

# Appendix 9( - Options for Managing Flood and Erosion Risk

## Long List of Options

### Policy Unit MA24.1 – Whitby Abbey to Saltwick Nab

Policy Unit Details – MA24.1			
Policy Unit start	Whitby Abbey	Policy Unit End	Saltwick Nab
Grid Ref (start)	490839E, 511080N	Grid Ref (end)	491500E, 511500N
Defence Description			
Defence Status	Undefended natural cliff	Manmade Defence Length	0m of 1362m
Residual Life	N/A	Land Use	Agricultural/Recreation
Overall Asset Condition (Coast Protection Assets and Coastal Slope Condition Analysis)	N/A	Flood map	



Figure 1: Policy Unit MA24.1 EA Flood Map (Source - Environment Agency)

## CSS Strategic Options considered

Option 1a – No Active Intervention

Option 1b – No Active Intervention [with H&S]

Option 2 – Adaptive Management [Property Roll Back Scheme]

Option 3 – Active Intervention Improve [Rock Armour at cliff toe in areas where property is at risk]

## Strategic Options Consideration and Associated FCRM Measures

### ***Option 1a – No Active Intervention***

**Engineering:** The entire Policy Unit is undefended against flooding as there is no threat from a 1 in 200 year event so this option will have no impact on flood risk. The Policy Unit is also undefended against erosion. At the south eastern end of the Policy Unit, erosion will impact on the caravan park in the medium to long term.

**Economics:** The areas at risk of erosion are mainly agricultural land with limited assets at either end of the Policy Unit. Assets at risk of future erosion include a farm storage facility and a number of static caravans, though these will only be affected in the medium to long term. This option has no capital and maintenance costs.

**Environmental Considerations:** See Appendix E and Appendix F for the environmental assessment of this option. The area would be expected to benefit from natural retreat of the cliff.

### ***Option 1b – No Active Intervention [with health and safety]***

**Engineering:** The entire Policy Unit is undefended against flooding as there is no threat from a 1 in 200 year event so this option will have no impact on flood risk. The Management Unit is also undefended against erosion. At the south eastern end of the Policy Unit, erosion will impact on the caravan park in the medium to long term. Erosion will impact on some residential and commercial property therefore a health and safety scheme to remove damaged property would be required.

**Economics:** The areas at risk of erosion are mainly agricultural land with limited assets at the either end of the Policy Unit. Assets at risk of future erosion include a farm storage facility and a number of static caravans, though these will only be affected in the medium to long term. This option has some costs of health and safety schemes associated to protect the public from damaged property caused by erosion. Costs for the removal of property lost through coastal erosion would be covered in the 'Coastal Erosion Assistance Grant' administered through the EA.

**Environmental Considerations:** See Appendix E and Appendix F for the environmental assessment of this option. The area would be expected to benefit from natural retreat of the cliff.

### ***Option 2 – Adaptive Management [Property roll back scheme]***

**Engineering:** There would be no specific engineering solutions on the coastline required for this option; however removal of damaged property would be required. A property roll back scheme would involve abandonment of parts of the farmhouse storage and allow planning for replacement buildings on the property owners land.

**Economic:** There would be some public funds required for this option, but would not be expected to be significant. Costs for the removal of property lost through coastal erosion could be covered in the 'Coastal Erosion Assistance Grant' administered through the EA subject to available funding. Identified land would then be made available by the National Park Authority for the construction of replacement properties outside of the Coastal Change Management Area (CCMA). In making such provision, the National Park Authority is obliged to ensure that 'the provision is close enough to maintain the integrity of the coastal community from which development has been displaced, and the provision is required in order to secure the long-term future sustainability of coastal areas.

**Environmental:** See Appendix E and Appendix F for the environmental assessment of this option. The area would be expected to benefit from natural retreat of the cliff.

### ***Option 3 – Active Intervention Improve [Rock Armour at cliff toe in areas where property is at risk]***

**Engineering:** The cliffs spanning the entire length of this Policy Unit are approximately 1.3 km long and would require a significantly sized engineering solution to halt or reduce the current erosion taking place. Rock armour at the toe of the cliff at places where property requires protecting, could be considered as an engineering option for this section of coast, however it is not known how effective this would be as weathering to the upper section of the cliff would still occur.

