Cromer to Winterton Ness Coastal Management Study

Appendix B: Economic Assessment Report

July 2013
North Norfolk District Council

Confidential

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Issue and revision record

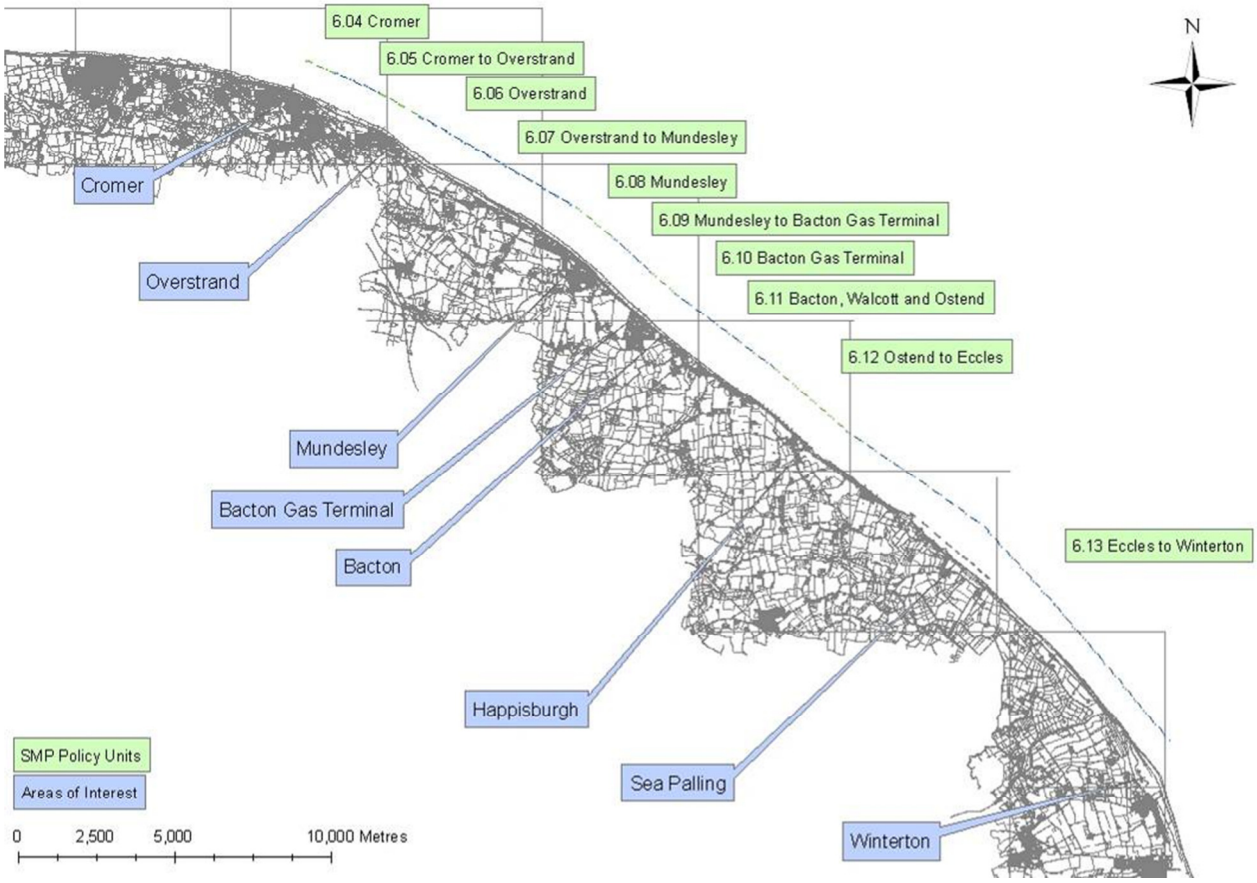
Revision	Date	Originator	Checker	Approver	Description
A	31/01/2013	S Hampshire B. Riley	N Bean	P. Phipps	Draft
B	26/02/2013	B. Riley	N. Bean	P. Phipps	Final for Issue
C	02/04/2013	S. Hampshire	N. Bean	P. Phipps	Revised final following comments
D	17/06/2013	B. Riley	N. Bean S. Hampshire	P. Phipps	For Issue
E	10/07/2013	B. Riley	N. Bean S. Hampshire	P. Phipps	Final for issue
F	29/07/2013	B. Riley	N. Bean S. Hampshire	P. Phipps	Final for issue

