted options and approaches (measures) that could be adopted to achieve these.

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

There is a shared tidal flood risk area for this frontage, which covers the frontages: 11c11.2, 11c11.3, 11c11.4, 11c11.5 and 11c12.3.1 (policy area 11c12 Leven Estuary). Due to the shared risk the costs and benefits for these frontages need to be considered together within the strategy in order to avoid double counting of benefits.

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. There is still uncertainty surrounding the outcome of the proposed developments at the GSK site which may require future change of policy.	
Technical	Under this option, no works would be undertaken, erosion of the shoreline would continue; releasing any potential contaminants from the reclaimed land into the estuary. Estimated rates of erosion are low and the bank is likely to provide some protection in the short to medium term. In the medium to longer term the reclaimed land would come under increased erosive pressure. Current predictions suggest that embankment width could be lost within strategy timescale. Throughout the strategy period, with future sea level rise intermittent overtopping could lead to increasing flood damages as the embankment erodes and the existing defences meet the end of their residual life 10 to 20 years.
Environmental	Continued No active intervention will in time help to result in a more naturally functioning coastline. However other actions are required if the eroding material poses a pollution risk. Current indications are contaminating risk is low but this requires confirmation. This option would not reduce risk of flooding or coastal erosion to the frontage. This may in the longer term impact on the risk of flooding to a number of properties and amenities within the flood risk area protected by the eroding slag bank, including the GSK south development site, a number of isolated properties including the Bay Horse Hotel and Restaurant, the Priority View Caravan and Campsite, and the unclassified roads that connect them. Reduced operation of the road may lead to risks to the health and safety of the residents and worker associated with the Glaxo site as a result of increased emergency response times that could result from impacts to these roads. While this option could allow for a more natural reinstatement of more natural coastal processes, thereby benefitting the various designations of the estuary, it could also result in risk of pollutants entering the wider environment.
Cost	There are no costs associated with the No active intervention option.
Damages	Assets at risk of flooding include properties and amenities within Ulverston and transport links including major roads A5087 and potentially in the long term the A590 and the railway. Large tracts of agricultural land and farmsteads are also at risk of flooding. The damages are estimated to be £148,260 k (this includes 11c12.3 due to the shared flood zone).

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

This option assumes that a new defence would be constructed. This currently does not accord with the SMP2 policy but is considered should further developments on the site are undertaken and would provide a flood defence function for the hinterland in the medium to longer term.	
Technical	The construction of 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

	<p>this location would be a rock revetment with a tie in to the seawall along the existing alignment at the north in 11c11.3.</p> <p>A sloping revetment is preferred to reduce wave scour and offer a resilient solution that can be easily repaired, should channel migration occur and scour potential increases. Rock armour is likely to provide the best option, although other revetment armouring solutions could be considered.</p>
Environmental	<p>The existing protection to the hinterland would be maintained by preventing erosion of the slag bank and the longer term 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.</p> <p>This option would result in changes to the existing landscape and visual amenity through the introduction of new hard structures.</p> <p>Contamination risk may remain depending on chosen alignment for the new defences.</p> <p>This option would defend the property, infrastructure and land use from flooding and coastal erosion, both from the current risk of flooding and additionally mitigating against future flood risk by taking into account potential for sea level change as a result of climatic factors.</p> <p>This option may have impacts on the SAC, SPA, and Ramsar so must be assessed fully under the Habitats and Species Regulations (2017) and impacts on the SSSI must be assessed under the Countryside and Rights of Way Act (2000).</p> <p>This option would also result in hydromorphological changes to the frontage and so there may be impacts on the WFD objectives of the waterbodies and this must be assessed.</p>
Cost	<p>The Present Value Capital Works are estimated to be £4,300 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £7,520 k.</p>
Benefits	<p>This option would provide benefits by providing protection to the at risk of increased flooding along the frontage and future proofing the infrastructure against potential increases in sea level, changes in wave climate and storminess. The benefits are estimated to be £138,400 k.</p>

Managed realignment: construct erosion slowing defences (Option 3a and b)