**Economics:** Any proposals for new defences are unlikely to attract public funding due to the lack of benefits associated with their construction. Whilst new defences would enable protection of the existing agricultural land and caravan park, the capital investment required to construct new defences would be very high, far exceeding the value of the assets protected.

**Environmental:** There are no environmental benefits to be gained from protecting the area with erosion or flood defences. An engineering solution such as rock armour could possibly have an adverse effect on the natural environment and reduce intertidal habitat areas through coastal squeeze. See Appendix E and Appendix F for the environmental assessment of this option.

## Options rejected and options taken to the next stage

There are very few assets at risk within this Unit; therefore any engineering scheme to protect the residential and commercial property will need to be low cost. Options that aid local residents, business and heritage and do not require hard structure engineering should be considered further as parts of the Policy Unit are in a SSSI. There appear to be very few social or community impacts with any of the considered options.

Policy Unit MA25.1 –Saltwick Nab to Hundale Point

Policy Unit Details - MA25.1			
Policy Unit start	Saltwick Nab	Policy Unit End	Hundale Point
Grid Ref (start)	491500E, 511500N	Grid Ref (end)	502500E, 494500N
Defence Description			
Defence Status	Undefended natural cliff	Manmade Defence Length	0m of 1362m
Residual Life	N/A	Land Use	Agricultural/Recreation
Overall Asset Condition (Coast Protection Assets and Coastal Slope Condition Analysis)	N/A	Flood map	Error! Reference source not found. and Error! Reference source not found.

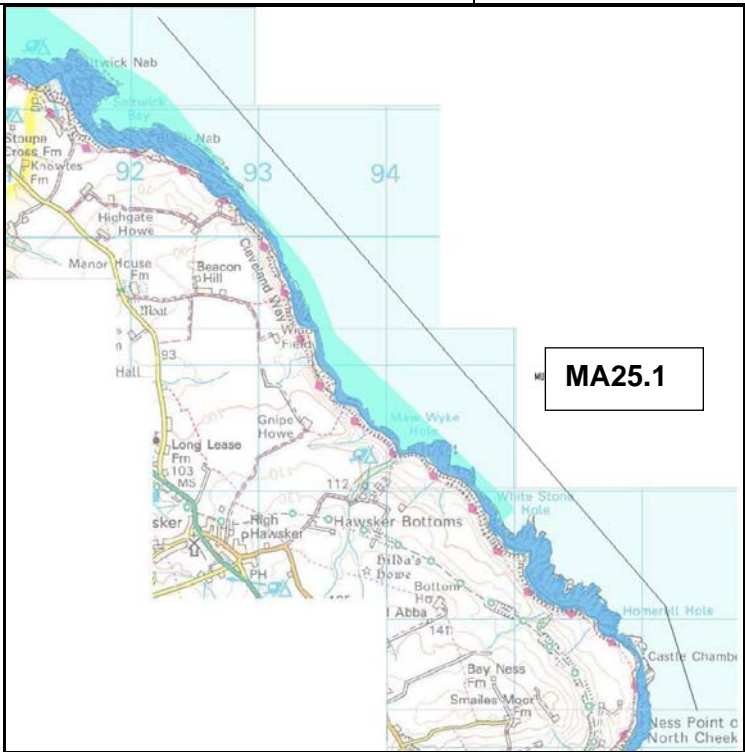


Figure 2: Policy Unit MA25.1 Saltwick Nab to Robin Hoods Bay Flood Map (Source – Environment Agency)

