



**11e8 Cardurnock to Scottish Border**

**(Technical report by Jacobs)**

# Policy area: 11e8 Cardurnock to Scottish Border

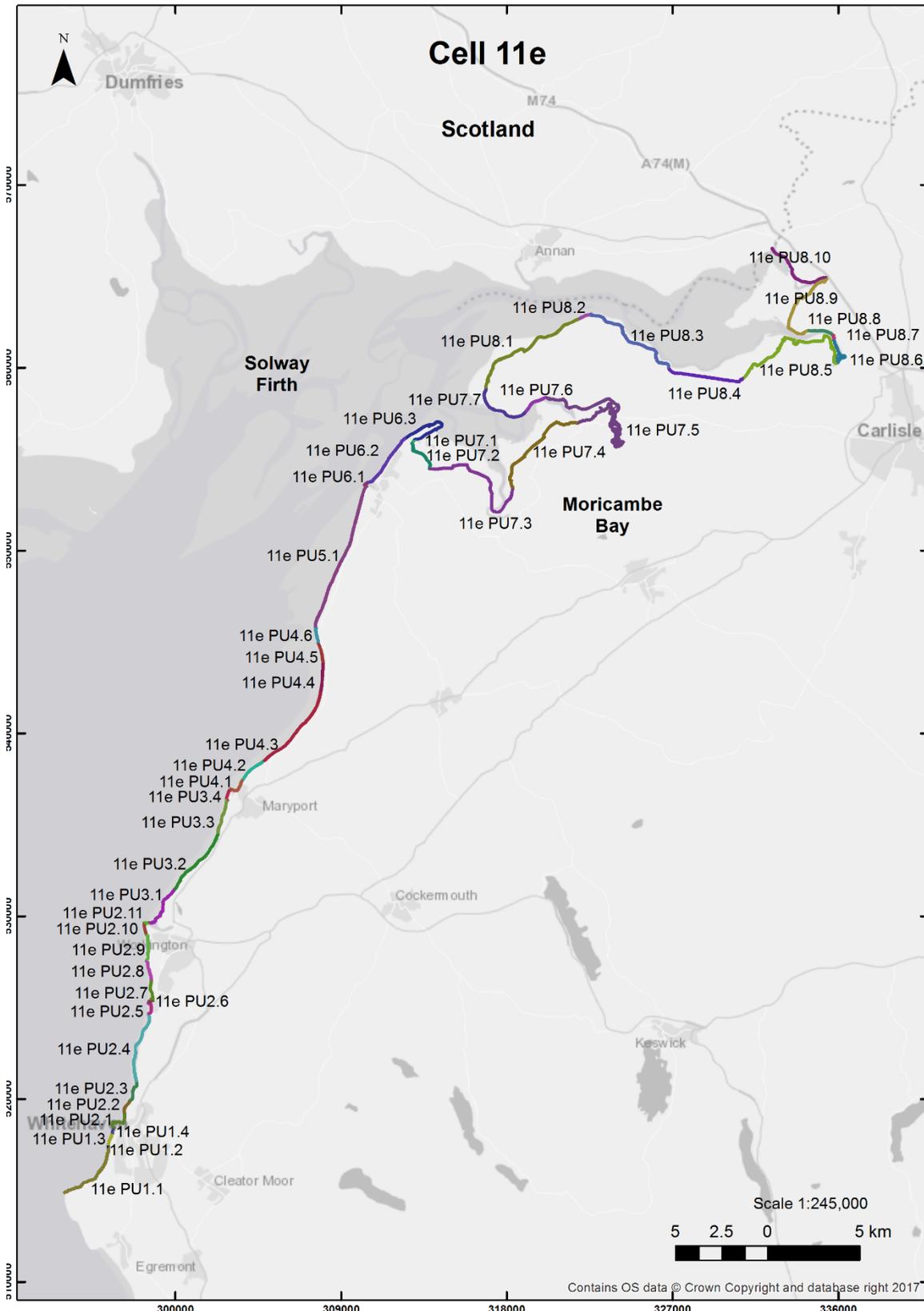


Figure 1 Sub Cell 11e St Bees Head to Scottish Border Location Plan of policy units. Baseline mapping © Ordnance Survey: licence number 100026791

# 1 Introduction

## 1.1 Location and site description

<p><b>Policy units:</b></p>	<p>11e8.1 Cardurnock to Bowness-on-Solway</p> <p><b>11e8.2 Bowness-on-Solway (priority unit)</b></p> <p>11e8.3 Bowness-on-Solway to Drumburgh</p> <p>11e8.4 Drumburgh to Dykesfield</p> <p>11e8.5 Dykesfield to Kingsmoor (Eden Normal Tidal Limit)</p> <p>11e8.6 Kingsmoor (Eden Normal Tidal Limit) to Rockcliffe</p> <p><b>11e8.7 Rockcliffe (priority unit)</b></p> <p>11e8.8 Rockcliffe to Demesne Farm</p> <p>11e8.9 Demesne Farm to Metal Bridge (Esk)</p> <p>11e8.10 Metal Bridge (Esk) to the River Sark</p>
<p><b>Responsibility:</b></p>	<p>Allerdale Borough Council</p> <p>Carlisle City Council</p> <p>Cumbria County Council</p> <p>Private landowners</p>
<p><b>Location:</b></p>	<p>This SMP policy area extends along the southern shoreline of the Solway Firth, from Cardurnock to the River Sark at the border between England and Scotland. It includes the dynamic inner section of the Solway Firth and its confluence with the rivers Eden, Esk and Sark.</p>
<p><b>Site overview:</b></p>	<p>The Solway Firth is a macrotidal funnel shaped, shallow embayment estuary. Shorelines within the estuary are sheltered from wave action and this frontage is characterised by large areas of intertidal saltmarsh, mudflats and sandflats. The channels and banks within the system are highly dynamic, and the position, size and orientation of channels and banks determines the degree to which both the northern and southern shorelines are exposed to currents and play an important role in maintaining the sediment balance within the estuary.</p> <p>It is the third largest estuary in the UK and as such supports a wide range of habitats and species. Along the coast, the frontage is internationally designated as a Special Area of Conservation (SAC) for its salt marshes and intertidal habitats, and as a Special Protection Area and Ramsar site for its populations of breeding birds and wintering waders and wildfowl. Inland, there are extensive areas of lowland raised bogs (mires), which are designated as South Solway Mosses SAC. These areas support unique communities of flora and fauna, with restoration works in progress to improve water management. All of the Solway Raised Mires are designated as Sites of Special Scientific Interest and some are National Nature Reserves.</p> <p>Much of this frontage is designated as part of the Solway Coast Area of Outstanding Natural Beauty (AONB), which stretches from Rockcliffe to Maryport, for its landscape and historic and scientific interest. The area is also a World Heritage Site (Frontiers of the Roman Empire (Hadrian's Wall)), in recognition of its significant historic importance. Associated with Hadrian's Wall, the Romans built a series of milefortlets, interspersed with small towers. The full extent of Roman defences along the Solway Coast is unknown; but remains of milefortlets exist between Port Carlisle in the north and beyond this unit, south of Maryport, and there were also some larger forts and garrisons in the area. More recently the landscape has been heavily influenced by medieval</p>

	<p>monastic activity, leaving a legacy of abbey ruins, tower houses, defensible farmsteads.</p> <p>There are several settlements, including Bowness-on-Solway, Port Carlisle, Drumburgh, Easton, Boustead Hill, Burgh by Sands and Rockcliffe, strung out along the coastal fringe; many of these are located on slightly higher ground and fronted by extensive saltmarsh, which forms an important natural defence. Farming remains a key industry of the area and there are several farms and farmsteads located along the coast, linked by the main coastal road. This road lies at the back of the saltmarsh and, in places, is regularly covered during high tides. The area is popular with visitors due to its landscape and tranquility, and is crossed by a number of trails and cycle routes. The route of the English Coast Path is yet to be adopted.</p>
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## 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); non priority units have been greyed out.

Table 1 Current SMP policy for policy area 11e8

**Overview:** *The long term plan for this area is to allow a return to a more natural shoreline and for the sea to return low lying areas to saltmarsh where practicable, creating a more sustainable and naturally functioning coastline. As there is insufficient justification to maintain shoreline defences this will result in a number of isolated properties, minor access roads and paths becoming increasingly at risk of flooding in the longer term. A number of Scheduled Monuments and part of Hadrian's Wall World Heritage Site will also be at increased risk of flooding. Some localised defences in current or retreated positions might be permissible to protect some agricultural land and property, but would be unlikely to attract national funding. The large areas of potential habitat creation as a result of this plan will compensate for any coastal squeeze in the defended sections and mitigate losses elsewhere in the shoreline management plan region where sea level rise and coastal squeeze due to defences is of more concern.*

Location		Policy and Approach (from 2010)		
		0-20 years	20-50 years	50-100 years
11e8.1	Cardurnock to Bowness-on-Solway	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.
11e8.2	Bowness-on-Solway	<b>Managed realignment</b> – Return to a more natural shoreline, permit landowners to maintain informal defences. Saltmarsh accretion provides natural defence. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Return to a more natural shoreline, permit landowners to maintain informal defences. Saltmarsh accretion provides natural defence. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.
11e8.3	Bowness-on-Solway to Drumburgh	<b>Managed realignment</b> – Plan for local diversion or setback of coastal road where at risk. Undertake study to evaluate coastal risks to Port Carlisle. Localised defences could be maintained. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Naturally functioning coast. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow natural coastal processes to re-establish. Allows measures to proactively adapt to future coastal changes.
11e8.4	Drumburgh to Dykesfield	<b>Managed realignment</b> – Plan for re-route or diversion of presently at risk undefended	<b>Managed realignment</b> – Naturally functioning coast. Allows measures to	<b>Managed realignment</b> – Allow natural coastal processes to re-establish.

		coastal road. Allows measures to proactively adapt to future coastal changes.	proactively adapt to future coastal changes.	Allows measures to proactively adapt to future coastal changes.
11e8.5	Dykesfield to Kingsmoor (Eden Normal Tidal Limit)	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.
11e8.6	Kingsmoor (Eden Normal Tidal Limit) to Rockcliffe	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow continued natural coastal evolution. Allows measures to proactively adapt to future coastal changes.
11e8.7	Rockcliffe	<b>Hold the line</b> – Undertake reactive management, i.e. maintain and upgrade defences with setback embankment if justified or required.	<b>Hold the line</b> – Undertake reactive management, i.e. by maintaining or extending defences if justified or required.	<b>Hold the line</b> – By maintaining defences.
11e8.8	Rockcliffe to Demesne Farm	<b>Managed realignment</b> – Seek opportunities to reroute or divert undefended coastal road. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Plan for reroute or diversion of undefended coastal road. Allows measures to proactively adapt to future coastal changes.	<b>Managed realignment</b> – Allow return to natural coastal evolution. Allows measures to proactively adapt to future coastal changes.
11e8.9	Demesne Farm to Metal Bridge (Esk)	<b>Managed realignment</b> – Investigate opportunity to realign defences to high ground. Rockcliffe Marsh also provides natural flood defence.	<b>Managed realignment</b> – Realign to high land allowing space for marsh rollback & habitat creation opportunities. Rockcliffe Marsh also provides natural flood defence.	<b>Managed realignment</b> – Allow return to natural coastal evolution.
11e8.10	Metal Bridge (Esk) to the River Sark	<b>Managed realignment</b> – Investigate opportunity to realign defences as maintenance of these may not be justified in medium or long term. Saltmarsh also provides natural flood defence.	<b>Managed realignment</b> – By constructing set back defences if required to reduce risk to Motorway embankment. Saltmarsh also provides natural flood defence.	<b>Hold the line</b> – By maintaining set back defences. Saltmarsh also provides natural flood defence.

### 1.3 Estuary Managed realignment

The SMP2 (Halcrow, 2011) long term plan for this area is to allow the shoreline to continue to evolve naturally as much as possible, allowing expected future sea level rise to return low lying areas to saltmarsh as a natural defence. As in Moricambe Bay, a Managed realignment policy for much of the inner Solway will allow organisations, local landowners and responsible bodies to proactively adapt to future coastal changes and manage risks to local assets and to World Heritage Site Features as well as allowing opportunities for future habitat creation to be included within the Environment Agency’s Regional Habitat Creation Programme.

There are a number of potential sites where Managed realignment could be delivered within the Solway Estuary. Either by removing, breaching or allowing defences to deteriorate over time or through Regulated Tidal Exchange (RTE), in locations such as where low lying areas are separated from the estuary by roads or former railway embankments.

The key issues and opportunities identified for a number of potential sites within the Solway Estuary include:

- New embankments may be required to constrain the set back in some locations to manage risk of flooding to properties, roads and terrestrial or freshwater designated environmental sites.
- Over time downstream reaches of channel may expand to accommodate tidal waters flooding site leading to pressure on adjacent shorelines and defences.
- Potential impacts to geomorphology of river or tidal channel and fringing habitats including erosion and flood risk implications to hinterland.
- Potential impacts on Natura 2000 sites, Habitat Regulations Assessment (HRA) requirement and potential need for compensatory habitat if losses predicted and realignment is undertaken as a managed scheme rather than through natural processes.
- Some locations may have potential for regulated tidal exchange (RTE) schemes for habitat creation, but careful design would be required to avoid impacts on adjacent frontages.
- None of the sites are completely free of constraints, although boundary refinement could help avoid some of the constraints in some areas.