<p>This would involve low tech measures to slow the rate of erosion along the existing reclaimed land: this could involve introduction of a (a) rock toe or (b) rock gabions.</p>	
Technical	<p>The use of planting, fencing and other erosion management techniques such as small scale rock toe protection or gabions should slow erosion of the existing reclaimed land embankment. However, in the long term there is still a risk of erosion and breach of the slag bank.</p>
Environmental	<p>This option would delay the erosion of the slag bank, thus extending period of defence to the property, infrastructure and land use from flooding and coastal erosion. The risk of pollution from the eroding slag bank and the licenced landfill remains and so would need further investigation.</p> <p>This option may have impacts on the SAC, SPA, and Ramsar so must be assessed fully under the Habitats and Species Regulations (2017) and impacts on the SSSI must be assessed under the Countryside and Rights of Way Act (2000).</p> <p>This option would also result in hydromorphological changes to the frontage and so there may be impacts on the WFD objectives of the waterbodies and this must be assessed.</p>
Cost	<p>Moderate capital costs associated with placement of rock or gabions, also maintenance costs associated with relocation of rock as required. Two options have been considered:</p> <ul style="list-style-type: none"> a) Rock toe: The Present Value Capital Works are estimated to be £4,120 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £6,690 k. b) Rock gabions: The Present Value Capital Works are estimated to be £4,070 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £6,820 k.
Benefits	<p>Potential delay to Do nothing damages by 10 to 20 years.</p>

11c11.4 - Discussion

Table 3 provides a summary of costs and benefits for the various options considered above.

The frontage has limited assets are at risk of coastal erosion, but there is potential contamination risk due to the reclaimed land and licenced landfill south of the Glaxo Factory Site. Although the

latest monitoring has shown little net change since monitoring began satellite imagery indicates some of this material (slag) is already eroding. The assessments for the GSK south site did not find significant contamination pollution risk but it is unclear if they considered the southern extent of the slag bank towards the licensed landfill. Further investigation into the potential contamination risk posed by ongoing erosion is therefore recommended.

There are existing defences that extend from within policy unit 11c11.3 into this area include a sea wall in a fair to good condition. However, for this assessment it has been assumed that the policy unit boundary should be located at the southern end of the defences at Hammerside Point. The former quay wall and defences at Ainslie Creek on the reclaimed ironworks are classified as high ground.

The predominant risk is from flooding to the hinterland, through the eroding slag bank or former iron works site. Given the current erosion risk and limited assets at risk, a Do nothing approach is considered a valid management policy in the short to medium term but should be reconsidered in the medium to long term to assess breach risk to the eroding bank outflanking other defences to south Ulverston. The inland South Ulverston tidal flood risk area is also at tidal flood risk from adjacent frontages with 11c11.2, 11c11.3, 11c11.4, 11c11.5 and 11c12.3.1 all providing potential flood routes. To avoid double counting of and benefits the costs and benefits for all these frontages need to be considered together, see Table 3.

Further consideration of the need for a policy change would also need to take account of potential future developments. In which case Option 3, Hold the line through the construction of a new revetment or seawall would provide a resilient long term solution if the economic justification can be made based on any future developments.

If a change in the SMP policy were to be considered, an SMP Change Process would need to be initiated. Any proposed changes to SMP policy should include community and stakeholder consultation prior to being submitted for approval by local authority cabinet, submission to the Regional Flood and Coastal Committee (RFCC) and final approval by the Environment Agency. The type and extent of consultation will however vary depending on the location and the nature of change however details of the consultation and its results should be included in any report for cabinet approval.

Table 3 Policy unit 11c11.2, 11c11.3, 11c11.4, 11c11.5 and 11c12.3.1 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 Hold the line: improve through constructing new revetments or seawalls (11c11.4)		9.42	16.11	138.41	8.6
Option 4 Hold the line: Improve through constructing new revetments or seawalls (11c12.3.1)					
Option 2 Hold the line: improve or construct new revetments or seawalls (11c11.4)		8.11	13.85	138.41	10
Option 3 Hold the line: Improve existing defences (11c12.3.1)					
Option 3 Managed realignment: construct erosion slowing defences (11c11.4)	a	4.12	6.7	-+	-
	b	4.07	6.8	-+	-
Option 5 Managed realignment: construct secondary embankments (11c12.3.1)		4.60	7.89	-+	-
*Present Value cost (Pvc) inclusive of 60% optimism bias					
* Benefits for MR options not evaluated at this stage due to multiple alternative options					

3 Appraisal of non priority units

There are five additional units within this area, which have been defined as non priority units:

- 11c11.1 Cark to Leven Viaduct
- 11c11.2 Leven Viaduct to Canal Foot cottages
- 11c11.3 Canal Foot
- 11c11.5 Sandhall to Conishead Priory
- 11c11.6 Conishead Priory to Bardsea

A light touch review has been undertaken of current SMP recommendations, taking into account conclusions from option appraisals for the adjacent frontages, where appropriate.