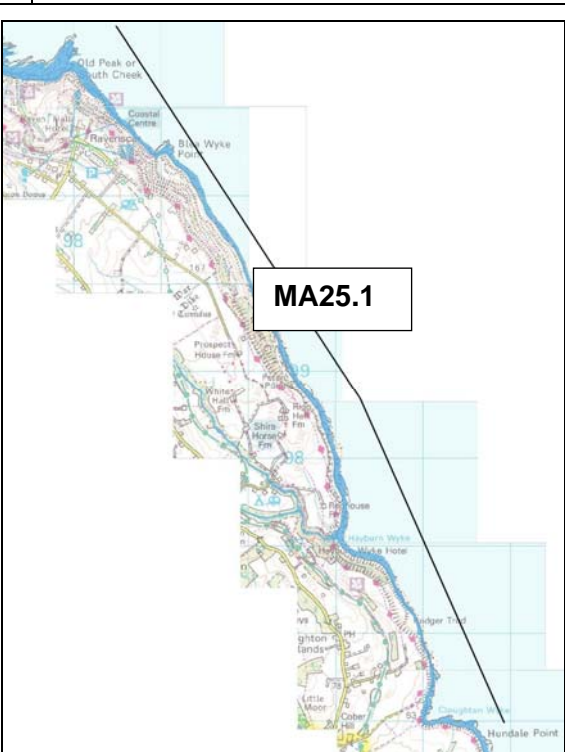


Figure 3: Policy Unit MA25.1 Robin Hoods Bay to Hundale Point Flood Map (Source – Environment Agency)

## CSS Strategic Options considered

Option 1a – No Active Intervention

Option 1b – No Active Intervention

Option 2 – Adaptive Management [Property Roll Back Scheme]

Option 3 – Active Intervention Improve [Rock Armour at cliff toe in areas where property is at risk]

## Strategic Options Consideration and Associated Potential FCRM Measures

### ***Option 1a – No Active Intervention***

Engineering: The entire Policy Unit is undefended against flooding as there is no threat from a 1 in 200 year event so this option will have no impact on flood risk. The Management Unit is also undefended against erosion. At the south eastern end of the Management Unit, erosion will impact on the caravan park in the medium to long term.

Economics: The areas at risk of erosion are mainly agricultural land with limited assets at either end of the Policy Unit. Assets at risk of future erosion total 14 individual residential and commercial properties, though these will only be affected in the medium to long term. This option has no or very little capital and maintenance costs. Costs for the removal of property lost through coastal erosion could be covered by the 'Coastal Erosion Assistance Grant' administered through the EA subject to funding being available.

Environmental Considerations: See Appendix E and Appendix F for the environmental assessment of this option. There are two Scheduled Ancient Monuments that will be lost through erosion over the next 100 years.

### ***Option 1b – No Active Intervention [with health and schemes to remove damaged property]***

Engineering: The entire Policy Unit is undefended against flooding as there is no threat from a 1 in 200 year event so this option will have no impact on flood risk. The Management Unit is also undefended against erosion. At the south eastern end of the Policy Unit, erosion will impact on the caravan park in the medium to long term. 189 h of agricultural land will be lost to coastal erosion.

Economics: The areas at risk of erosion are mainly agricultural land with limited assets at the either end of the Policy Unit. Assets at risk of future erosion total 14 individual residential and commercial properties, though these will only be affected in the medium to long term. This option has no or very little capital and maintenance costs. Costs for the removal of residential property lost through coastal erosion would be covered in the 'Coastal Erosion Assistance Grant' administered through the EA.

Environmental Considerations: See Appendix E and Appendix F for the environmental assessment of this option. There are two SAM's that will be lost through erosion over the next 100 years.

### ***Option 2 – Adaptive Management [Property roll back scheme]***

Engineering: There would be no specific engineering solutions on the coastline required for this option; however removal of damaged property would be required. A property roll back scheme would involve abandonment of the 14 residential and commercial properties and allow planning for replacement buildings on the property owners land or further land that can be released by Scarborough Borough Council or the North York Moors National Park Authority.

Economic: There would be public funds required for this option, but would not be expected to be significant. Costs for the removal of residential property lost through coastal erosion could be covered by the 'Coastal Erosion Assistance Grant' administered through the EA subject to available funding.

Environmental: The overall coastal area would benefit from natural erosion being allowed to take place, and possibly creating further intertidal habitats. There are two SAM's that will be lost through erosion over the next 100 years with this option. See Appendix E and Appendix F for the environmental assessment of this option.