Further studies are required prior to the shortlisting of sites or implementation of specific schemes:

- Clarification of the objectives for undertaking Managed realignment
- More detailed desk top assessment of sites (e.g. lengths of footpaths with site, potential for contaminated land issues)
- Incorporation of local knowledge to better characterise sites.
- Preliminary designs - quantifying the length of new defences where required, number and positions of breaches, requirements for creek systems etc.
- Hydrodynamic modelling to determine effects on flood risk and geomorphology of estuary as well as the likely inundation of the sites.
- Costs and economics - Quantifying the costs for the works and future maintenance versus existing management activities.
- Approaching landowners and tenants to discuss implications of MR sites and gauge the level of support.
- Consideration of requirements for consenting, such as Marine Management Organisation (MMO) marine licence and Local Planning Authority planning application, Environmental Impact Assessment (EIA), HRA, Water Framework Directive (WFD).

## 2 Appraisal of priority units

Two policy units have been defined as priority units in this policy area:

- 11e8.2 Bowness-on-Solway
- 11e8.7 Rockcliffe

### 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 these priority units. The primary justifications for the policies at the SMP level were:

The justifications for the policies are as follows:

- Social: For policy units 11e8.2 the key justification for Managed realignment is that there are primarily gardens at risk at Bowness-on-Solway. At 11e8.7 holding the line was to manage the risk to properties in Rockcliffe village.
- Environmental: Managed realignment at 11e8.2 was justified by it helping condition of internationally designated sites and providing opportunities for future habitat creation. At 11e8.7, the possibility of setting back a defence outside the internationally designated sites was identified (although this seems contrary to the Hold the line policy).
- Economic: at 11e8.2, it was concluded that there was insufficient economic justification for public funding of defences, but private funding of defences was permitted.

#### 2.1.2 Current defences

No specific design details have been obtained for this frontage. Based upon the most recent asset inspections (CH2M, 2017) undertaken as part of the North West Regional Monitoring Programme, the condition of the existing defences ranges from Fair (3) to Good (2), with sections of undefended artificial and natural cliff. Table 2 provides a summary of the condition and estimate residual life for the various defence structures, whilst 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).

Table 2 Existing defence condition for priority units and estimated residual life (CH2M, 2017)

Unit	Location	EA Asset Ref	Defence Type	Condition	Residual Life (years)
11e8.1	Herdhill Embankment	011KE90520201C02	Masonry revetment	Good (2) to Fair (3)	10-20
11e8.2	Greenend Car Park to Bowness-on-Solway Outfall	011KE90530101C03	Masonry wall and concrete revetment	Fair (3)	10-20
11e8.7	Rockcliffe	-	No formal defences	-	-

Figure 2 shows policy units, together with a summary of defence lengths between Cardurnock and the Scottish Border.

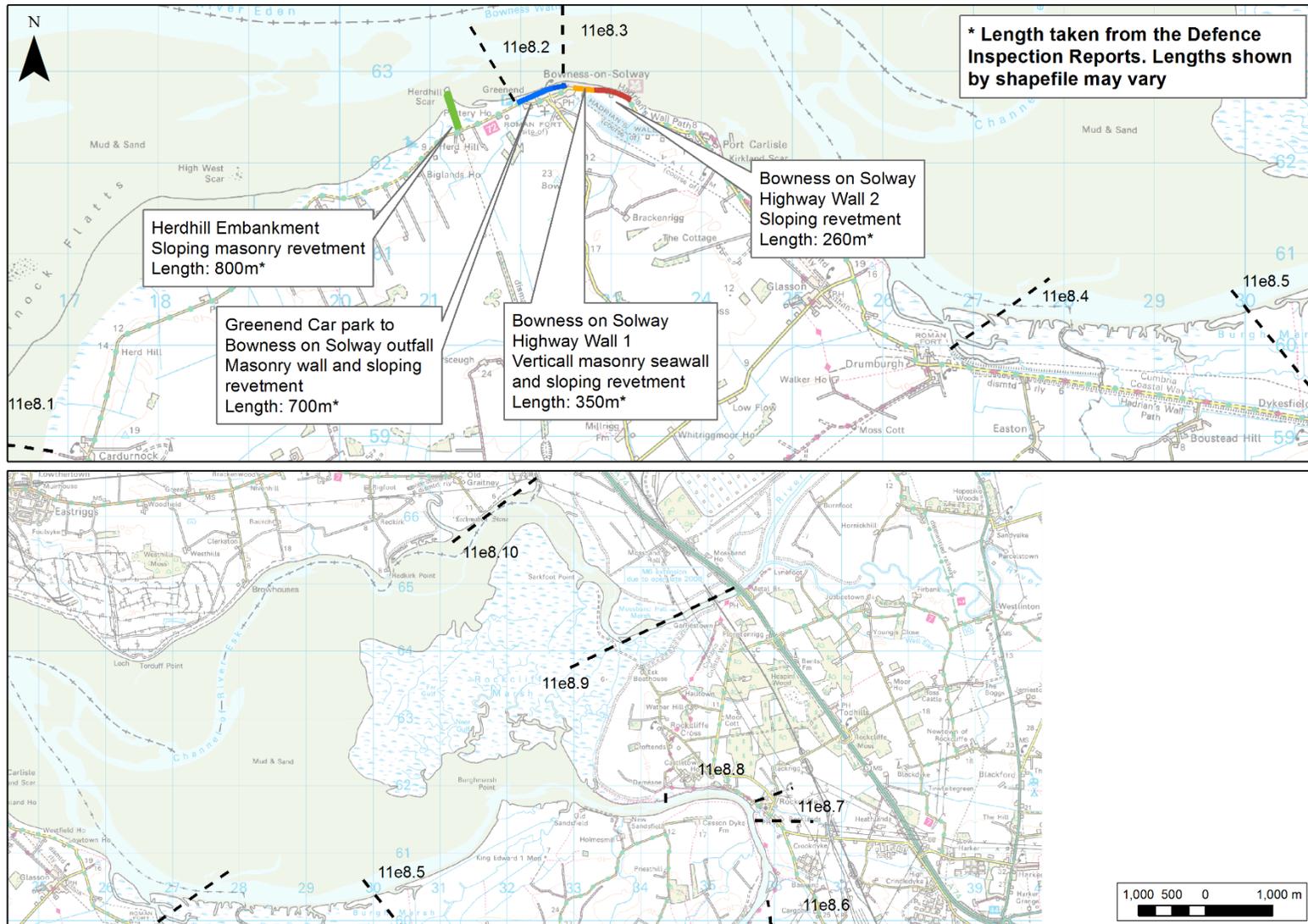


Figure 2 Policy units and summary of defence lengths between Cardurnock and the Scottish Border. Baseline mapping © Ordnance Survey; licence number 100026791.

### Policy unit 11e8.2 (Bowness-on-Solway)

#### **Greenend Car Park to Bowness-on-Solway Outfall: masonry wall and concrete revetment (700 m) – Private**

The defences along this stretch consist of intermittent stretches of blockwork and concrete walls (Figure 3). In places sloping concrete revetments have been added.

Along the frontage the condition of the walls varies from good to poor, with stretches where no defences are present. Previously, some remedial works have been carried out by landowners, but no new works were evident from the most recent inspection (CH2M, 2017a). In places the defences lie on the back of the shingle beach, whilst elsewhere defences are fronted by a strip of saltmarsh. Where defence are less exposed, vegetation covers the defence.



Figure 3 Privately owned seawalls between Greenend Car Park and Bowness-on-Solway Outfall. Photograph taken during CH2M (2017) asset inspection.

### Policy unit 11e8.7 (Rockcliffe)

There are no formal flood defences for Rockcliffe but there are private garden walls that may provide some protection to the lower lying properties. The village is situated inland of the Coast Protection boundary.



Figure 4 Rockcliffe village frontage looking south west, 2015. Photograph ©North West Regional Monitoring Programme.

### 2.1.3 Shoreline change

Analysis reports are produced to report on analysis of beach level data collected as part of the North West Monitoring Programme: the Allerdale and Carlisle report covers this frontage and includes analysis of data up to October 2016 (CH2M, 2017b).

The sandflat at Bowness is volatile and can vary by up to 2 m in elevation (CH2M, 2017b), whilst further east between Bowness-on-Solway and Drumburgh, the sand and mud flats tend to fluctuate in level by around  $\pm 0.4$  m, mainly due to the movement of small creeks.

#### Drumburgh to Scottish Border (11e8.4 to 11e8.10)

Flood risk is the predominant issue along this frontage, therefore no predictions of future erosion are available from NCERM. Although the SMP2 did not predict rates of future change it did conclude that sea level rise and the movement of the Eden channel landwards would exacerbate saltmarsh erosion to the east of Bowness-on-Solway. Although some roll back of the marsh could occur, it was concluded that the predicted increase in erosion combined with sea level rise would be likely to result in eventual marsh submergence and drowning as rollback is constrained by the gently rising hinterland. Should The Grune become breached or eroded, this could allow a widening of the Solway Firth mouth, increasing exposure along this shoreline.

Further east, the SMP2 predicted continued erosion of Burgh Marsh, exacerbated by sea level rise or increased wave energy, but vertical accretion of marshes at Rockcliffe Marsh. The SMP2 proposed that an increase in tidal prism of the estuary, as sea levels rise, may raise water levels in the inner estuary and consequently increase the risk and occurrence of hinterland flooding along low lying areas.

A more recent study into the regime of the Solway Firth by Royal HaskoningDHV (2015) concluded that the upper reaches of the Solway Firth and the confluence point of the Rivers Esk and Eden are pressure points in the estuary and that here the estuary form should be wider than it currently is. Their prediction was that further erosion would be anticipated, resulting in loss of fringing marshes if the high water mark is unable to migrate landwards; a trend which is likely to be exacerbated by future sea level rise. However, the idealised regime theory approach used does not account for natural geological constraints in the estuary and assumes a simple funnel shape. This has resulted in their findings not being in accordance with observations that indicate the inner Solway is accreting (Halcrow 2010, 2011) and it is noted that they also predicted that areas of the outer Solway, e.g. at Silloth, should be accreting at present whereas evidence from monitoring shows erosion. In addition, it should be recognised that at present, the current trends of accretion and erosion are driven by changes in the position of low water channels.

## 2.2 Outline of the problem

### 2.2.1 Background

The Solway is a very dynamic estuarine system with strong tidal currents and highly mobile banks and channels. It has been shown to be a strong sink for sediments with sediment primarily supplied from the North East Irish Sea and historically has been an area of falling relative sea level (Halcrow, 2010). The analysis and supporting studies for the SMP concluded that the area is expected to continue to accrete over the short medium and long term with overall net gains of intertidal habitat despite local losses and gains of saltmarsh due to channel movements (Halcrow, 2011).

Flooding is a key issue within the policy area, but there are no formal tidal defences managed by the Environment Agency or local authorities. Coastal settlements are mostly located on areas of slightly higher land but there are a considerable number of properties at tidal or fluvial flood risk that have adapted to or have local resilience to regular flooding. There are a number of historical embankments including the routes of former railway lines that may provide a flood defence function but are not recognised as formal defences.

Land drainage is a key issue because medieval draining of the natural mires resulted in net subsidence of the land. In some areas the Environment Agency is in the process of withdrawing from maintenance of land drainage. Currently a Water Management Committee is being established – anticipated within 5 years, before that the Environment Agency will continue maintenance.

## 2.2.2 Issues, constraints and opportunities

There are risks from both flooding and erosion. The SMP2 policy of Managed realignment at 11e8.2 has been queried as the defences protect a number of properties.

At Rockcliffe, the SMP policy is currently Hold the line although there are no formal defences here. Adjacent to the village of Rockcliffe, the coastal road (U1068) is prone to flooding in sections, whilst elevated sections have recently suffered from erosion of the underlying cliffs. There are currently investigations underway to consider the issues.

Following the 'improvement' of land through drainage for farming, much of the land supporting raised mires has dried out, resulting in net subsidence of the land. Internal land drainage is therefore a current issue. Issues also occur when periods of high precipitation coincide with spring tides.

The saltmarsh and intertidal systems are of national and international importance. There may be opportunities, with future sea level rise, to conserve or improve the Inner Firth Intertidal Flats for nature conservation and possibly restore drained farmed areas to intertidal marshes, through changes in land management. There are also potential environmental opportunities within the estuary through implementing Managed realignment but this requires further consideration of technical viability and wider impacts, refer to Section 1.3.

There is significant heritage interest in the whole area, which lies within the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site.