3.1 11c11.1 Cark to Leven Viaduct

3.1.1 Existing approach to flood and coastal erosion risk management

The Cark to Leven Viaduct frontage (11c11.1) is located along the eastern bank of the Leven Estuary (see Figure 10).

The existing SMP policy for this frontage is for No active intervention from the short term, with works only undertaken if the railway is at risk. In the medium term this is extended to include the potential consideration of regulated tidal exchange habitat scheme to offset future coastal squeeze losses due to the railway.

Justification for the policy was that it would allow a natural functioning shoreline to form and there is insufficient justification to defend the land seaward of the railway on the present alignment, whilst allowing the important railway link to be maintained.

The SMP recommended that the viability of regulated tidal exchange habitat creation landward of the railway in conjunction with wider scale assessment of long term coastal squeeze of the internationally designated sites in relation to the railway be investigated. A potential funding partnership between Network Rail and the Environment Agency was proposed.

The railway embankment that extends along this frontage is understood to be in a fair condition, although the latest asset inspection (CH2M, 2018b) reported that it was largely unseen due to vegetation cover and access restrictions. Some heavy rutting due to vehicular traffic was reported at most eastern point of the asset, close to railway crossing and River Eea, (CH2M, 2018b).



Figure 10 11c11.1 Railway embankment and saltmarsh extending south; 2015 aerial images © North West Regional Monitoring Programme.

3.1.2 Strategy considerations

The coastal monitoring undertaken under the North West Regional Monitoring Programme includes three profiles in this policy unit (CH2M, 2017). These indicate modest vertical accretion since 2006, but rapid erosion of the saltmarsh edge, causing retreat of up to 80 m in a single year between October 2015 and October 2016 and up to 450 m of overall saltmarsh edge retreat since 2012 (CH2M, 2018a). Ordnance Survey mapping shows that this is an area where the marsh has previously accreted significantly and that it is this accreted material which is now eroding. The limited saltmarsh towards the northwest of the marsh (see Figure 10, left image) is where the railway embankment crosses the estuary (i.e. to the west of the unit boundary) and is likely to be related to the proximity of main Leven channel to this shoreline at this location and increased pressure as the estuary is forced to narrow at the viaduct.

Along the western bank of the estuary, there has been cyclical behaviour, driven by the movement of the Leven channel. Since 2013, the channel appears to have been steadily moving back towards the western shoreline (CH2M, 2018a). This cyclical behaviour may result in the recent erosional trend in 11c11.1 switching back to accretion. It is recommended that the monitoring is reviewed annually to monitor the risk.

There are limited hinterland assets at risk, with the area mainly used for agricultural. The properties associated with Holker Farm are located on slightly higher land. The Cumbrian Coastal Railway Line is therefore the key social and economic asset within the area.

National and international nature conservation designations cover the foreshore area, namely Morecambe Bay Ramsar, SAC and SSSI and Morecambe Bay and Duddon Estuary SPA. The SSSI unit covered by this frontage is currently in favourable condition (last assessed in 2010). It is noted that the railway line limits the transitions to terrestrial habitats and upper saltmarsh communities are poorly represented as a result. It is recognised that the area is used by roosting and breeding birds, but the SSSI assessment suggests the marsh is probably too low lying to support many breeding birds. Since the SMP2 was adopted there have been no changes in environmental designation.

Natural England is working on proposals to improve public access along this coast but as yet the route is undefined.

3.1.3 Discussion

The policy allows for intervention only if the railway becomes at risk. The monitoring data indicates that the wide saltmarsh that provides natural protection to the railway has recently been progressively eroding, following a period of accretion, due to possibly cyclical movements of the low water channel from the Leven.