### ***Option 3 – Active Intervention Improve [Rock Armour at cliff toe in areas where property is at risk]***

Engineering: The cliffs spanning the entire length of this Management Unit are approximately 21 km long and would require a significantly sized engineering solution to halt or reduce the current erosion taking place. Rock armour protecting the toe of the cliff in areas where individual properties were affected by erosion could be a feasible engineering option after 50 years.

Economics: Any proposals for new defences are unlikely to attract public funding due to the lack of benefits associated with their construction. Whilst new defences would enable protection of the existing agricultural land and caravan park, the capital investment required to construct new defences would be very high, far exceeding the value of the assets protected.


Environmental: There are no environmental benefits to be gained from protecting the area with erosion or flood defences. An engineering solution such as rock armour could possibly have an adverse effect on the natural environment. There are two SAM's that will be lost through erosion over the next 100 years through this option however there could be a consideration to protect these structures if socially and economically justified. See Appendix E and Appendix F for the environmental assessment of this option.

**Options Rejected**

There are very few assets at risk within this Unit; therefore any scheme to protect the property will need to be low cost. Through options such as property roll back schemes, residential and commercial assets can be safeguarded in the community; however archaeological sites such as the two SAMs at Saltwick Nab could possibly be lost over the next 100 years. Options that allow natural erosion of the coast will benefit the natural coastal environment. There appear to be very few social or community impacts with any of the considered options. Due to the very few options that are available for this coast, all options considered should be taken further for appraisal.



Policy Unit MA25.2 –Robin Hoods Bay Village

Policy Unit Details – MA25.2			
Policy Unit Start	Robin Hoods Bay Village (North)	Policy Unit End	Robin Hoods Bay Village (South)
Grid Ref (start)	495345E, 505540N	Grid Ref (end)	495345E, 504845N
Defence Description			
Defence Status	Partly defended	Manmade Defence Length	681m of 889m
Residual Life	See <b>Appendix C3</b> (Coast Protection Assets and Coastal Slope Condition Analysis, 2010)	Land Use	Residential
Overall Asset Condition	See <b>Appendix C3</b> (Coast Protection Assets and Coastal Slope Condition Analysis, 2010)	Flood map	Figure 6
			
<b>Figure 4: Policy Unit MA25.2 Flood Map</b>			
Strategic Options discussed			
<p>Option 1a – No Active Intervention</p> <p>Option 1b – No Active Intervention [with H&amp;S]</p> <p>Option 2 –Active Intervention [‘Property Roll Back Scheme’ and drainage investigation in the northern part of the Village Capital Improvement to Coastal Defence Asset in the southern part of the Village]</p> <p>Option 3 – Active Intervention Maintain [Northern part of Village drainage Investigation and remedial works with deep rooted vegetation slope stabilising Capital Improvement to Coastal Defence Asset in the Southern Village]</p> <p>Option 4 – Active Intervention Maintain [Southern Village capital improvement scheme to existing coastal defence assets]</p> <p>Option 5 – Active Intervention Maintain [Northern Village drainage Investigation and remedial works with deep rooted vegetation slope stabilising and capital improvement to Coastal Defence Asset]</p> <p>Option 6 – Active Intervention Improve [Soil nailing and horizontal drainage installation in northern part of Village with a Capital Improvement to Coastal Defence Asset in the southern part of the Village]</p> <p>Option 7 – Active Intervention Improve [Contiguous bored pile wall with a Capital Improvement to Coastal Defence Asset in the southern Village]</p> <p>Option 8 – Active Intervention Improve [Rock Armour at base of sea cliffs with a Capital Improvement to Coastal Defence Asset in the southern Village]</p>			
Strategic Options Consideration and Associated Potential FCRM Measures			
<p><b>Option 1a – No Active Intervention</b></p> <p>Engineering: In a No Active Intervention option, approximately 60 properties (42 in the lower village and 18 in the upper village) would be affected by coastal erosion in the long term (up to 100 years). Erosion would continue at approximately 0.3 m p/y, however it is not possible to specify time scales of a cliff failure. There is a low risk of a cliff failure in the short term (0 to 20 years). There would be a significant social impact to the Village with tourism also being A Geotechnical Risk Register for this option is contained within Chapter 7 of Appendix C2.</p> <p>Economics: No public funds would be required for this option, however costs for the removal of residential property lost through coastal erosion could be covered by the ‘Coastal Erosion Assistance Grant’ administered through the EA, subject to available funding.</p>			

Environmental Considerations: See Appendix E and Appendix F. The overall coastal system here would benefit from natural erosion.