## 2.2.3 Strategy considerations and general approach

### Key considerations

Since the SMP was produced further monitoring data has been collated. The strategy risk workshops identified the need to consider the following:

- Reconsider options for policy unit 11e8.2, looking at potential wider impacts.
- Reconsider policy options for policy unit 11e8.7, taking account of plans for U1068.
- Impact of changes in management need to be considered for wider estuary.
- Consider environmental opportunities that could bring benefits to wider strategy area.

### Strategy approach

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

- Privately owned or funded defences – these are locations where the SMP policy may allow Hold the line subject to private funding or investment. The strategy will investigate the performance or 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.
- 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.

## 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 3 Long list options considered for priority units in 11e8 Cardurnock to Scottish Border

Priority Unit	Hold the line							Managed realignment				Other	
	Maintain: proactive maintenance	Maintain: reinforce existing defences	Sustain: reinforce and raise 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
11e8.2 Bowness-on-Solway	✓	✓	✓	✓	✓	✓			✓	✓			
11e8.7 Rockcliffe						✓					✓		✓

No potential for habitat creation sites has been identified in the above frontages, but there are significant opportunities in adjacent policy units, see Section 3.

The second stage has been to appraise the short listed options, the sections below outline 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 have been costed and the benefits of the strategic options were identified and evaluated. The Do nothing option provides the baseline for the economic appraisal. This is reported in the [Economic assessment](#) report.

## 2.4 11e8.2: Bowness-on-Solway

The policy in the SMP is for Managed realignment in all three epochs, but to allow landowners to maintain informal or private defences if required. The village is mostly located on an area of relatively high ground and so not at significant tidal flood risk. The defences provide erosion protection although most of the properties are slightly set back from the shoreline on higher ground, see Figure 5.



Figure 5 Bowness-on-Solway, 2015. Photograph ©North West Regional Monitoring Programme.

### 2.4.1 11e8.2 - Initial screening of options

Although the policy here is for Managed realignment it allows for private maintenance of defences and so Hold the line options have been considered in the long list, alongside Managed realignment.

Table 4 below summarises the rationale for taking long options forward to the short list stage.

Table 4 Screening of long list options for 11e8.2

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 erosion risks to the village of Bowness-on-Solway. It has been assessed for comparative purposes only.
Do minimum	Reactive patch and repair of defences only.	Yes	This may be the default position if no funding is available or if conditions remain stable or improve. If conditions continue to worsen, then this would not manage long term erosion to the village of Bowness-on-Solway.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defence.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure for several more years and as such is a viable option to be 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.	Yes	Options to modify and adapt existing defences may offer a suitable short term approach to future management of assets along this coastline, although consideration needs to be given to the expected performance and design life to be attained. It is a viable option to be considered.
Hold the line: Improve existing defences	Measures to improve defence resilience, such as rock toe works	Yes	Options to modify and adapt existing defences, through strengthening them or providing toe protection, may offer a suitable approach to future management of assets along this coastline, although consideration needs to be given to the

			expected performance and design life to be 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, breakwaters.	Yes	Although this would have significant impacts on the foreshore, which is designated, this option could be implemented in order to attempt to hold the channel away from the shoreline. Similar to the effect of the Herdhill Embankment. It would, however, also incur a significant cost.
Hold the line: Improve through constructing new revetments or seawalls	New shore parallel defences replacing or extending existing defences	Yes	Rock armour, concrete armour units, or riprap, would be potentially suited to conditions and requirements here. Construction of a new seawall may also be appropriate, although high cost. Therefore, this option has been taken forward for further consideration.
Managed realignment: Construct erosion slowing defences	Low tech measures such as gabion baskets to reduce erosion rates.	No	Rock toe works are considered as a separate option. The intention of these would be to allow some overtopping, which would not be a viable option in terms of the backing defences. This has not been taken forward for further consideration.
Construct defences once set back	Allow erosion to occur and defence to fail, with the view of constructing new defences in a setback location.	No	Along the central part of the frontage, it is mainly gardens of properties that would be at immediately risk, but most properties lie within 20 to 35 m of the current shoreline. Given that once exposed the till cliffs could erode fairly quickly, this is not considered a reasonable option and has not been taken forward for further consideration.

## 2.4.2 11e8.2 - Development and appraisal of short listed options

### Do nothing (Option 1)

<b>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.</b>	
<b>Technical</b>	<p>Defences here consist of masonry walls and concrete revetment, which to date have been effective due to protection afforded by fronting intertidal and saltmarsh. Recent loss of marsh along this frontage, driven by natural changes in the channel position, have increased vulnerability of these structures. Should this situation continue and possibly worsen, it is likely that without any further works the walls would start to fail and collapse. This would expose till cliffs behind. It is unlikely that these cliffs would offer much resistance, therefore erosion would commence, with greatest retreat anticipated where the shoreline is currently most exposed.</p> <p>Erosion of the cliffs would release some sediment, but their composition is not known, so whether this will contribute to building beaches is uncertain. However, there is a risk that the proximity of the low water channel would quickly remove any eroded material, unless it was particularly coarse.</p>
<b>Environmental</b>	<p>There are several properties within 20 to 30 m of the current shoreline and these could be at risk of damage from erosion within the short to medium epochs, affecting both individuals and the wider community of Bowness-on-Solway, which consists of less than 100 houses.</p> <p>The perimeter of the Roman Fort and settlement Scheduled Monument also lies within 25 m of the shoreline and there is potential for loss of part of the site, together with exposure of unknown buried archaeology. These monuments are a part of the Hadrian's Wall World Heritage Site.</p> <p>The coastal road would be likely to be affected by the medium to long term which would increase the isolated nature of the community and could risk the health of the population.</p> <p>In the short term, failure of defences and the impact on the village would be detrimental to the objectives of the AONB, due to the eyesore created and effect on the coastal community.</p> <p>In terms of nature conservation, failure of defences and reactivation of cliffs would reduce the pressure on the system, but there would still be natural coastal squeeze due to the migration of the channel landwards and comparative resistance of the till cliffs. It would be working with natural processes, which is in line with the objectives of the various designations. The impacts of this option on the integrity of the Natura sites may require further consideration and assessment under the Habitats and Species Regulations (2017). Similarly, consideration of the impacts on the WFD</p>

	objectives of the waterbodies may also be required; in the short term failure of defences could represent a contamination risk, particularly if uncontrolled erosion results in exposure of pipelines etc.
<b>Cost</b>	There are no costs associated with the Do nothing option.
<b>Damages</b>	The key damages are associated with loss of properties and impact on the community, together with risk to heritage assets. Erosion damages not calculated at this stage as not covered by NCERM data. Flood risk damages £160 k

### Do minimum (Option 2)

<b>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.</b>	
<b>Technical</b>	Such works may be sufficient if the current situation stabilises or improves. However, if there is continued migration of the channel, this is unlikely to be sufficient to prevent failure of the current defences. There may be a delay in the onset of erosion, compared to Option 1 of up to 10 years, but beyond this, the Do nothing scenario would apply.
<b>Environmental</b>	Once defences fail, the impacts would be as for the Do nothing option. See Option 1 for description of potential impacts.
<b>Costs</b>	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 £40 k.
<b>Damages</b>	The key damages are associated with loss of properties and impact on the community, together with risk to heritage assets. It is unlikely, under this option, that works would significantly delay failure beyond that estimated for Do nothing (Option 1). Erosion damages not calculated at this stage as not covered by NCERM data.

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

<b>Measures to maintain the existing standard of protection. This is would be a continuation of current activities involving patch repairs to the defences, based upon regular inspections and as part of a scheduled programme of works.</b>	
<b>Technical</b>	In many cases, patch repairs if carried out well and are timely, can be effective in maintaining the integrity of the structure for several more years. However, where these are not carried out then further problems can arise which can then necessitate far more substantial and expensive interventions later on. Works to prevent undermining and scour at the toe, together with a proactive approach to patch and repair of the masonry wall, may help to maintain the stability of this seawall for another 10 to 20 years. Beyond this, the situation may revert to Do nothing if repair works become too expensive or extensive.
<b>Environmental</b>	For the purposes of this initial assessment, the environmental impacts are being assessed in terms of the worst case scenario. For this option, this assumes that the defences will eventually fail. Because of this, the impacts the same as the Do nothing or Do minimum options, with only a relatively short delay on the impacts occurring.
<b>Costs</b>	Costs would be limited to proactive repairs and reinforcement works only. The Present Value Capital Works are estimated to be £500 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £840 k.
<b>Damages</b>	The key damages are associated with loss of properties and impact on the community, together with risk to heritage assets. This option may delay failure 10 to 20 years beyond that estimated for Do nothing (Option 1). Erosion damages not calculated at this stage as not covered by NCERM data. Flood risk damages £160 k

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

<b>This would involve more low cost measures to maintain, but not improve, the existing standard of protection. It could involve rock gabions or similar sacrificial defence options.</b>	
<b>Technical</b>	Rock gabions might offer a temporary solution to quickly fix problems and delay failures by a few more years, but are not considered a sustainable solution due to the short design life and the need to remove the failed mesh before a longer term solution could be installed. Ad hoc rock armour placement to the toe of the defence could be used to address the immediate issues of undermining,

	<p>which is understood to be the key failure mechanism along this frontage, but is unlikely to be suitable as a long term solution. During severe events sacrificial defence options are likely to become damaged and therefore require repair or replacement, there is also a risk that prior to repair works damage could be caused to the defence behind by subsequent storms.</p>
<b>Environmental</b>	<p>Depending on the level of risk, which in turn depends upon future movements of the channel, this option could be effective for several years and would be cheaper than more formal works considered under Option 5. It would therefore continue to protect properties, the community of Bowness-on-Solway and historical heritage assets, for a period, although long term security would not necessarily be assured.</p> <p>However, this option would involve placing (probably) rock gabions along the toe of the current defences and would therefore potentially encroach slightly into the internationally and nationally designated saltmarsh and intertidal zone. The direct and indirect (e.g. coastal squeeze losses) impacts would require assessment through a HRA under the Habitats and Species Conservation Regulations (2017) and may require a CRoW assessment (with regard to the SSSI).</p> <p>The impacts of this option on the WFD objectives of the relevant water bodies would require assessment (to include consideration of hydromorphological constraints).</p> <p>Although there would be a visual impact, this is likely to be less detrimental to the AONB designation and the setting of the World Heritage Site than allowing defences to fail. Although construction of the new defences may impact on undiscovered archaeology that may be present.</p>
<b>Costs</b>	<p>The Present Value Capital Works are estimated to be £250 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £440 k.</p>
<b>Benefits</b>	<p>The village of Bowness-on-Solway and associated community and infrastructure would remain protected for some time. However, eventually it may become uneconomic to continue replacing or repairing gabions and the situation may revert to Do nothing from the medium term. Benefits not quantified at this stage as not covered by NCERM data.</p>

### Hold the line: improve existing defences (Option 5)

<p><b>This would involve more substantial measures to maintain the existing standard of protection through improving the resilience of the existing defences. A sound toe structure is needed (i.e. rock armour with suitable filter layer, rather than gabions) to ensure that the wall cannot be undermined by further lowering of the foreshore.</b></p>	
<b>Technical</b>	<p>This erosion slowing measure should address the issues of undermining, which is understood to be the key failure mechanism along this frontage. Rock is also a 'dynamic' and flexible structure, so can naturally accommodate some movements and readjustment that may result from large wave impacts or foreshore lowering. In the latter case, a 'falling toe' is often designed to ensure that undermining will not occur and the integrity of the revetment remains intact. This option will require some monitoring and maintenance to ensure it is providing sufficient protection to the existing defences under changes in forcing conditions, channel migration and increased water levels over the duration of the strategy.</p> <p>Such works are unlikely to affect adjacent frontages due to limited littoral drift along the frontage. However, it would involve a much larger footprint across the foreshore.</p>
<b>Environmental</b>	<p>This approach would continue to protect properties and the community of Bowness-on-Solway for a period, and provide some assurance for those living there.</p> <p>However, this option would involve placing (probably) rock along the toe of the current defences and would therefore encroach into the internationally and nationally designated saltmarsh and intertidal zone. The direct and indirect (e.g. coastal squeeze losses) impacts would require assessment through a HRA under the Habitats and Species Conservation Regulations (2017) and may require a CRoW assessment (with regard to the SSSI). Potential impacts on the Solway Firth Marine Conservation Zone will also have to be considered.</p> <p>The impacts of this option on the WFD objectives of the relevant water bodies would require assessment (to include consideration of hydromorphological constraints).</p> <p>There would be a visual impact, which could be considered detrimental to the AONB designation and the setting of the World Heritage Site, depending upon the size of structure used. Construction of new structures may also have impacts of any undiscovered archaeology that may be present.</p>
<b>Costs</b>	<p>The Present Value Capital Works are estimated to be £500 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £860 k.</p>
<b>Benefits</b>	<p>The village of Bowness-on-Solway and associated community and infrastructure would remain protected, possibly through to the long term. Benefits not calculated at this stage.</p>