The latest data shows that there was about 450 m marsh width from the railway to the saltmarsh edge. It is anticipated that in the medium or long term with sea level rise there may be a need to protect the railway, for example with rock armouring, if the erosion trend continues. This would artificially constrain the coastal processes, cause coastal squeeze and potentially result in direct and indirect losses of habitat in the internationally designated sites.

To mitigate or compensate for these potential impacts on the designated sites the SMP suggested that habitat creation through Managed realignment elsewhere in the estuary or through a regulated tidal exchange scheme to allow tidal inundation behind the railway should be considered. A separate supporting report has undertaken an initial review of estuary locations where the short, medium or long term policy is Managed realignment, and this includes the area north of the railway in 11c11.1.

There is currently no justification for any change in policy as it already accounts for managing risk to the railway. Therefore, the recommendation would be for the policy to remain, but remain subject to monitoring.

Future actions include:

- Continued monitoring of intertidal change, as part of the North West Regional Monitoring Programme – specific focus is to identify whether the current erosion trend continues and to assess any increase in risk level. Three profiles cover this frontage, but it is recommended that this be supplemented or replaced by saltmarsh edge monitoring using remote sensing (CH2M, 2018a).
- Continued inspection and maintenance of the existing structures, with repairs and remedial works undertaken as necessary. Consider development of a management plan to indicate the need for advance planning of works, including identification of possible funding sources and suitable options, such as the viability of regulated tidal exchange habitat creation landward of the railway. Any modification to or replacement of the existing structures would also require consent from Natural England due to the designation of the intertidal zone and a scheme level HRA and AA could need to be undertaken. Therefore, earlier discussions between Network Rail, Natural England, Cumbria County Council and South Lakeland District Council are recommended.
- Safe siting of the England Coast Path; Natural England is working on proposals to improve public access to the coast between Silecroft and Silverdale. (see <https://www.gov.uk/government/publications/england-coast-path-in-the-north-west-of-england>).

3.2 11c11.2 Leven Viaduct to Canal Foot Cottages

3.2.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy for this frontage is for No active intervention from the short term. The aim of the policy is to allow the shoreline to continue to evolve naturally while investigating the contamination risk, then allowing an approach of No active intervention to continue unless a contamination risk is identified.

At the northern end of this unit, there is a section of railway embankment, which is an extension of the viaduct. The railway line then moves away from the coast. The rest of the unit from where the viaduct abuts the shoreline to the Canal Foot cottages is undefended.

The railway embankment consists of a sloped blockwork revetment (Figure 11). The latest asset inspection (CH2M, 2018b) identified the structure to be in fair condition with some vegetation cover and missing mortar in several locations. At the western end rock armour revetment has been added to the western end of the asset which is in a good condition (CH2M, 2018b).



Figure 11 11c11.2 Railway embankment. Taken from CH2M (2018b).

3.2.2 Strategy considerations

The area at risk from flooding narrows towards the south of the unit, constrained by naturally rising land. There are, however, properties at potential risk from flooding at Plumpton Hall and Canal Foot Cottages. The Cumbrian Coastal Railway Line moves inland and therefore it is only the section which adjoins the viaduct that is at risk from erosion.

There are two historical licenced landfill sites at Plumpton quarries and the risk of contamination was raised by the SMP2. The SMP2 recommended investigations into these landfill sites, but these do not appear to have been undertaken to date.

National and international nature conservation designations cover the foreshore area, namely Morecambe Bay Ramsar, SAC and SSSI and Morecambe Bay and Duddon Estuary SPA. The SSSI unit covered by this frontage is currently in favourable condition (last assessed in 2010), with no signs of interference or damage occurring noted.

Natural England is working on proposals to improve public access along this coast but as yet the route is undefined.

3.2.3 Discussion

There are two monitoring points where data are collated as part of the North West Regional Monitoring Programme but these only cover the southern end of the frontage, at Canal Foot Cottages. The data indicates cyclical behaviour, probably driven by fluctuations in the position of the Leven Channel (CH2M, 2018a). Most recently there appears to have movement of the Level Channel towards the shoreline, with the position of mean high water in 2016 similar to that recorded in 2009 (CH2M, 2018a).