***Option 1b – No Active Intervention [With a health and safety scheme to remove damaged property and assets]***

Engineering: In a No Active Intervention option, approximately 60 properties (42 in the lower village and 18 in the upper village) would be affected by coastal erosion in the long term (up to 100 years) although there is uncertainty as to the timing of larger cliff failures that would affect some of the 18 properties in the northern village. Erosion would continue at approximately 0.3 m p/y. It is not possible to specify time scales of a cliff failure. There is a low risk of a cliff failure in the short term (0 to 20 years). A Geotechnical Risk Register is contained within Chapter 7 of Appendix C2 which details risks associated with a deep seated failure in this area. Continued monitoring of the cliff behaviour would be required to ensure the public, particularly property owners in the northern village, are given informed and timely safety advice.

Economics: Public funds would be required to safely remove the coastal defence assets in the south of the village and see to safe removal of the properties lost in the Mount Pleasant area in the northern village in the long term. Costs for the removal of residential property lost could be covered by the 'Coastal Erosion Assistance Grant' administered through the EA subject to available funding.

Environmental Considerations: See Appendix E and Appendix F. The overall coastal system here would benefit from natural erosion; however should erosion or large cliff failures affect the foul drainage around the Mount Pleasant North area then this could cause a diffuse pollution incident.

***Option 2 –Adaptive Management/Active Intervention Maintain [Property roll back scheme in the northern Village and Capital Improvement to Coastal Defence Assets in the southern Village]***

Engineering: There would be no specific hard engineering solutions on the coastline required for the northern part of the village; however removal of damaged property would be required. Although no hard engineering structures would be required, it is advisable that a drainage investigation is carried out to identify both the effects of exfiltration and the surface water drainage outfalls on coastal erosion. The diversion of surface water that is outfalling at the cliff could delay erosion to the 18 properties in the northern part of the Village. A property roll back scheme would involve abandonment of up to 18 residential and commercial properties over the next 100 years and allow planning for replacement buildings on the property owners land or further land that can possibly be released by The National Park Authority in liaison with Scarborough Borough Council subject to a feasibility study. The second part of the option would require Capital Improvement works to provide concrete patching and facing work to the current manmade coastal defence assets in the southern section of the village (NFCDD asset no. 1221D901D1003C01, 1221D901D1003C02, 1221D901D1003C04, 1221D901D1003C05, 1221D901D1003C06 and 1221D901D1003C10) (see Appendix C3 for asset information). Current defects of the defence assets include the exposed joint between defended and undefended section of the large vertical seawall (NFCDD asset no. 1221D901D1003C02) and damage to the concrete capping beam on the seawall and promenade in the southern extent of the village (NFCDD asset no. 1221D901D1003C10). This part of the option would provide protection for the short term (0-20 years) and would not include any improvement works to other undefended areas in the village. To provide protection in the medium to long term (to 100 years), capital improvement would be required every 30 years until 2070.

Economic: There would be public funds required for the property roll back study, but would not however be expected to be significant. Costs for the removal of residential property lost through coastal erosion could be covered in the 'Coastal Erosion Assistance Grant' administered through the EA subject to available funding. The capital improvement to the assets in the southern section of the village would require significant levels of public funds. It has to be considered that the tourism value of the area benefits the local economy; therefore protecting parts of the village should be assessed with this in mind.

Environmental: The overall coastal area would benefit from natural erosion being allowed to take place in the northern section of the village and possibly create further intertidal habitats. However, in the southern section of the village, assets would continue to cause coastal squeeze.