### Hold the line: improve through constructing new shore control structures (Option 6)

<p><b>This may involve constructing a headland structure (using rock or concrete armour units) intended to act upon both waves and currents to keep the deeper water channel away from the eroding shoreline</b></p>	
<p><b>Technical</b></p>	<p>The aim of the structure would be to deflect tidal current flows and keep the deeper water channel away from the eroding shoreline. The structure would also diffract waves and therefore could help to modify produce greater shoreline stability, as has been observed at the Herdhill Embankment, to the west of Bowness-on-Solway. The structure would be in the form of a ‘fishtail groyne’, typically built as a rock mound, or using concrete armour units in place of the armour rock.</p> <p>Configuration of the seaward end of the headland structure would require careful design as some shapes may lead to pronounced eddies and increased scour. Design would involve significant modelling to inform the best configuration, location, size and elevation. It is possible that some toe protection works would still be required at the current defence.</p>
<p><b>Environmental</b></p>	<p>This approach has the potential to provide long term protection to properties and the community of Bowness-on-Solway for a period, and provide some assurance for those living there.</p> <p>It would involve substantial construction works across the foreshore and intertidal zone, with potential for high impact on the internationally designated sites. There is therefore a very high environmental risk associated with this option. There is also a very high risk that it could result in detrimental impacts on adjacent frontages, due to modifying currents and thereby affecting migration of the low water channel. This has been observed historically with the construction and subsequent removal of the Solway viaduct.</p> <p>The potential direct and indirect impacts, both locally and on adjacent shorelines, would require assessment through a HRA under the Habitats and Species Conservation Regulations (2017) and may require a CRoW assessment (with regard to the SSSI). Potential impacts on the Solway Firth Marine Conservation Zone will also have to be considered.</p> <p>The impacts of this option on the WFD objectives of the relevant water bodies would also require assessment (to include consideration of hydromorphological constraints).</p> <p>There would be a visual impact, which could be considered detrimental to the AONB designation and the setting of the World Heritage Site. Construction of new structures may also impact or damage undiscovered archaeology that may be present on the shoreline.</p>
<p><b>Costs</b></p>	<p>The Present Value Capital Works are estimated to be £170 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £3,270 k.</p>
<p><b>Damages</b></p>	<p>This option should continue to protect Bowness-on-Solway village, although there may still be a requirement for toe protection. Benefits not calculated at this stage.</p>

### Hold the line: improve through constructing new revetments or seawalls (Options 7a and b)

<p><b>This may involve constructing (a) a seawall along this length replacing the current structure OR (b) constructing a full height rock revetment in front of the existing masonry walls.</b></p>	
<p><b>Technical</b></p>	<p>(a) The new seawall would be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a long term solution to currently foreseen issues of undermining. It would require a substantial toe and there is a risk of scour and outflanking along unprotected shorelines to the south. There is little information regarding the current defence and the impact of removing would need to be considered, due to the risk of unstable cliff behind. There may be potential to set back defences slightly to reduce pressure at the shoreline, but this could mean loss of land (mainly gardens) for residents.</p> <p>(b) An alternative would be a rock revetment, larger scale structure than considered in Option 5.</p>
<p><b>Environmental</b></p>	<p>Both options would provide long term protection to properties and the community of Bowness-on-Solway and provide security for those living there.</p> <p>This would involve substantial construction works across the foreshore, with high impact on the internationally designated sites. There is therefore a high environmental risk associated with these options.</p> <p>The direct and indirect (e.g. coastal squeeze losses) impacts would require assessment through a HRA under the Habitats and Species Conservation Regulations (2017) and may require a CRoW assessment (with regard to the SSSI). Potential impacts on the recommended Solway Firth Marine Conservation Zone will also have to be considered.</p>

	<p>The impacts of this option on the WFD objectives of the relevant water bodies would require assessment (to include consideration of hydromorphological constraints).</p> <p>There would be a visual impact, which could be considered detrimental to the AONB designation and the setting of the World Heritage Site. Construction of new structures may impact or damage undiscovered archaeology in the area.</p>
<b>Costs</b>	<p>a) The Present Value Capital Works are estimated to be £5,690 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £9,170 k.</p> <p>b) The Present Value Capital Works are estimated to be £3,610 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5,950 k.</p>
<b>Damages</b>	Both options would continue to protect Bowness-on-Solway village and future proof the infrastructure against potential increases in sea level rise, risk of undermining or storminess. Benefits not calculated at this stage.

### 2.4.3 11e8.2 - Discussion of options

Table 5 summaries the cost and benefit calculations for the various options presented above.

The current SMP policy for this frontage is one of Managed realignment, but allowing maintenance of private defences. Given the proximity of properties to the shoreline and the current presence of defences, the relevance of this policy is questioned. It is therefore recommended that the SMP policy be revised to Hold the line (dependent upon available funding) to reflect the risk to assets.

The risk to this frontage may change in the future, as it depends upon the alignment of the low water channel. Therefore, in the immediate term (next 5 years) it is recommended that monitoring of the situation continues, to appraise whether there is an ongoing trend of increasing risk. A beach management plan is recommended, which would include triggers for further actions.

Assuming a long term need to Hold the line for this policy unit, modifying the existing structure (toe protection and repairing) may be adequate for many years, depending upon changes in future risk (Option 3, 4 or 5, depending upon available funds). At some point it may be necessary to consider more substantial works, but these would incur significant costs. Of these longer term options, Option 6 is likely to have too high an environmental risk and there would be considerable uncertainty associated with potential wider scale impacts – these would require significant modelling, further increasing design costs. More likely would be Option 7a and b, but these would both mean a wider defence footprint (although possible Option 7a could involve some minor setback of the cliff), with impacts on the internationally designated intertidal habitats.

Table 5 Policy unit 11e8.2 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (PVc)* £m	PV Benefit (Damage Avoided)++ £m	Average Benefit Cost Ratio
<b>Option 1 Do nothing</b>	0	0	-	-
<b>Option 2 Do minimum</b>	0	0.05	0	0
<b>Option 3 Hold the line: maintain through proactive maintenance</b>	0.8	1.2	0	0
<b>Option 4 Hold the line: Sustain through modifying but not replacing existing defences</b>	0.3	0.5	0	0
<b>Option 5 Hold the line: improve existing defences</b>	0.5	1	0.08	<<1
<b>Option 6 Hold the line: Improve through constructing new shore control structures</b>	0.2	4	0.08	<<1
<b>Option 7 Hold the line: improve through constructing new revetments or seawalls</b>	4	6	0.08	<<1

\*Present Value cost (PVc) inclusive of 60% optimism bias  
 ++ Included flood risk benefits only. Erosion risk benefits not evaluated at this stage.

## 2.5 11e8.7: Rockcliffe

The current SMP policy here is for Hold the line from the short term, this was justified by the potential risk to the village. Implementation was through undertaking reactive management, i.e. maintenance and upgrade of defences with construction of set-back embankment if required and justified.

The primary risk to the village is from flooding, with both fluvial and tidal flooding a risk, although only the lower part of the village and coastal road is located with the EA Flood Zone. A United Utilities pressured main also runs along the road. During 2018 Storm Eleanor, one property had to be evacuated, the pub car park was flooded as well as other nearby homes, and the coastal road had to be closed. Further west, the land rises and erosion of the till cliffs becomes an issue, in terms of sustainability of the coastal road, but this is discussed in non priority unit 11e8.8, in a later section.

### 2.5.1 11e8.7 - Initial screening of options

There are currently no formal defences along this frontage. Therefore, only options involving the construction of defences have been considered.

Table 6 below summarises the rationale for taking long list options forward to the short list stage.

Table 6 Screening of long list options for 11e8.7

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 flood risk to the coastal road or village of Rockcliffe. However, this may become the default option if funding is no longer available.
Hold the line: improve through constructing new revetments or seawalls	New defences constructed along the shoreline and river bank	Yes	This would involve the construction of a wall or embankment along the current shoreline position to minimise flood risk to the coastal road and village.
Managed realignment: construct secondary embankments	New defences constructed in a setback location	Yes	Although the SMP policy is Hold the line, the location of properties and road relative to the shoreline means that defence could be constructed along a setback location rather than along the shoreline to minimise flood risk to the coastal road and village.
Adaptation measures	Lower cost measures to address flooding at a local level	Yes	As only a few properties are at potential risk, there may be potential for incorporation of flood defences into private gardens. This would not however, protect the coastal road. An alternative would be temporary barriers.

### 2.5.2 11e8.7 - Development and appraisal of short listed options

#### Do nothing (Option 1)

<b>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.</b>	
<b>Technical</b>	There are no defences along this shoreline, so this would be a continuation of the current situation. Under this option this risk of flooding and inundation may increase in frequency and magnitude in the future due to climate change, with the greatest risks when fluvial and tidal extreme events coincide.
<b>Environmental</b>	There would be no change from the current situation in terms of environmental designations. There would be an increasing future risk to property within the village and the coastal road may need to be

	<p>closed on a more frequent basis, possibly cutting off access to properties at Redhill (which are not at flood risk but are linked to Rockcliffe by the coastal road). The increased frequency of road closures would increase the isolation of the community of Rockcliffe, which can increase of risk to the health of the community.</p> <p>The Crown and Thistle Pub is a Grade II listed building and lies within the Flood Zone: this is the only heritage feature likely to be affected, but it should be noted that this area falls with the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site.</p>
<b>Cost</b>	There are no costs associated with the Do nothing option.
<b>Damages</b>	Damage to a few properties (and associated infrastructure), pub and coastal road. PV damages estimated as approximately £480 k.

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

<b>This would involve the construction of a new wall or raised embankment along the current shoreline and river bank.</b>	
<b>Technical</b>	<p>This would involve construction of a low floodwall or earth embankment. There are a range of materials that could be used for the floodwall; brick, masonry, concrete, sheet piling or a combination of these.</p> <p>There would be a need to consider the potential for trapping of water landward of the defence, during fluvial events, or following a surge, which could increase flood risk or prolong time for drainage of the site.</p>
<b>Environmental</b>	<p>The flood risk to the village and coastal road would be minimised and the structures would be designed to take account of the implications of future sea level rise.</p> <p>Careful consideration of the location of the new defence would be required. Under this option the works would be undertaken along the current shoreline and river bank, so there would be implications in terms of conservation designations along the frontage. There would also be loss of natural floodplain.</p> <p>The direct and indirect (e.g. coastal squeeze losses) impacts would require assessment through a HRA under the Habitats and Species Conservation Regulations (2017) and may require a CRoW assessment (with regard to the SSSI). The impacts of this option on the WFD objectives of the relevant water bodies would also require assessment (to include consideration of hydromorphological constraints), particularly as this would directly affect natural functioning of the river. Potential impacts on the recommended Solway Firth Marine Conservation Zone will also have to be considered.</p> <p>Construction of new structures along the river bank would also be counter to the objectives of the AONB.</p> <p>Construction would require careful consideration of the heritage landscape and the potential for buried archaeology to be discovered or damaged during the process.</p>
<b>Costs</b>	<p>a) Construct new wall: The Present Value Capital Works are estimated to be £1,240 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,020 k.</p> <p>b) Construct new embankment: The Present Value Capital Works are estimated to be £3,130 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5,030 k.</p>
<b>Benefits</b>	The flood risk to the village and coastal road would be minimised and the structures would be designed to take account of the implications of future sea level rise. PV benefits £410 k.

### Managed realignment: construct secondary embankments (Option 3)

<b>This would involve the construction of a new wall or raised embankment along a setback location.</b>	
<b>Technical</b>	<p>This would involve construction of a low flood wall or earth embankment. Walls generally require less maintenance but are potentially more unsightly in such a rural setting, compared to an embankment, and can be more expensive. Embankments require a large footprint but require more regular inspection and maintenance.</p>
<b>Environmental</b>	<p>The flood risk to the village and coastal road would be minimised and the structures would be designed to take account of the implications of future sea level rise.</p> <p>As the works would be undertaken along a setback location, possibly adjacent to the road alignment, there would be less direct loss of natural floodplain due to the defence footprint than for option 2</p>

	<p>and there would be less implications for impacts on the river environment. The direct and indirect (e.g. coastal squeeze losses) impacts would still require assessment through a HRA under the Habitats and Species Conservation Regulations (2017) and may require a CRoW assessment (with regard to the SSSI). The impacts of this option on the WFD objectives of the relevant water bodies would also require assessment (to include consideration of hydromorphological constraints), particularly as this was directly affect natural functioning of the river. Potential impacts on the recommended Solway Firth Marine Conservation Zone will also have to be considered.</p> <p>The decision regarding a wall or embankment may be informed by the objectives of the AONB. Construction would require careful consideration of the heritage landscape and the potential for buried archaeology to be discovered.</p>
<b>Costs</b>	<p>a) Construct secondary walls: The Present Value Capital Works are estimated to be £920 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1.500 k.</p> <p>b) Construct secondary embankments: The Present Value Capital Works are estimated to be £1,460 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,350 k.</p>
<b>Benefits</b>	<p>The flood risk to the village and coastal road would be minimised and the structures would be designed to take account of the implications of future sea level rise. PV benefits £410 k.</p>

#### Adaptation measures (Option 4)

<b>There are a range of possible options, but would not involve the construction of a permanent barrier to flooding.</b>	
<b>Technical</b>	<p>There are various solutions available for providing a temporary barrier against flooding, from the traditional sandbag wall to temporary and demountable defences. Sand bag walls offer flexible and versatile emergency protection, but cannot produce a watertight defence and require a lot of effort to erect and remove. Temporary and demountable defences can be constructed from a range of materials and can be quicker to erect, but are more costly and if not stored locally expedient access to Rockcliffe could be difficult.</p> <p>An alternative would be for households to incorporate flood walls within their property boundaries. These would need to consider the impact on the wider flood plain.</p>
<b>Environmental</b>	<p>This would not provide a long term solution for protecting the whole village, but may be appropriate given the level of current risk.</p> <p>Any permanent works may require consent from Natural England and depending upon the scale an HRA and WFD may be required to appraise impacts on the conservation and water environment.</p>
<b>Costs</b>	<p>There are no Present Value Capital Works and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5 k to £10 k per property.</p>
<b>Benefits</b>	<p>Risk from flooding to individual properties could be minimised but risk will remain. The coastal road may not be protected and increased closures may be necessary. Benefits not calculated at this stage.</p>

### 2.5.3 11e8.7 - Discussion of options

Table 7 summaries the cost and benefit calculations for the various options presented above.