Despite this recent change, there is currently no justification for any change in policy, subject to further investigation in the contamination risk from the landfill sites. Therefore, the recommendation would be for the policy to remain.

It should be noted, however, that the SMP does not specifically include the Leven Viaduct. Under the No active intervention policy for 11c11.1 the SMP2 allows works if the railway becomes at risk. It is assumed that a similar condition would apply to the short section of railway embankment within this unit.

Future actions include:

- Continued monitoring of intertidal change and channel movement, as part of the North West Regional Monitoring Programme – specific focus is to identify whether the current erosion trend continues, as a result of channel movement, and to assess any increase in risk level. There are currently only two profiles, therefore a recommendation would be for an additional profile along the Plumpton quarries frontage.
- Investigation into the potential contamination risk posed by future erosion of two historical licenced landfill sites at Plumpton quarries.
- Continued inspection and maintenance of the existing structures, with repairs and remedial works undertaken as necessary. Consider development of a management plan to indicate the need for advance planning of works, including identification of possible funding sources and suitable options, such as the viability of regulated tidal exchange habitat creation landward of the railway. Any modification to or replacement of the existing structures would also require consent from Natural England due to the designation of the intertidal zone and a scheme level HRA and AA could need to be undertaken. Therefore, earlier discussions between Network Rail, Natural England, Cumbria County Council and South Lakeland District Council are recommended.
- Safe siting of the England Coast Path; Natural England is working on proposals to improve public access to the coast between Silecroft and Silverdale. (see <https://www.gov.uk/government/publications/england-coast-path-in-the-north-west-of-england>).

3.3 11c11.3 Canal Foot

3.3.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy is Hold the line, managing the flood and erosion risk to community and amenities by maintaining the existing defences. The SMP2 noted that the existing defences may not be adequate and may require upgrading in epoch 2. Hold the line policy was considered economically viable due to assets at risk in flood cell; there is a flood route link to policy unit 11c11.5.

This frontage (Figure 12) consists of saltmarsh, shingle and boulders and the channel bank is at a shallow angle although some cliffing of the saltmarsh has been observed (CH2M, 2018b).

The latest asset inspection (CH2M, 2018b) noted that there are a number of structures present along the frontage, in variable condition, with some stretches in poor condition (Figure 13). It is also evident that works have been undertaken by residents to reduce overtopping, namely the placement of earth filled bags along the crest of the wall adjacent to the road. There is a parapet on the landward face of a flood gate which is loose and needs immediate repair and may become a health and safety issue.



Figure 12 11c11.3 Canal Foot. 2015 aerial photograph © North West Regional Monitoring Programme.



Figure 13 Canal Foot- vertical walls and earth filled bags. Taken from CH2M (2018b).

3.3.2 Strategy considerations

The existing wall defences along the entire asset have not been consistently maintained, with a series of private defences constructed to protect housing. Their current condition and residual life is not considered to be sufficient to implement the current policy of Hold the line for the length of the strategy. Consideration of measures to maintain and possibly refurbish the defences will therefore need to be considered in future.

There is a single beach monitoring point, where data are collated as part of the North West Regional Monitoring Programme. These data indicate cyclical behaviour in terms of bed levels at this location, with no obvious trend evident (CH2M, 2018a), but foreshore levels can fluctuate by over 1.5 m.

National and international nature conservation designations cover the foreshore area, namely Morecambe Bay Ramsar, SAC and SSSI and Morecambe Bay and Duddon Estuary SPA. The SSSI unit covered by this frontage is currently in favourable condition (last assessed in 2010), with no signs of interference or damage occurring noted. Since the SMP2 was adopted there have been no changes in environmental designations or in level of risk along the frontage.

Natural England is working on proposals to improve public access along this coast but as yet the route is undefined.

3.3.3 Discussion

There is no justification for any change in policy, due to the assets potentially at risk resulting from the flood route link to policy unit 11c11.5, but given their current condition, defences will need to be upgraded in future. The asset inspection reported noted that in the event of a south westerly storm, floodwaters may become channelled through the gap of the Leven Viaduct. If intervention does not occur, the properties behind the existing berm (road) will be at risk from inundation, also the road is the only access to these properties (CH2M, 2018b).