Content

1. Introduction

The Cromer to Winterton Ness coastline forms part of the 'Kelling to Lowestoft Ness Shoreline Management Plan' (2005). This 35km stretch of coastline comprises various coastal defence assets which protect a number of settlements. The Shoreline Management Plan divided the coastline into a number of individual Policy Units (Figure 1.1). From Cromer to Winterton Ness there are 14 Policy Units defining the policy for adoption at each stretch from short term (0-20 years) to medium (21-50 years) and long term (51-100 years). The policies vary considerably along this stretch of coastline with some sections being considered under Hold The Line policies, whilst others are recommended to be managed under No Active Intervention or Managed Realignment policies.

Figure 1.1: Map of frontage and SMP Policy Units



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This Appendix Report supports the main Study Report which aims to provide an updated economic appraisal of the potential benefits and costs of implementing coastal defence works along the Study frontage since the previous Strategy (2003). This will incorporate more recent guidance and best practice. The Study Report forms the basis for decision making in terms of the planning of future works and maintenance regimes, in accordance with and challenging the existing Shoreline Management Plan Policies. It will also help identify areas where further detailed study should be focused. This Appendix Report presents the details on the methods and results from the economic assessment carried out as part of the Study.

2. Background

2.1 Assessment approach

The economic assessment is based on the latest Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM–AG, 2010), which provides guidance on the methodology to undertake effective appraisals. The guidance assists in considering economic benefits and losses that arise from particular options.

The economic assessment utilises the spreadsheet templates provided by the Environment Agency (2012), which is the basis on which the Environment Agency will approve coastal defence schemes and grant funding. The economic assessment includes information from the HM Treasury Green Book (2011) and Multi-Coloured Manual (Middlesex University, 2010). It should be noted that the economic assessment was undertaken in line with current DEFRA and treasury guidance (FCERM-AG, 2010) and is appropriate as any future government funding for schemes will be assessed against this criteria.

This economic assessment provides a framework for assessing the advantages and disadvantages of the options by expressing all of the potential effects and benefits of an option in terms of its monetary cost. The assessment considers the value (cost) of the options and whether investment in any option is worthwhile against the benefits. Benefits include protection of residential and non-residential properties, infrastructure and tourism/ recreation. An option is considered to be 'justified' if the benefits outweigh the costs (i.e. the benefit cost ratio is greater than one).

Costs and benefits can be expressed in terms of their cash value in pounds sterling but also in terms of their Present Value (PV). The Present Value of the future pound is assumed to fall away through time. To include this in the benefit cost ratio the discount factor provided in the HM Treasury Green Book (2011) is applied. The long term discount rates are included in the benefit cost ratio analysis to allow the uncertainty of the future to be included. This uncertainty is shown to cause a decline in discount rates over time. The HM Treasury Green Book recommends that for benefit cost analyses which accrue for more than 30 years the following discount rates should be used: 3.5% (0 to 30 years), 3% (30 to 75 years) and 2.5% (75 to 100 years). Present Value benefits are calculated by discounting which depends on the year of loss of that benefit e.g. the year a house is lost to coastal erosion. Present Value costs are calculated by discounting the year in which works are implemented. For example when the works are implemented in year 10 then it is necessary to discount the current cash value to work out how much the scheme will cost in the future (Figure 2.1).

Figure 2.1: Summary of steps undertaken within an economic assessment. Cash value is the current value of the benefits or the costs. Present Value is the discounted value of benefits or costs depending on the year of loss or implementation of works.