Of the two options looking at long term protection from flood risk, Option 3 is the more likely to be acceptable. Constructing setback defences will incur less cost and will not affect functioning of the majority of the natural flood plain. Conversely Option 2 may constrain the future natural adjustment of the river channel with potential for impacts elsewhere.

Given the limited properties at risk, the potential for either temporary defences or individual adaptation measures, Option 4, should be considered to be more realistic, rather than reverting to a Do nothing approach. In the short term there is a need to monitor risks to the frontage. Possible responses to the issue along the adjacent unit (11e8.8) need to be taken into account, as there is potential for impacts on this area, or alternatively to develop a more strategic approach to address both issues.

Table 7 Policy unit 11e8.7 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (Pvc)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
<b>Option 1 Do nothing</b>	0	0	-	-
<b>Option 2 Hold the line: improve through constructing new revetments or seawalls</b>	1 - 3	2.0 – 5.0	0.5	<<1
<b>Option 3 Managed realignment: construct secondary embankments</b>	1 – 1.5	1.5 – 2.4	0.5	<<1
<b>Option 4 Adaptation measures</b>	<0.1	<0.1	0.4	-

*\*Present Value cost (Pvc) inclusive of 60% optimism bias*

## 3 Appraisal of non priority units

Eight policy units have been defined as non priority units in this policy area:

- 11e8.1 Cardurnock to Bowness-on-Solway
- 11e8.3 Bowness-on-Solway to Drumburgh
- 11e8.4 Drumburgh to Dykesfield
- 11e8.5 Dykesfield to Kingsmoor (Eden Normal Tidal Limit)
- 11e8.6 Kingsmoor (Eden Normal Tidal Limit) to Rockcliffe
- 11e8.8 Rockcliffe to Demesne Farm
- 11e8.9 Demesne Farm to Metal Bridge (Esk)
- 11e8.10 Metal Bridge (Esk) to the River Sark

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

### 3.1 11e8.1 Cardurnock to Bowness-on-Solway

#### 3.1.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy along this frontage is Managed realignment from the short term to allow “continued natural coastal evolution”. The SMP policy statement indicates that this “allows measures to proactively adapt to future coastal changes”.

The primary justifications for the policy included: insufficient economic justification for public funding of new defences, the need to maintain the condition of Internationally designated sites and the potential to provide opportunities for future habitat creation.

This frontage is characterised by a fringing saltmarsh of variable width (Cardurnock Marsh), backed by informal earth embankments and sloping land, fronted by sand and mudflats (Cardurnock Flats). The marsh and flats narrow east of North Plain, due to the proximity of the main low water channel of the River Eden, with very little intertidal area now present in front of Bowness-on-Solway (covered in policy unit 11e8.2). Inland of the marshes is a band of reclaimed semi improved or improved pastoral land that is used for grazing, beyond which lies the remnant raised mire of Bowness Common, which is a large peat body.

The only shoreline structure along this unit is the Herdhill Embankment, a privately owned masonry seawall which is the remains of the lead in embankment of the former Solway Viaduct. It is not a formal defence but does have a local impact on shoreline behaviour locally (CEUK, 2013). In the past, there has been damage to blockwork at the seaward end of the structure, but limited changes have been observed over the past 10 years of inspections. This structure has a localised influence on the shoreline and may be helping to retain marsh locally.

#### 3.1.2 Strategy considerations

Although flood risk is limited by naturally rising land inland of the coastal edge, flooding issues along the frontage occur due to coincidence of spring tides and high levels of precipitation. Some properties and sections of the main coastal road that are at risk from flooding: this is the key link road for coastal communities.

Recent monitoring data indicate that the movement in the position of River Eden channel (and Swatchway) has resulted in erosion of the lower foreshore. Since 2010, there has been net recession of Cardurnock Marsh and east of North Plain (Scargavel Point) the intertidal flats have narrowed and steepened (CH2M, 2017b).

The Solway Firth is of significant importance for non breeding birds and is afforded the highest protection (Ramsar, SPA, SAC, SSSI), forming a link in the chain of west coast estuaries used by migratory and wintering birds. Most of the littoral sediment habitat is in favourable condition (last assessed in 2008 and 2014) and grazing level over the whole marsh is considered to be acceptable, though overgrazing and coastal squeeze are concerns with coastal access identified as a risk in terms of stock management on the site. Erosion along the eastern end of the site mean that there is only limited extent of lower marsh. Other potential issues of conservation concern are shellfishing, recreational disturbance including wildfowling and appearance of non-native *Spartina* which is now starting to colonise the Solway.

Since the SMP2 was adopted there have been no changes in environmental designations although this part of the Firth may become designated as a marine conservation zone in 2019, which would lend more protection to the seabed species and habitats found at the site. In addition, there have been no changes in land use and no significant development has taken place. Although not directly a coastal management issue, the Environment Agency are withdrawing from maintenance of drainage ditches and the running of the drainage pumps in this area. Currently a Water Management Committee is being established, anticipated within 5 years, before that the Environment Agency will continue to maintain.

This coastline has significant historical value, recognised by its designation as part of the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site. These assets, many of which are Scheduled Monuments, are generally located along the seaward edge of the marsh, broadly following the route of the road. As well as being a potential risk from flooding and erosion, their location means that there would be a high risk of damage should the road need to be relocated.

The proposed route of the England Coast Path follows the coastal road along the length of this unit. Part of the route of the trail on this length of coast (east of North Plain and Scargavel Point) would be able to change without further approval from the Secretary of State in response to coastal erosion or other geomorphological processes, or encroachment by the sea.

### 3.1.3 Discussion

At the current time there is no justification for a change in SMP2 policy from Managed realignment, which is in accordance with the management principles of the AONB designation and the national and international environmental designations for the site, which would not support construction of new sea defences. Under this policy there is the possibility of opening up improved pastureland, which is currently used for grazing cattle, along the coastal edge, which could mitigate the impact of narrowing saltmarsh habitat, which is currently resulting from the shorewards migration of the Swatchway and River Eden Channel. Through this there would be potential to increase the mosaic of habitats supported. The extent of habitat gain would, however, be restricted by the natural rising topography of the land. Limited saltmarsh is likely to be created, with much of the area likely to develop as transitional grassland. This would require a change in grazing patterns and will therefore have an impact on landowners. The change in management, which could involve the introduction of ditches, changes to informal embankments and a change in grazing patterns would also require consent from Natural England.

Risks to the coastal road need to be monitored, given the current trend of marsh and intertidal narrowing, driven by the onshore movement of the Swatchway and River Eden Channel. Currently the road is subject to occasionally flooding, but frequency of flooding and risk of undermining could increase if the channel continued to move towards the shoreline, particularly between North Plain and Bowness-on-Solway. There may be potential to improve resilience of the road as part of implementing Managed realignment and the possible landward relocation of short stretches of road to higher land, should also be considered

There is also potential for some heritage sites, namely the milefortlets and other archaeology associated with the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site, to become at increasing risk in the future. Given that any future change in the channel migration pattern could result in intertidal expansion and subsequent marsh regrowth, only monitoring is required at this

time. Further erosion of the marsh has potential to reveal further archaeological evidence, given the rich history of the area; it is unlikely that any intervention works would be justified in these circumstances, therefore mitigation would involve recording and, where appropriate, collection of finds.

Future actions include:

- Continued monitoring of changes in the extent of marsh and intertidal areas, as part of the North West Regional Monitoring Programme, to appraise risk to the coastal road and identify any changes in observed trends.
- Detailed discussion between landowners, Cumbria County Council, Allerdale Borough Council, Solway Coast AONB and Natural England to consider potential for management changes along the coastal fringe.
- Monitoring of risk to historical assets and liaison with Historic England to enable sufficient time for recording and, where appropriate, collection of finds.

## 3.2 11e8.3 Bowness-on-Solway to Drumburgh

### 3.2.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy along this frontage is Managed realignment from the short term, although it was recognised that there would be a need for local diversion or setback of the coastal road where at risk.

The primary justifications for the policy included: the potential for future habitat creation in support of the internationally designated sites, insufficient justification for defences to highway and insufficient economic justification for national funding to provide local defences to reduce risk to properties in Port Carlisle. The policy does, however, allow for provision for private funding of defences if they are required.

Most of the coastline is undeveloped; the village of Port Carlisle located along the coast and the main coastal link road runs along the backshore. As such the majority of this section is undefended and consists of natural saltmarsh of variable width; there are two sections of seawall between Bowness-on-Solway and Grey Havens:

**Bowness-on-Solway Highway Wall 1: masonry wall and concrete revetment (350 m) – Cumbria County Council**



Figure 6 Highway wall at Bowness-on-Solway.  
Photograph taken during CH2M (2017) asset inspection.

This is a vertical blockwork retaining wall with additional concrete toe and apron which protects the public highway. In 2014, two new land drainage outfalls were constructed through the wall (CEUK, 2015). During the earliest inspections undertaken as part of the North West Regional Monitoring, areas at the toe of the wall were already damaged. No remedial works appear to have been undertaken but for a number of years there was no observed change in defence condition.

The most recent inspection (CH2M, 2017a) notes that remnants of toe piles are currently exposed, with some scour evident along the defence toe (Figure 6). No change to the upper structure was observed.

**Bowness-on-Solway Highway Wall 2: concrete revetment (260 m) – Cumbria County Council**

Figure 7 Highway revetment at Bowness-on-Solway.  
Photograph taken during CH2M (2017) asset inspection.

This is a sloping blockwork retaining wall with additional concrete toe and apron which protects the public highway (Figure 7).

Little change in defence condition was observed between 2010 and 2015, but in 2016, the inspection noted that a fall in beach levels at eastern end had undermined sloped concrete protection (CEUK, 2016). The latest inspection noted that in response to this, the sloped concrete protection at the eastern end had been fitted with a new concrete toe to prevent undermining and avoid further erosion.

The shoreline is characterised by a series of fringing marshes which have developed in to slight embayments formed by natural headlands. The marshes are fronted by mud and sand flats, the width of which is affected by the position of the River Eden channel, which runs close to the shoreline between Bowness and Drumburgh. At Port Carlisle the configuration of the coast has changed due to changing use of the area. The village was developed as a port in 1819, as the entry point for the Carlisle Canal, constructed in 1819 to 1823, to enable sea-going vessels to reach the centre of the city. The canal was replaced by the Port Carlisle Railway in 1854, but issues of the port silting up, together with the construction of a deep water port at Silloth, meant the port fell into disuse by 1856. By the Ordnance Survey map of 1901, most of the structures had been removed, but the impact of the port on the local subtidal morphology is still evident, in the form of tidal pools, and some remnants of the structures remain. Siltation of the port is believed to be linked to large scale changes in the low water channels attributed to construction of the Solway railway viaduct at Bowness.

### 3.2.2 Strategy considerations

The coastal road is prone to flooding and has previously suffered water damage and erosion. Bowness Corner to Port Carlisle and Port Carlisle to Glasson are key risk areas for the road. A pressurised sewer (United Utilities) also runs beneath the road and it is understood that the toe works to sea wall in front of road immediately east of Bowness was undertaken by United Utilities in association with construction of a pumping station and associated protection of associated infrastructure. This is the rising main pipeline route from Bowness-on-Solway to a new waste water treatment works (WWTW) at Glasson. Although the majority of properties at Port Carlisle are located above the flood risk level, some remain at risk.

Recent monitoring data indicate that onshore migration of the River Eden channel has resulted in recession of the marsh at Port Carlisle and Drumburgh, where there has been 7 and 17 m of recession, respectively, a 10 year period up to 2016. The marshes are also affected by changes to the main drains which run through them, for example Easton Marsh at Drumburgh.