Possible options to address future risk could include:

- **Rock toe works:** this would be the construction of a rock toe as required along the existing defences. This would not, however, address any future deterioration of the existing defences and in places their current poor condition.
- **New sea wall, with sheet piled toe:** this would be costly and would involve extensive and intrusive works with a larger footprint than the current structure. It would also significantly change the landscape. Impacts on the SSSI would also need to be considered as the designation covers the area at the top of the existing wall. This option could, however, be considered as part of any regeneration plans for the marina and would provide long term protection to the frontage and could be designed to improve access along the frontage.
- **Full height rock revetment:** rather than replacing the structure with a new seawall, an alternative could be to encase the existing structure with a full height rock revetment. This

would be fairly expensive and would change the landscape of the frontage. It would involve an increased footprint, with an impact on the foreshore. This option could, however, be considered as part of any regeneration plans for the marina and would provide long term protection to the frontage and could be designed to improve access along the frontage.

- Modifications to the existing structure: given the deterioration of the current structures and the variety of defences this would be difficult to implement and would not reduce exposure of the structure and further works may be required at a later date. This option is therefore not considered suitable.

Future actions include:

- Continued monitoring of intertidal change and channel movement, as part of the North West Regional Monitoring Programme.
- Continued inspection and maintenance of the existing structures, with repairs and remedial works undertaken by private owners as necessary.
- Investigation to allow a strategic defence to be developed along the frontage, inclusive of the lock gate, to manage and adapt to the increasing long term risk of flooding due to sea level rise. This work will also need to consider possible funding sources. Any modification to or replacement of the existing structures would also require consent from Natural England due to the designation of the intertidal zone and a scheme level HRA and AA could need to be undertaken. Therefore, early discussions with Natural England are recommended.
- Safe siting of the England Coast Path; Natural England is working on proposals to improve public access to the coast between Silecroft and Silverdale. (see <https://www.gov.uk/government/publications/england-coast-path-in-the-north-west-of-england>).

3.4 11c11.5 Sandhall to Conishead Priory

3.4.1 Existing approach to flood and coastal erosion risk management

The short term SMP2 policy for this frontage (see Figure 14) is Hold the line, managing the flood and erosion risk by maintaining the existing defences, while investigating the potential to set back the defences in the medium term (Managed realignment). This approach will manage the flood risk to the communities and amenities in the large South Ulverston Flood cell, risk to the historically land fill sites and industrial or commercial sites, avoiding pollution risk. The SMP2 considered that the while there are limited assets at short term risk there is a potential flood route through to south Ulverston that would increase in flood risk with future sea level rise.



Figure 14 11c11.5 Sandhall to Conishead Priory. 2015 aerial photograph © North West Regional Monitoring Programme.

The banks of the channel are in a fair condition, comprising of shingle and sand. The higher ground consists of a dilapidated sea wall, rock debris, rock armour and earth, Figure 15. The latest asset

inspection (CH2M, 2018b) concluded that all defence elements are in poor condition with debris being strewn along the beach (Figure 15).



Figure 15 11c11.5, illustrating that debris is being strewn along the narrow backshore. Taken from CH2M (2018b).

3.4.2 Strategy considerations

There is a flood route link to policy unit 11c11.5, although defence may not necessarily be necessary along the existing shoreline.

National and international nature conservation designations cover the foreshore area, namely Morecambe Bay Ramsar, SAC and SSSI and Morecambe Bay and Duddon Estuary SPA. The SSSI unit covered by this frontage is currently in favourable condition (last assessed in 2010), with no signs of interference or damage occurring noted. Since the SMP2 was adopted there have been no changes in environmental designations or in level of risk along the frontage.

Natural England is working on proposals to improve public access along this coast but as yet the route is undefined.

3.4.3 Discussion

There is no justification for any change in policy, due to the assets potentially at risk resulting from the flood route link to policy unit 11c11.5, but given their current condition, defences will need to be upgraded or replaced in future.

Future actions are:

- Investigation opportunities and need for set back the defences in the medium term, to reduce flood risk to south Ulverston and provide most cost effective approach to policy delivery. Confirm preferred approach, extent of Managed realignment potential for habitat gains. This work will also need to consider possible funding sources.
- Any realignment of the existing structures would also require consent from Natural England due to the designation of the intertidal zone and a scheme level HRA and AA could need to be undertaken. Therefore, early discussions with Natural England are recommended.
- Safe siting of the England Coast Path; Natural England is working on proposals to improve public access to the coast between Silecroft and Silverdale. (see <https://www.gov.uk/government/publications/england-coast-path-in-the-north-west-of-england>) – the route will need to take account of any future realignments planned.