***Option 3 – Active Intervention Maintain [Northern part of Village drainage Investigation/remedial works with deep rooted vegetation slope stabilising. Capital Improvement to Coastal Defence Assets in the southern part of the Village ]***

Engineering: The first stage for this scheme would be to identify ownership of assets for the entire drainage network located in the northern section of Robin Hoods Bay Village. This would require a collaborative approach from the local authority (Scarborough Borough Council), the water authority (Yorkshire Water) and the Environment Agency. Once ownership has been established, each of the authorities would then carry out drainage investigations using 'in pipe CCTV' on the assets under their ownership as part of the second stage. The third stage would be to commission a scheme for each of the authorities to carry out works to drainage displaying exfiltration or sources contributing to the ground water levels. This would be completed as part of their existing maintenance programmes. Section 8.2.1. of the Ground Investigation Report (Appendix C2) indicates that there are a number surface water discharge points which outfall on the cliff fronting the Mount Pleasant area, therefore a surface water diversion scheme would also be required to divert flows to outfall at a lower part of the village.

Also, as part of this option, deep rooted vegetation would be planted on the coastal slope as far as practicable inland using all available space including existing properties. Property owners consent will be required for this option. The Ground Investigation Report (Appendix C2) does not recommend this as a solution to the immediate stability of the slope, however for properties set back from the slope, a deep rooted vegetation system would have several years to establish around the properties. The root systems of woody perennial species are considered one of the most beneficial types of vegetation for bioengineering, due to the ability of the strong woody root systems to penetrate the soil at depth, providing an anchoring system to the substrate, whilst binding the soil particles together, thus increasing the shear strength of the top slope around Mount Pleasant North. Roots of vegetation also decrease the soil water content by water uptake through the root system. The higher the rate of evapotranspiration of the plant, the more water will be required, so larger plants with high rates of evapotranspiration are favoured from a bioengineering perspective.

This option would also include a capital improvement works to provide concrete patching and facing work to the current manmade coastal defence assets in the southern section of the village (NFCDD asset no. 1221D901D1003C01, 1221D901D1003C02, 1221D901D1003C04, 1221D901D1003C05, 1221D901D1003C06 and 1221D901D1003C10) (see Appendix C3 for asset information). Current defects of the defence assets include the exposed joint between defended and undefended section of the large vertical seawall (NFCDD asset no. 1221D901D1003C02) and damage to the concrete capping beam on the seawall and promenade in the southern extent of the village (NFCDD asset no. 1221D901D1003C10). This option would provide protection for the short term (0-20 years) and would not include any improvement works to other undefended areas in the village. To provide protection in the medium to long term (to 100 years), capital improvement would be required every 30 years until 2070.

Economics: There would be public funds required to carry out drainage investigations to firstly identify ownership of assets and to also identify exfiltration which contributes to the ground water and slope instability. Costs of CCTV investigations would be borne by the owning authority if

grant aid funding is not available.

Environmental: This scheme is not thought to have any adverse implications in terms of the environment. A fully functioning drainage system limiting exfiltration will improve ground water quality. Planting deep rooted vegetation would provide natural enhancement to the area.

***Option 4 – Active Intervention Maintain [Capital Improvement to Coastal Defence Asset in the southern part of the Village]***

Engineering: This option would require Capital Improvement works to provide concrete patching and facing work to the current manmade coastal defence assets in the southern section of the Village (NFCDD asset no. 1221D901D1003C01, 1221D901D1003C02, 1221D901D1003C04, 1221D901D1003C05, 1221D901D1003C06 and 1221D901D1003C10) (see Appendix C3 for asset information). Current defects of the defence assets include the exposed joint between defended and undefended section of the large vertical seawall (NFCDD asset no. 1221D901D1003C02) and damage to the concrete capping beam on the seawall and promenade in the southern extent of the village (NFCDD asset no. 1221D901D1003C10). This option would provide protection for the short term (0-20 years) and would not include any improvement works to other undefended areas in the Village.

Economics: There would be considerable public funding required for a capital improvement scheme for the existing coastal defence assets for a short term solution. This option will only consider protecting the property in the southern village; therefore will only protect the village as a whole for approximately 15-20 years when coastal erosion begins to affect the northern village. Costs for the removal of property lost through coastal erosion could be covered in the 'Coastal Erosion Assistance Grant' administered through the EA subject to available funding.