The Solway Firth is of significant importance for non breeding birds and is afforded the highest protection (Ramsar, SPA, SAC, SSSI), forming a link in the chain of west coast estuaries used by migratory and wintering birds. The Inner Solway is considered particularly important for the diverse and concentrated nature of the species it supports. The changing channels of the Eden and Esk form an ever changing complex and sand and mud banks between the shorelines of England and Scotland.

The littoral sediment habitat of Westfield Marsh is in favourable condition (last assessed in 2010), but the adjacent mud and sandflat units is defined as unfavourable recovering condition (last assessed in 2010) with a notable (natural) reduction in mussel and cockle numbers.

This coastline has significant historical value, recognised by its designation as part of the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site. The course of the Wall and its associated Vallum (ditch), which are designated Scheduled Monuments, lie inland from the coast along much of this stretch, but at Glasson the Wall runs along the coastal edge. There are a number of additional Scheduled Monuments, which are along the coast and therefore at risk from erosion and flooding, including Knockcross camp at Grey Haven, between Bowness and Port Carlisle, and Drumburgh Roman Fort. Port Carlisle has features a number of listed properties, dating from its development as a port in the early 1800s.

Since the SMP2 was adopted there have been no changes in environmental designations although this part of the Firth may become designated as a marine conservation zone in 2019, which would lend more protection to the seabed species and habitats found at the site. In addition, there have been no changes in land use and no development has taken place. Although not directly a coastal management issue, the Environment Agency is withdrawing from maintenance of drainage ditches and the running of the drainage pumps in this area. Currently a Water Management Committee is being established, anticipated within 5 years, before that Environment Agency will continue to maintain.

The proposed route of the England Coast Path follows the coastal road between Bowness-on-Solway and Port Carlisle, but at Port Carlisle it lies seaward of the road and follows a before cutting inland at Glendale Caravan Park and following the Vallum and then an inland coastal path. Part of the route of the trail on this length of coast (east of North Plain and Scargavel Point) would be able to change without further approval from the Secretary of State in response to coastal erosion or other geomorphological processes, or encroachment by the sea.

### 3.2.3 Discussion

The current SMP2 policy of Managed realignment is in accordance with the management principles of the AONB designation and the national and international environmental designations for the site, which would not support construction of new sea defences. This policy would, however, mean increasing risks of erosion and flooding to the main coastal road.

Defences are already in place between Bowness Corner and Knockcross. Since the early Ordnance Survey maps, this has been an exposed location and therefore does not appear to have been any marsh here at least since the earliest Ordnance Survey maps from the 1860s. At this time there may have been embankments protecting agricultural land, but was no defined road nor formal defences present. There is both erosion and flood risk to road and recent asset inspection data suggests that there are currently issues with dropping beach levels, which have caused recent undercutting of defences. There is currently no other viable road between Bowness-on-Solway and Port Carlisle (the former route is now a discontinuous track). Rerouting or setback of the road may be possible; unless a significant realignment is undertaken, the road is likely to remain within the tidal flood risk zone, but erosion risk could be reduced.

Since the SMP, there has however been a £10.8M United Utilities (UU) project to provide a new wastewater treatment works (WwTW) at Glasson. This has involved the construction of new pumping stations located at Bowness-on-Solway, Port Carlisle and Drumburgh and a new rising mains to the new Glasson WwTW, mainly located in the coast road. This project was completed in 2010. Given the scale of investment it is unlikely that relocation of the UU assets and road between Bowness and Glasson is likely to be a viable option in the short term. Currently the only exposed stretch of road is east of Bowness, where recent works have been undertaken at the toe of the defence to reduce the risk of undermining and erosion. Elsewhere the road is subject to periodic tidal inundation, but fringing marsh provides protection from undermining. It is understood that there are currently investigations underway to consider these issues.

Between Glasson to Drumburgh, there are more opportunities to consider a localised Managed realignment, as the road is located further landward. With the possibility of creating a more diverse mosaic of wetland habitats through opening up current agricultural areas to wetland. Given the designations along this shoreline, any change in management, which could involve introduction of

ditches, changes to informal embankments and a change in grazing patterns would also require consent from Natural England. New embankments may need to be constructed to minimise risk of flooding to the road and UU assets, which lie further inland. As the route of Hadrian's Wall and its associated Vallum is not absolutely defined, any new embankments would need to be carefully sited to avoid locations if possible. Works that could potentially cross the route of Hadrian's Wall (or Vellum) would require extensive investigation with Historic England. It may be possible to utilise any embankments associated with the former railway which ran along this frontage; but this would require further investigation.

Future actions include:

- Continued monitoring of changes in the extent of marsh and intertidal areas, as part of the North West Regional Monitoring Programme, to appraise risk to the coastal road (and UU assets) and identify any changes in observed trends. Longer term plans for the road and UU assets need to be discussed to appraise the need to change the current SMP policy in the short term.
- Continuing monitoring of defences assets between Bowness-on-Solway and Port Carlisle to assess the need to additional work to address undermining. Any further works would require consent from Natural England and a scheme HRA and AA would need to be undertaken, given the significant environmental value of the littoral and sublittoral zones.
- Detailed discussion between landowners, Cumbria County Council, Allerdale Borough Council, Solway Coast AONB, and Natural England to consider potential for management changes along the coastal fringe, with the view to create more wetland areas, particularly between Glasson and Drumburgh. Any works will need to be undertaken between April and September so as not to disturb the overwintering birds.
- Monitoring of risk to historical assets and liaison with Historic England to enable sufficient time for recording and, where appropriate, collection of finds. Any requirement for additional embankments or construction of ditches to facilitate management realignment and habitat creation between Glasson to Drumburgh would require further discussion with Historic England to define routes which should minimise disturbance to historical assets where possible or otherwise determine appropriate mitigation measures, such as the need for hand digging and recording of finds.
- Estuary wide feasibility studies into Managed realignment opportunities, to include hydrodynamic modelling to determine effects on flood risk and geomorphology of estuary as well as the likely inundation of the sites and habitat creation, Section 1.3.

## 3.3 11e8.4 Drumburgh to Dykesfield

### 3.3.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy along this frontage is Managed realignment from the short term to enable a "naturally functioning coast". This involves the need to plan for the re-route or diversion of presently at risk undefended coastal road and refers to "measures to proactively adapt to future coastal changes".

There are no formal coastal defences along this frontage, but there are privately maintained earth embankments at various locations along Drumburgh Marsh and the railway embankment, inland of the road may provide some flood protection; limited information is available on these. The SMP2 estimated a residual defence life of between 6 and 10 years, but this would depend on exposure conditions.

The road east of Drumburgh is regularly covered by high tide and land to landward floods. Most properties at Drumburgh, Boustead Hill and Dykesfield lie on naturally high land, but properties at Easton remain within the flood risk zone.

The shoreline is fronted by extensive marsh (Easton Marsh and Burgh Marsh), which widens eastwards, towards Dykesfield. The main low water channel of the River Eden remains close to the shoreline and is a key influence on changes along Burgh Marsh. This has been the situation since at least the earliest Ordnance Survey maps from the 1890s.

### 3.3.2 Strategy considerations

Recent monitoring data indicate that onshore migration of the River Eden channel has resulted in recession of the marsh. The edge of the saltmarsh receded by between 15 and 30 m between 2006 and 2016, the greatest distance occurring adjacent to the outside of meanders of the River Eden and at Ridding Sough. The SMP2 predicted continued erosion of Burgh Marsh, exacerbated by sea level rise or increased wave energy.

The coastal road runs along the back of the marsh; this links the string of coastal settlements along this frontage but is regularly flooded. A United Utilities pressured main lies along part of it, linking Easton to Drumburgh.

Burgh Marsh is one of the most extensive areas of saltmarsh in the Solway and is of significant importance for non breeding birds, and is designated as such under the Solway Firth SAC, Ramsar, SPA and SSSI. Since the SMP2 was adopted there have been no changes in environmental designations although this part of the Firth may become designated as a marine conservation zone in 2019, which would lend more protection to the seabed species and habitats found at the site. In addition, there have been no changes in land use and no development has taken place. Although not directly a coastal management issue, the Environment Agency are withdrawing from maintenance of drainage ditches and the running of the drainage pumps in this area. Currently a Water Management Committee is being established, anticipated within 5 years, before that the Environment Agency will continue their maintenance.

This coastline has significant historical value, recognised by its designation as part of the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site. Although there is no defined course of Hadrian's Wall through this stretch (which may have been destroyed during construction of the canal and later railway), there is a high potential for undiscovered archaeology. The route of the former Victorian railway and canal lie adjacent to the coastal road and there are listed buildings along this route as well as at Easton, Boustead Hill and Dykesfield and Longburgh.

The proposed route of the England Coast Path runs behind the road between Drumburgh and Easton, but between Easton and Dykesfield the route runs along the centre of the marsh, possibly following the course of an old embankment or drainage channel. Burgh Marsh is Registered Common Land and the public therefore has a right of access (under the Countryside and Rights of Way Act 2000 (CROW Act)). The route of the trail on this length of coast would be able to change without further approval from the Secretary of State in response to coastal erosion or other geomorphological processes, or encroachment by the sea.

The littoral sediment habitat of Easton Marsh is in unfavourable recovering condition (last assessed in 2010), whilst the adjacent mud and sandflat unit is defined as unfavourable recovering condition (last assessed in 2010) with a notable reduction in mussel and cockle numbers. Although recovery of Easton Marsh was recorded during the last inspection, a review of status was recommended: key reasons for its unfavourable status were high grazing pressure, previous improvement, impact of man-made structures, and uniform structure of the marsh, which mean the habitat is not ideal for invertebrates and the main interest is restricted to the margins of a few deep creeks. The adjacent saltmarsh habitat of Burgh Marsh is in favourable condition (last assessed in 2015), with the adjacent mud and sandflat unit defined as unfavourable recovering.

### 3.3.3 Discussion

The current SMP2 policy of Managed realignment is in accordance with the management principles of the AONB designation and the national and international environmental designations for the site, which would not support construction of new sea defences. Under this policy there would, however,

be increasing risks of tidal flooding to the main coastal road and it is likely that in the future the road may need to be closed on a more frequent basis, with potential for damage to the road surface. Erosion is not currently an issue to the road, due to the expanse of saltmarsh, although recent monitoring data do indicate the marsh is narrowing over time due to shoreward advancement of the low water channel.

There is potential for habitat creation along this frontage which has the potential to improve or maintain the status of the SSSI. West of Easton, United Utilities assets run beneath of the road, which is currently afforded additional protection by a private embankment; therefore, future plans would depend upon the strategic importance of these assets and the cost of relocation. Between Easton and Boustead Hill, and Boustead Hill to Longburgh (Dykesfield), there is more potential for Managed realignment, which could improve the mosaic of habitats supported, but this would require relocation or closure of the coastal road which would allow marginal farmland lying inland of the road to be opened up. The SMP2 noted that there are culverts under the old railway embankment, but that the embankment would constrain future change, even under a policy of no active intervention.

There are a number of possible options, including:

- Closure and subsequent removal of the road (and breach of railway embankment) between Easton and Longburgh, with traffic forced to use existing alternative routes. This would mean an extra 4.5 km travel distance for travellers between Easton and Boustead Hill and a potentially difficult turning onto the B5307. Parts of the alternative route are within the flood risk zone. For travellers between Boustead Hill and Longburgh, this would mean an extra 6.5 km travel distance, and a potentially difficult turning onto the B5307, with additional traffic passing through the villages of Kirkbampton and Thurstonfield. Removal of the road and breach of the railway embankment would require careful investigation with Historic England, as this is a possible route of Hadrian's Wall and additional time and costs may be involved if hand digging is required. Easton presently benefits from informal secondary flood defence function provided by the former railway embankment and so any modification to it would need careful consideration in a flood risk assessment and mitigation such as a new set back defence may be required.
- Closure of the existing road and construction of a setback route, connecting the villages. Any new road could be made more resilient to flooding and there is also the potential to incorporate improvement flood protection to Easton and properties along the village margins into the design. This would, however, be an expensive option and there is no obvious alternative inland route. Between Easton and Boustead Hill, following the higher land would mean little improvement from the existing alternative route, although this approach would be more viable between Boustead Hill and Longburgh. A shorter route would mean the road would remain within flood risk zone 2 and would also fall within the SSSI Impact Risk Zone, meaning that any planning application would need to assess likely impacts on the SSSI, SAC, SPA and Ramsar site. If the route also fell within the World Heritage Site buffer zone and the Registered Common Land, further consents would be required.
- To simply address the flooding issues to the road, rather than the objectives for habitat creation, the current route could be made more resilient to flooding, for example through raising the road surface and culverting. As well as an increase in the road height, this would also require an increase in footprint, with impact on the environmental designated sites and World Heritage Site buffer zone.

There therefore needs to be a feasibility study including an Environmental Impact Assessment to appraise potential impacts, such as: disruption to local residents during construction, effects on ecology due to habitat loss, landscape and visual effects, water flow and flood risk in adjacent areas, impact of the National Trail and coastal access, and cultural heritage. As part of the assessment Regulated Tidal Exchange habitat creation opportunities should be considered.