3.5 11c11.6 Conishead Priory to Bardsea

3.5.1 Existing approach to flood and coastal erosion risk management

The SMP policy for 11c11.6 Conishead Priory to Bardsea is No active intervention from the short term. However, private defences may be permitted subject to consent. The aim of the policy is to allow the shoreline to evolve naturally, providing sediment from the eroded low cliffs to the down drift defences. The SMP considered that a Hold the line policy could not be justified on an economic basis, however private defences could be constructed at a later date if required.

There are variable defences along this frontage, which have been assessed as part of the latest asset inspections (CH2M, 2018b); these are described below.

From Red Lane south, the revetment is in a poor condition, but it does have some residual protection given by presence of loose material from revetment at toe of slope (Figure 16).



Figure 16 11c11.6 – South of Red Lane – defences in poor condition. Taken from CH2M (2018b).

South of here, to Cooper Lane, a length of 280 m, there is a stone revetment, which varies from good to poor condition (Figure 17). Significant loss of stone blocks, which have been washed out in places, although the failed blocks are still providing protection to toe of defence in some areas.



Figure 17 11c11.6 –non main water course to Cooper Lane – revetment varies from poor to good condition. Taken from CH2M (2018b).

From Cooper Lane to Wadhead Hill, a new rock armour revetment has been placed on top of the existing wall (Figure 18). Outflanking has occurred at the end of the defence, where the ground has become eroded. The rock armour is in fair condition with slumping visible in places and some rock displacement.



Figure 18 11c11.6 –Cooper Lane to Wadhead Hill – rock revetment. Taken from CH2M (2018b).

From Wadhead Hill to Coast Road there is a sloped revetment, which is in poor condition, with failed concrete patch repairs and large holes visible. The vertical masonry wall has failed and lost extensive sections of brickwork (Figure 19). The crest of the structure has lowered, with large area of crest missing. Rock armour has been placed to fill the gap between missing areas of wall but this is in poor condition.



Figure 19 11c11.6 –Wadhead Hill to Coast Road – revetment

3.5.2 Strategy considerations

There are isolated properties and land at flood and erosion risk, but insufficient assets to justify strategic policy unit wide defences. There are highway assets at potential risk of flooding and erosion, namely the A5087 and coastal access roads (Red Lane and Cooper Lane). Near Wadhead Hill there is a factory and highway at tidal flood risk.

National and international nature conservation designations cover the foreshore area, namely Morecambe Bay Ramsar, SAC and SSSI and Morecambe Bay and Duddon Estuary SPA. There is also a Country Park at Bardsea. The SSSI unit covered by this frontage is currently in favourable condition (last assessed in 2010), with no signs of interference or damage occurring noted. Since the SMP2 was adopted there have been no changes in environmental designations or in level of risk along the frontage.

Natural England is working on proposals to improve public access along this coast but as yet the route is undefined.

3.5.3 Discussion

There is no justification for any change in policy, which supports the environmental designations for this frontage and recognises the limited assets at risk and insufficient justification for intervention. Therefore, the recommendation would be for the policy to remain.

There are existing defences, most of which are believed to be owned by South Lakes District Council. The SMP policy potentially allows continued maintenance of these, subject to consent.

Future actions include:

- Continued monitoring of intertidal change and channel movement, as part of the North West Regional Monitoring Programme.
- Continued inspection and maintenance of the existing structures. Any modification to or replacement of the existing structures would also require consent from Natural England due to the designation of the intertidal zone and a scheme level HRA and AA could need to be undertaken.
- Undertake an initial assessment of local or property level options for managing flood the factory and highway near Wadhead Hill.
- Safe siting of the England Coast Path taking account of a No active intervention policy along this stretch; Natural England is working on proposals to improve public access to the coast between Silecroft and Silverdale. (see <https://www.gov.uk/government/publications/england-coast-path-in-the-north-west-of-england>).

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