Environmental: This option would continue to hold the existing defended line in the southern section of the village and reduce intertidal habitat through coastal squeeze. The upper section of the village would be allowed to continue to retreat naturally and could mitigate the lost intertidal habitat in the southern village. Also See Appendix E and Appendix F for environmental assessments. The overall coastal system here would benefit from natural erosion in the northern village.

***Option 5 – Active Intervention Improve [Soil nailing and horizontal drainage installation with a capital Improvement scheme to existing defence assets]***

Engineering: Installation of a grid of soil nails on the coastal slope would increase the stability of the slope. Given the potential for deep seated failure it is anticipated that the nails would need to be long (in excess of 20m) and spaced typically at 2m horizontal spacing and 1m vertically, giving a minimum of 1500 nails/100m length of slope treated. The nails would need to be galvanised to resist the marine environment. This option will necessitate the use of A-frame rigs and roped access so there are health and safety implications. It is likely that significant vegetation clearance and some reprofiling will be required to facilitate access to the slope for this process. The nails are anchored at the surface by a pattsess plate and the entire surface would be meshed/netted. This would have a major impact on the SSSI. The use of long nails, possibly extending beneath the houses, will require way-leaves to be signed by the landowners. This option would benefit from installation of horizontal drainage wells to relieve the water pressure within the laminated clay and at rock head and would slow down the rate of regression and reduce the potential for large scale instability of the clay mass, but not eliminate the risk entirely. This would require specialist roped access. The water from the wells would need to be collected. This option would also include a capital improvement works to provide concrete patching and facing work to the current manmade coastal defence assets in the southern section of the village (NFCDD asset no. 1221D901D1003C01, 1221D901D1003C02, 1221D901D1003C04, 1221D901D1003C05, 1221D901D1003C06 and 1221D901D1003C10) (see Appendix C3 for asset information). Current defects of the defence assets include the exposed joint between defended and undefended section of the large vertical seawall (NFCDD asset no. 1221D901D1003C02) and damage to the concrete capping beam on the seawall and promenade in the southern extent of the village (NFCDD asset no. 1221D901D1003C10). This option would provide protection for the short term (0-20 years) (Although this is still uncertain) and would not include any improvement works to other undefended areas in the village. To provide protection in the medium to long term (to 100 years), capital improvement would be required every 30 years until 2070.

Economics: Soil nailing would require significant amounts of public funding, however the horizontal drainage could be completed with the same equipment saving mobilisation costs.

Environmental: This solution would disturb the natural area as the soil nails and drains would be drilled in to the coastal slope. See outline options in Appendix C2 for environmental risks and considerations of this option.

***Option 6 – Active Intervention Improve [Contiguous bored pile wall with a capital improvement scheme to existing defence assets]***

Engineering: This option would prevent further recession of the upper slope on the landward side of the wall. The wall would be constructed on top of the slope. The land on the seaward side of the wall would continue to degrade and there would be a reduction in lateral support in the long term. It would therefore be necessary to drill the piles in to the rock and install anchors through the capping beam. A preliminary calculation, using Reward, indicates an embedment length of 44m for the piles where the clay slope is 31m high (depth to bedrock 31m) and 22m where the clay slope is 12m high (depth to bedrock 12m). A long construction period is anticipated. Vibration and loading during the works may trigger further movement of the slope. Restricted access to the coastal slope, for the large plant needed to construct the wall, could be problematic. At the north east end of the village the area between the house and the top of the slope is only 4-5m wide which would prove difficult for the construction of a wall. This option would also include a capital improvement works to provide concrete patching and facing work to the current manmade coastal defence assets in the southern section of the village (NFCDD asset no. 1221D901D1003C01, 1221D901D1003C02, 1221D901D1003C04, 1221D901D1003C05, 1221D901D1003C06 and 1221D901D1003C10) (see Appendix C3 for asset information). Current defects of the defence assets include the exposed joint between defended and undefended section of the large vertical seawall (NFCDD asset no. 1221D901D1003C02) and damage to the concrete capping beam on the seawall and promenade in the southern extent of the village (NFCDD asset no. 1221D901D1003C10). This option would provide protection for the short term (0-20 years) and would not include any improvement works to other undefended areas in the village. To provide protection in the medium to long term (to 100 years), capital improvement would be required every 30 years until 2070.