Habitat creation could also be achieved through decreased levels of water level management in some areas leading to 'wetting up' of areas with resultant diversity gains; such actions could be undertaken in advance of any road relocation. Any scheme would need to consider potential impacts on Easton, which lies within the flood risk area; there could be potential to reduce risks here through careful design.

Future actions include:

- Continued monitoring of changes in the extent of marsh and intertidal areas, as part of the North West Regional Monitoring Programme, to appraise risk to the coastal road (and UU assets) and identify any changes in observed trends. Currently there is no erosion risk to the road, due to the extent of marsh, but tidal flooding will remain a periodic issue.
- Detailed discussion between landowners, Cumbria County Council (including highways), Allerdale Borough Council, Solway Coast AONB, and Natural England to consider potential for land management changes along the coastal fringe, with the view to creating more wetland areas, particularly between Easton and Boustead Hill.
- Feasibility study to assess best options for addressing long term sustainability of the coastal link road.
- Monitoring of risk to historical assets and liaison with Historic England to enable sufficient time for recording and, where appropriate, collection of finds. Any requirement for additional embankments or construction of ditches to facilitate Managed realignment and habitat creation would require further discussion with Historic England to define routes which should minimise disturbance to historical assets where possible or otherwise determine appropriate mitigation measures, such as the need for hand digging and recording of finds.
- Estuary wide feasibility studies into Managed realignment opportunities, to include hydrodynamic modelling to determine effects on flood risk and geomorphology of estuary as well as the likely inundation of the sites and habitat creation, Section 1.3.

## 3.4 11e8.5 Dykesfield to Kingsmoor (Eden Normal Tidal Limit)

### 3.4.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy along this frontage is Managed realignment from the short term to "allow continued natural coastal evolution" and refers to "measures to proactively adapt to future coastal changes". Justification for this policy was the limited assets at flood risk, condition of internationally designated sites and potential for habitat creation.

This unit covers the estuary coastline between Dykesfield and Casson Dyke Farm and the east bank of the River Eden, up to the normal tidal limit. There are no formal coastal or flood defences but private earth embankments are present in places.

Insufficient data is available for Burgh Marsh to determine trends of change. No monitoring data is collated as part of the North West Regional Monitoring data upstream of Burgh Marsh, therefore changes in position or form of the Eden and its banks are unknown.

### 3.4.2 Strategy considerations

The frontage between Dykesfield and Casson Dyke Farm is covered by the Solway Firth international and national designations (Ramsar, SPA, SAC, SSSI and AONB). Between Dykesfield and where the shoreline changes in orientation at Old Sandsfield, the shoreline is fronted by the extensive marshland of Burgh Marsh. This littoral habitat is currently in favourable condition (last assessed in 2015). Between Old Sandsfield and Casson Dyke Farm lies Sandsfield Marsh, which is also in

favourable condition (last assessed in 2010). Due to onshore migration of the low water channel, no pioneer or lower marsh zones are present at this location. The vegetation structure was deemed suitable for both breeding and wintering birds. The southeastern corner of this part of the unit comprises mediaeval ridge and furrow.

Upstream from Casson Dyke Farm the shoreline is designated as part of the River Eden and Tributaries SSSI and Riven Eden SAC, which is designated for its diversity of aquatic plants and high invertebrate interest. The Eden also supports a high diversity of breeding birds and is of regional importance for wintering wildfowl and otters. The condition of this reach of the river is unfavourable – recovering (last assessed in 2010). The shoreline up to Beaumont is also part of the AONB. Upstream of Beaumont falls within the Eden and Esk Drinking Water Protected Area (surface water), which is a designated area in which the use of certain substances must be carefully managed to prevent the pollution of raw water sources that are used to provide drinking water.

Since the SMP2 was adopted there have been no changes in environmental designations although this part of the Firth may become designated as a marine conservation zone in 2019, which would lend more protection to the seabed species and habitats found at the site. In addition, there have been no changes in land use and no development has taken place.

Although not directly a coastal management issue, the Environment Agency are withdrawing from maintenance of drainage ditches and the running of the drainage pumps in this area. Currently a Water Management Committee is being established, anticipated within 5 years, before that the Environment Agency will continue to maintain.

This coastline has significant historical value, recognised by its designation as part of the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site and this whole frontage is within the defined buffer zone. The only listed buildings within the flood risk zone is the Grade II\* King Edward I monument in Burgh Marsh.

There is an inland constraint to the marshlands due to naturally rising lands, but it is evident that previous wetlands within the coastal margin have been 'improved' historically for agricultural use, such that there is potential for saltmarsh expansion with sea level rise if drained farmed areas were restored to marsh, particularly between Old Sandsfield and Casson Dyke Farm, and High Sand.

The proposed route of the England Coast Path runs along the centre of Burgh Marsh, possibly following the course of an old embankment or drainage channel. Burgh Marsh is Registered Common Land and the public therefore has a right of access (under the Countryside and Rights of Way Act 2000 (CROW Act)). At New Sandsfield the course of the route turns inland to cross the beck at Holmesmill, before returning to the bank of the River Eden near Casson Dyke Farm, which it generally follows until the river crossing at Knockupworth Bridge. Parts of this route would be able to change without further approval from the Secretary of State in response to coastal erosion or other geomorphological processes, or encroachment by the sea.

### 3.4.3 Discussion

The current SMP2 policy of Managed realignment is in accordance with the management principles of the AONB designation and the national and international environmental designations for the site.

There are opportunities to enable expansion of current saltmarsh, and thereby potentially offset future issues of coastal squeeze, through agri-environment schemes to allow saltmarsh accretion and land level rise to offset sea level rise. This is also an objective of the AONB. Given the designations along this shoreline, any change in management, which could involve introduction of ditches, changes to informal embankments and a change in grazing patterns would also require consent from Natural England. At a scheme design stage, the potential to elevate pressure on the adjacent bank (covered by policy unit 11e8.8) should be considered: here there is currently an issue of slope erosion due to the proximity of the U1068 to the bank.

For those properties that remain at flood risk, such as New Sandside, flood adaptation measures should be considered to reduce the impact of flooding and ensure safe exit during extreme events.

Future actions include:

- Continued monitoring of changes in the extent of marsh and intertidal areas, as part of the North West Regional Monitoring Programme, to identify any changes in observed trends and any possible increase in risk level.
- Detailed discussion between landowners, Cumbria County Council (including highways), Allerdale Borough Council, Solway Coast AONB, and Natural England to consider potential for land management changes along the coastal fringe, with the view to creating more wetland areas.
- Monitoring of risk to historical assets and liaison with Historic England to enable sufficient time for recording and, where appropriate, collection of finds. Any requirement for additional embankments or construction of ditches to facilitate Managed realignment and habitat creation would require further discussion with Historic England to define routes which should minimise disturbance to historical assets where possible or otherwise determine appropriate mitigation measures, such as the need for hand digging and recording of finds.
- Estuary wide feasibility studies into Managed realignment opportunities, to include hydrodynamic modelling to determine effects on flood risk and geomorphology of estuary as well as the likely inundation of the sites and habitat creation, Section 1.3.

## 3.5 11e8.6 Kingsmoor (Eden Normal Tidal Limit) to Rockcliffe

### 3.5.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy along this frontage is Managed realignment from the short term to “allow continued natural coastal evolution” and refers to “measures to proactively adapt to future coastal changes”. Justification for this policy was the limited assets at flood risk, condition of internationally designated sites and potential for habitat creation.

This unit covers the east bank of the River Eden, up to the normal tidal limit. There are no formal coastal or flood defences but private earth embankments are present in places. Between Kingsmoor and Cargo flood risk is limited by the local topography, with the land rising steeply away from the river. Between Cargo and Rockcliffe there is an extensive flood risk area, but mainly agricultural land is at risk, together with a sewage works at Cargo; the extent of the flood zone low lying area is naturally constrained by higher surrounding land.

No monitoring data is collated as part of the North West Regional Monitoring data along this frontage, therefore changes in channel position or form are unknown.

### 3.5.2 Strategy considerations

There are no specific environmental designations along the shoreline, but the river is designated as part of the River Eden and Tributaries SSSI and Riven Eden SAC, which is designated for its diversity of aquatic plants and high invertebrate interest. The Eden also supports a high diversity of breeding birds and is of regional importance for wintering wildfowl and otters. The condition of this reach of the river is unfavourable – recovering (last assessed in 2010); the banks are within the defined SSSI Impact Risk Zone, some riparian habitats are also a part of the SAC designation. Part of this area falls within the Solway Tweed Drinking Water Protected Area (surface water) (2014), which is a designated area in which the use of certain substances must be carefully managed to prevent the pollution of raw water sources that are used to provide drinking water. Current Risk Status of this area in ‘At Risk’.

The area between the river shore and the railway line is designated as part of the Frontiers of the Roman Empire (Hadrian's Wall) for its historical value. There are also Grade II listed properties at Cargo and one along bank of the river.

The proposed route of the England Coast Path runs along the river bank, using an existing public right of way. At Carr Bed the route lies along the shoreward edge, but here it is recognised the implementation of roll back may be more complex, potentially requiring further discussions with landowners.

### 3.5.3 Discussion

Although the river course is naturally constrained along part of this frontage, there could be potential for some localised Managed realignment along the southern extent of low lying peninsula at Cargo and further north at Carr Bed. Both would be relatively small sites near the normal tidal limit; this may result in infrequent tidal flooding of the sites therefore habitat diversity could be limited, and it is unlikely that sites would be created to compensate potential habitat losses elsewhere in the strategy area. There is potential, however, for these to be developed to create flood storage areas, with potential to reduce flood risk further upstream. Further studies would be required to appraise this, which will need to take account of: potential changes in water levels and flows up and downstream, habitat opportunities, impact on heritage and changes to the England Coast Path.

Future actions include:

- Estuary wide feasibility studies into Managed realignment opportunities, to include hydrodynamic modelling to determine effects on flood risk and geomorphology of estuary as well as the likely inundation of the sites and habitat creation, Section 1.3.

## 3.6 11e8.8 Rockcliffe to Demesne Farm

### 3.6.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy along this frontage is Managed realignment from the short term, which involves in seeking opportunities to re-route or divert undefended coastal road. The SMP also refers to allowing "measures to proactively adapt to future coastal changes".

There are no formal flood defences along this stretch, but privately owned embankments may exist.

No monitoring data is collated as part of the North West Regional Monitoring data along this frontage, apart from one profile at Demesne Farm, therefore changes in channel position or form are unknown. The data for Demesne Farm indicates little or no net change since 2012.

### 3.6.2 Strategy considerations

This stretch includes the shore road between Rockcliffe and Castletown Farm (the U1068) is at potential erosion risk, as it lies on an outer bend of the river, but for the most part is high enough to be outside of any flood risk. A United Utilities pressured main also runs along the road. The road continues further west as a trackway, linking Castletown Farm to Demesne Farm. The small settlement of Redhill, west of Rockcliffe, is located on higher land, so is not at risk from flooding. Further west, beyond Castletown Farm, the cliff line cuts inland slightly and is fronted by fringing marsh (part of Demesne Marsh).

A preliminary geotechnical sources study has previously has been undertaken to appraise this section of the U1068 (Opus, 2017). This concluded that there are signs of instability along the slope from the U1068 down to the River Eden, with base soil evident over a significant portion of its length. Historical evidence does not suggest a significant change in the area over time, therefore Opus (2017) attributed the change in the slope in recent years to storm events in 2015. Although the report concluded that the slope is probably not stable in its present form and is at risk from further erosion at the site during storm and flood events, they could not find any evidence of large scale

movement along the site. The report considered a number of options, which are discussed further in the section below.

East of Castletown Farm the river lies within the River Eden and Tributaries SSSI and Riven Eden SAC, which is designated for its diversity of aquatic plants and high invertebrate interest. The Eden also supports a high diversity of breeding birds and is of regional importance for wintering wildfowl and otters. The condition of this reach of the river is unfavourable – recovering (last assessed in 2010); the banks are within the defined SSS Impact Risk Zone. West of Castletown Farm, the shoreline and channel fall within the Upper Solway Flats and Marshes Ramsar, SPA, SAC and SSSI and Solway Coast AONB. Demesne Marsh is in unfavourable recovering condition (last assessed in 2010). High grazing and poor structure of the marsh due to improvements for agriculture, are recognised as pressures and the 2010 survey states that the habitat is not ideal for invertebrates, with the main interest restricted to the margins of a few deep creeks.

This is designated as part of the Frontiers of the Roman Empire (Hadrian's Wall) for its historical value. There is also a Grade II listed property located just inland of the U1068.

The proposed route of the England Coast Path follows the shore road and then the existing track between Castletown Farm and Demesne Farm, using an existing public right of way. Parts of this track are at potential risk of tidal flooding.

### 3.6.3 Discussion

A key issue in this area is the long term sustainability of the U1068 road, a narrow country lane which links Rockcliffe and Redhill to Castletown, given recent slope erosion. A previous study has been undertaken by Opus (2017), which in addition to possible monitoring concepts, considered a number of possible options to address the risk:

- Sheet pile wall: Opus (2017) suggested this as a permanent, long life solution, but identified the possible risk of disturbance during installation and the expense. In addition to the points raised by Opus (2017), due to the environmental designations in place, this would require consent from Natural England. Although the footprint of the structure would be small, this would inhibit natural functioning of the river and there is potential for flows to be diverted to the opposite bank. Construction of new structures is also counter to the objectives of the SMP, AONB and international designations, which are all working towards a more naturally functioning system. Any works would require a detailed SEA, Habitat regulations Assessment and most likely Appropriate Assessment (AA).
- Rock armour: Opus (2017) suggested this as a cheaper long term solution which could reduce the rate of erosion, but identified the impact on coastal users as well as the visual impact. As for the sheet piling option, due to the environmental designations in place, this would require consent from Natural England; construction of new structures is also counter to the objectives of the AONB and international designations. Any works would require a detailed SEA, Habitat regulations Assessment and most likely Appropriate Assessment (AA).
- Diversion of the Redhill Road: Opus (2017) proposed that this could allow greater access to the area and the design could reduce width restriction of the road. However, it was identified that private land would need to be purchased and that this would be an expensive option. The report also stated that the slope would continue to deteriorate with “potential impact on the River Eden” – this however, would be regarded as a positive outcome as it allows natural functioning of the river.
- Divert energy from the River Eden: Opus (2017) proposed this as an innovative permanent solution, but the report does not provide any detail on how this could be achieved. It does, however note that this would lead to potential problems to move to another area of the river bank. This would be seen as a key objection to this option; particularly along this stretch, where the river narrows considerably. This option is also counter to the objectives of the SMP, AONB and international designations which are all working towards a more

naturally functioning system. Any works would require a detailed SEA, Habitat regulations Assessment and most likely Appropriate Assessment (AA).

There are two additional options:

- Eventual closure of the road, once it is considered unsafe, with traffic forced to divert through Rockcliffe. This could cause disruption to local communities who currently use this route; however, a viable alternative route is available. Historical evidence suggest that the recent change was due to extreme events in winter 2014 and 2015; therefore the road could remain safe for a number of years.
- Reduce pressure on this shoreline: The zone of erosion is located on the outer bend of the River Eden, where erosional forces of the river are likely to be greatest. It may be possible to consider reducing flows here through considering Managed realignment along the opposite bank of the River Eden, at Casson Dyke (policy unit 11e8.5), where the SMP policy is already Managed realignment. Further studies would be required to ensure pressure points are not simply moved to a different location and to assess potential impacts on internationally designated sites.

Future actions include:

- Monitoring the risk to the road. Currently this frontage is not included in the North West Regional Monitoring., therefore site specific monitoring will be required. Opus (2017) proposed that that targets could be installed along the slope, which could be read remotely from a total station on the opposite bank of the river. Asset inspections should also be undertaken along the road to appraise signs of cracking and evidence of subsidence. It is understood an intrusive ground investigation was carried out in November 2017, but results of this have not been provided at the time of writing.
- Continued discussions between Cumbria County Council (who are responsible for the road), Allerdale District Council and Rockcliffe Parish council to discuss sustainability of the road and the possibility of combining works to protect the village (considered in unit 11e8.7 and the road).
- Road closure procedures to be put in place: should there be any further slope movement, it may be necessary to close the road at short notice.
- Estuary wide feasibility studies into Managed realignment opportunities, to include hydrodynamic modelling to determine effects on flood risk and geomorphology of estuary as well as the likely inundation of the sites and habitat creation. Specifically, at this location this needs to consider whether alignments elsewhere could reduce pressures at this site.

## 3.7 11e8.9 Demesne Farm to Metal Bridge (Esk)

### 3.7.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy along this frontage is Managed realignment from the short term, including investigating opportunity to realign defences to high ground. Justification for this policy was that it provides opportunities for future habitat creation and that there was insufficient economic justification for public funding of defences. However, the policy allows for provision for private funding of defences if required.

The defences along this frontage consist of privately maintained earth embankments which lie behind extensive saltmarsh and sandflats (approximately 3.5 m at the widest point). Either side of the policy unit are rivers Eden and Esk where flood embankments are fronted by fringing marsh (approximately 20 m at the narrowest point). The majority of these embankments were newly constructed or modified prior to 2006. The embankments predominately protect farmland from flooding with only two farmstead and properties located adjacent to the Environment Agency

defined Flood Zones 2 and 3 along the River Esk and Eden. The M6 crosses the River Esk but is elevated above flood levels.

Along the Rockcliffe Peninsula, the marsh along the southern side (Demesne Marsh) has remained relatively stable, whilst the northern side is affected by changes in the meanders of the River Esk. Up to 20 m recession of the saltmarsh edge has occurred since 2010, coinciding with the outer edge of the River Esk meander, and 10 m recession around to the north east of the marsh adjacent to the River Esk.

Along the northern section of this frontage a small (10 ha) regulated tidal exchange has been implemented by Natural England in January 2011 (Natural England, 2011).

### 3.7.2 Strategy considerations

Land adjacent along the entire length of the frontage is covered by environmental designations including Upper Solway Flats and Marshes Ramsar, SSSI and SPA sites and Solway Firth SAC, as well as the River Eden and tributaries SSSI and River Eden SAC. The intertidal areas are important sites which support breeding and wintering birds such as Bar-tailed Godwit and contain a number of saltmarsh vegetation species which are used as grazing marsh. Most of protected areas are in a favourable condition except for one unit in the River Eden which was assessed as of 2010 as unfavourable – recovering.

Two properties are Grade II listed at Garristown and another property adjacent to the M6 located approximately 150 and 500 m south of the River Esk respectively. The proposed route of the England Coast Path runs along the privately owned flood embankments. The area falls into the Hadrian's Wall World Heritage Site buffer zone and is within the Solway Firth AONB.

Most of the farmland located behind the embankment lies within flood zones with little or no infrastructure and therefore may be considered as possible Managed realignment sites. At the mid to northern ends of the site the land is close to the tidal limit and may not be inundated regularly partly due to the large extent of saltmarsh fronting the embankments which may offer limited habitat potential. Further south near the Demesne Marsh at banks of the River Eden may also be developed into a smaller Managed realignment site which could aid flood risk to the Eden through flood storage, however construction of new embankments around a larger perimeter may make this scheme economically unfeasible. Furthermore, any proposed Managed realignment scheme along this frontage would require careful consideration on the potential erosion of current protected marshland and riverine habitats and morphological effects which may increase flood risk to the Rivers Esk and Eden.

### 3.7.3 Discussion

The current SMP2 policy of Managed realignment is in accordance with the management principles of the AONB designation and the national and international environmental designations for the site, which would not support construction of new sea defences. This policy would, however, mean increasing risks of erosion and flooding to the main coastal road.

Defences are already in place through the entire length of the frontage which appear to have been present since at least 1900. The early Ordnance Survey maps, also indicate the relative stability of the river Eden and the extent of sandflats and saltmarsh in front of the embankments. Assessments from aerial imagery and the presence of fringing marsh around the entire extent of the frontage indicates, at present, there is limited erosion risk to the embankments by tidal flows.

There is scope for potential managed realignment sites along the frontage which could be implemented as much of the land is low lying and vulnerable to tidal flooding, with mainly farmland at risk. However, there is little economic or ecological justification for Managed realignment as, at present, current defences are not at risk of erosion nor do there appear to be local habitat losses which require compensation. It is likely that any Managed realignment in this site would require further investigations into the potential effects upon flood risk and erosion of protected habitats including sand flats and marshland which front the embankments and River Eden.

Future actions include:

- Continued monitoring of changes in the extent of marsh and intertidal areas, as part of the North West Regional Monitoring Programme.
- Monitoring of risk to historical assets and liaison with Historic England to enable sufficient time for recording and, where appropriate, collection of finds. Consultation with Natural England regarding any requirement for additional embankments or construction of ditches to facilitate management realignment and habitat creation.
- Estuary wide feasibility studies into Managed realignment opportunities, to include hydrodynamic modelling to determine effects on flood risk and geomorphology of estuary as well as the likely inundation of the sites and habitat creation, Section 1.3.
- Site inspections of coastal defences to update records and provide details of asset properties and potential weaknesses.

## 3.8 11e8.10 Metal Bridge (Esk) to the River Sark

### 3.8.1 Existing approach to flood and coastal erosion risk management

The existing SMP2 policy along this frontage is Managed realignment over the short term (0 to 20 years and 20 to 50 years), including investigating opportunity to realign defences to high ground. Over the long term (50 to 100 years) the existing SMP2 policy is Hold the line. Justification for this policy was that it provides opportunities for future habitat creation and to manage the risk of flooding to agricultural land and the motorway. Economic viability of this policy may depend on the inclusion of infrastructure (A74 and M74) which was not considered in the 2010 SMP.

The defences along this frontage consist of privately maintained earth embankments which protect agricultural land from flooding from the River Esk. Seaward of the embankments are fringing saltmarsh and sandflats which extend up to approximately 60 m into the River Esk. The land behind the embankments until an unclassified road boundary next to the M6 lies in Environment Agency defined Flood Zone 2 and 3. Only one property and farmstead reside in the flood zone (protected by the embankments) with surrounding land used for agricultural purposes. National Grid pylons also pass through the flood zone and there are sewage pipelines to the property.

### 3.8.2 Strategy considerations

The shoreline along the entire length of the frontage is protected by several environmental designations including Upper Solway Flats and Marshes Ramsar, SSSI and SPA sites and Solway Firth SAC, as well as the River Eden and tributaries SSSI and River Eden SAC. The intertidal areas are important sites which support breeding and wintering birds such as Bar-tailed Godwit and contain a number of saltmarsh vegetation species which are used as grazing marsh. Most of protected areas were assessed as of 2010 as unfavourable – recovering due to signs of historic nutrient enrichment, however one unit near to the River Eden was assessed as of 2010 in a favourable condition.

A historic landmark (Milestone south of Gretna) is Grade II listed and lies within the flood zone approximately 300 m from the M6 motorway. at Garristown and another property adjacent to the M6 located approximately 150 and 500 m south of the River Esk respectively. The proposed route of the England Coast Path runs along the privately owned flood embankments.

Most of the farmland located behind the embankment is at potential flood risk. There is little or no infrastructure and therefore this area may be suitable for potential Managed realignment sites following more detailed investigations on the impacts of local flood risk and effects to protected habitats. This site may offer defence savings as assuming the entire site were to be realigned, the defence perimeter would be smaller than present. However, in the short-term it is unlikely that the condition of these defences require setback due to the sheltered nature of the site as indicated by the extent of intertidal habitats currently fronting the embankments.

Towards the rear of the site, the land is close to the normal tidal limit and may not be inundated regularly (assuming tidal channel is not modified by the Managed realignment site itself) which may offer limited intertidal habitat potential. Depending on the size of the proposed Managed realignment site there may also be potential modifications to the size of the Esk channel with possible increases to flood risk as well as erosion to sandflats and saltmarsh located seaward of the site. Furthermore, depending on the location and size of the breaches for the proposed Managed realignment site there could also be erosion risks to the M6 road and railway bridges and embankments.

### 3.8.3 Discussion

The current SMP2 policy of Managed realignment is in accordance with the management principles of the AONB designation and the national and international environmental designations for the site. In the long term (50 – 100 years) Hold the line policy could be implemented which may conflict with the present site designations unless it is deemed that there are significant economic and social justifications such as flooding of key infrastructure including the M6 and the railway.

Potential Managed realignment of the frontage could allow tidal water to flood up to the M6 and railway increasing flood risk to these important national transport routes. If the Managed realignment policy is implemented, new defences or significant modification of embankments would be required to prevent erosion of the motorway and railway. Furthermore, there is the potential for increased flood risk to the River Esk (including railway and M6 road bridges) and erosion of protected intertidal habitats due to the larger tidal prism created by the Managed realignment site. These factors would require careful consideration and planning before this policy could be implemented.

Future actions include:

- Continued monitoring of changes in the extent of marsh and intertidal areas, as part of the North West Regional Monitoring Programme.
- Detailed discussion between landowners, Cumbria County Council (including highways), Allerdale Borough Council, Solway Coast AONB, and Natural England to consider potential for land management changes along the coastal fringe, with the view to creating more wetland areas. Due to proximity to Scottish border, discussions should also involve the Dumfries and Galloway Council, Scottish Environment Protection Agency (SEPA), and Scottish Natural Heritage (SNH).
- Monitoring of risk to historical assets and liaison with Historic England to enable sufficient time for recording and, where appropriate, collection of finds. Any requirement for additional embankments or construction of ditches to facilitate management realignment and habitat creation. Discussions should also be undertaken with Historic Scotland.
- Estuary wide feasibility studies into Managed realignment opportunities, to include hydrodynamic modelling to determine effects on flood risk and geomorphology of estuary as well as the likely inundation of the sites and habitat creation, Section 1.3.
- Site inspections of coastal defences to update records and provide details of asset properties and potential weaknesses.

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