Economics: A scheme of this size would be expected to cost in excess of £6m of public funds and is not thought to be feasible due to the limited extent of damages on the northern section of the village.

Environmental: Significant disturbance of the SSSI would occur during the construction period due to the location and size of the scheme. Post construction, the landward section of the cliff from the bored pile wall would eventually fall away and leave a facing side of the piles visible. This would initially create intertidal habitat, however coastal squeeze due to sea level rise would reduce the area. See outline options in Appendix C2 for environmental risks and considerations of this option.



***Option 7 – Active Intervention Improve [Rock Armour at base of sea cliffs with a capital Improvement scheme to existing defence assets]***

Engineering: This option would involve the installation of rock armour to the base of the cliff fronting the Mount Pleasant area. Rock installed at the base of the cliff would need to be a minimum of 8 to 12 tonne rock size to provide any level of stability to the slope and to also protect against coastal marine processes. The height of the rock armour structure would also need to be considerably high, possibly up to 10 to 15 m to provide any safe level of stability (although this is uncertain and further study would be required to assess suitability). This option would also include a capital improvement works to provide concrete patching and facing work to the current manmade coastal defence assets in the southern section of the village (NFCDD asset no. 1221D901D1003C01, 1221D901D1003C02, 1221D901D1003C04, 1221D901D1003C05, 1221D901D1003C06 and 1221D901D1003C10) (see Appendix C3 for asset information). Current defects of the defence assets include the exposed joint between defended and undefended section of the large vertical seawall (NFCDD asset no. 1221D901D1003C02) and damage to the concrete capping beam on the seawall and promenade in the southern extent of the village (NFCDD asset no. 1221D901D1003C10). This option would provide protection for the short term (0-20 years) and would not include any improvement works to other undefended areas in the village. To provide protection in the medium to long term (to 100 years), capital improvement would be required every 30 years until 2090.

Economics: A scheme of this size would be expected to cost in excess of £5m of public funds and is not thought to be feasible due to the limited extent of damages to property and infrastructure in the northern section of the village.

Environmental: Significant disturbance of the natural environment would occur during the construction period due to the location and size of the scheme. Coastal squeeze and significant loss of intertidal habitat would occur initially and over the next 100 years. See outline options in Appendix C2 for environmental risks and considerations of this option.

## **Options Rejected**

The northern section of this Policy Unit is undefended and at some risk of cliff failure according to the Ground Investigation Report (Appendix C2) although further investigation and continued monitoring is required to achieve more certainty as to the timing of such failures. Hard structure engineering solutions for the upper part of the village would be costly and in some cases may not be a total solution in terms of stability to the properties at risk around the Mount Pleasant North area in the short term. Identifying large engineering schemes at this stage with a high level of uncertainty would not be advised. It would also be of concern that the natural environment would be adversely affected by extensive engineering works. There would be little or no road infrastructure or services (Gas, water and electricity mains) effected by a by a cliff failure with up to 18 properties at risk over the next 100 years. The damage caused by a cliff failure around the Mount Pleasant North area is not considered at a level to attract public funds for large engineering schemes; therefore lower cost options to move the properties should be further investigated. It is important to undertake continued monitoring and investigation purely for the safety of the property owners at risk in the upper village. It is also recommended that should monitoring and further site investigations identify that the northern village is unsafe then provisions for abandonment of homes should be in place.

Social and community impacts could be considered as significant should a large cliff failure occur, with tourism being a factor. To allow the defences in the southern village to degrade over time in a 'No Active Intervention' option would have a significant impact, not only on the continued prosperity of the coastal tourism but also the future of the individual property owners. There would be up to 42 properties lost, along with road and services infrastructure in the long term and the lack of investment in coastal defence here would not attract future tourism.

Maintenance to the existing hard coastal defence structures in the lower section of the village at this stage appear to be economically feasible. Further investigation should be undertaken to identify properties at risk in the short term for public safety.