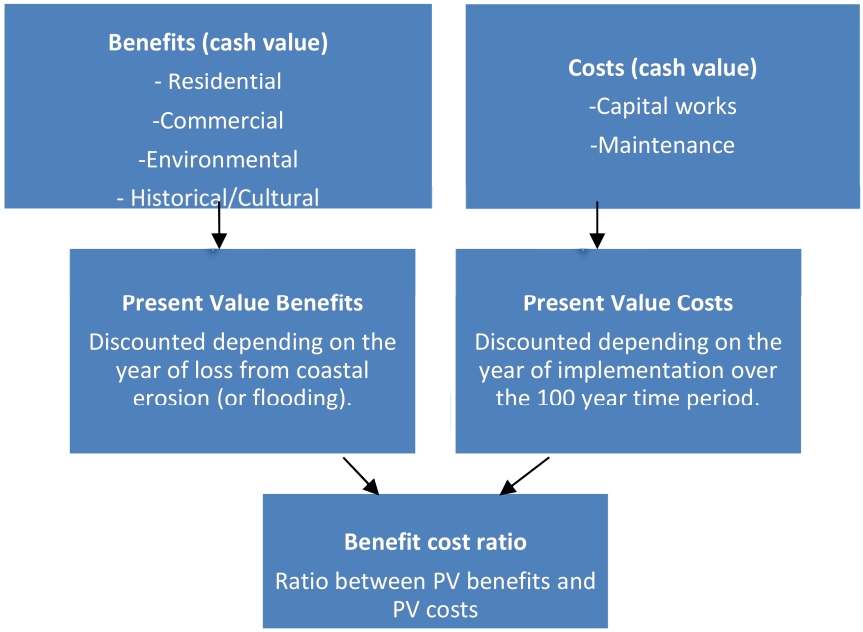


Figure 2.2: Example Environment Agency economic assessment spreadsheet – Present Value Costs spreadsheet. In this example maintenance costs have been added to the white columns on the left hand side for each year from 0 to 20. The cash costs are presented in column P and PV maintenance costs are displayed in column R.

Present Value Costs for all options

Client/Authority	North Norfolk Distr									
Project name										Res
Project reference	Cromer to Winterto				Option 1				Option 2	
Base date for estimates (year 0)					Do-nothing				Monitor and make gro	
Scaling factor (e.g	PV total costs				0				153,305	
Initial discount rate										
		Option 2	Monitor and make groynes safe			TOTALS:	PV	PV	PV	PV
		Capital	Maint.	Other	Negative costs	Cash	Capital	Maint	Other	Negative costs
	cash sum	0	128682	70000	0	198682.00	0.00	83305.26	70000.00	0.00
year	Discount Factor									
0	1.000		4000	70000		74000.00	0.00	4000.00	70000.00	0.00
1	0.966		4000			4000.00	0.00	3864.73	0.00	0.00
2	0.934		4000			4000.00	0.00	3734.04	0.00	0.00
3	0.902		4000			4000.00	0.00	3607.77	0.00	0.00
4	0.871		4000			4000.00	0.00	3485.77	0.00	0.00
5	0.842		4000			4000.00	0.00	3367.89	0.00	0.00
6	0.814		4000			4000.00	0.00	3254.00	0.00	0.00
7	0.786		4000			4000.00	0.00	3143.96	0.00	0.00
8	0.759		4000			4000.00	0.00	3037.65	0.00	0.00
9	0.734		4000			4000.00	0.00	2934.92	0.00	0.00
10	0.709		4000			4000.00	0.00	2835.68	0.00	0.00
11	0.685		4000			4000.00	0.00	2739.78	0.00	0.00
12	0.662		4000			4000.00	0.00	2647.13	0.00	0.00
13	0.639		4000			4000.00	0.00	2557.62	0.00	0.00
14	0.618		4000			4000.00	0.00	2471.13	0.00	0.00
15	0.597		4000			4000.00	0.00	2387.56	0.00	0.00
16	0.577		4000			4000.00	0.00	2306.82	0.00	0.00
17	0.557		4000			4000.00	0.00	2228.82	0.00	0.00
18	0.538		4000			4000.00	0.00	2153.44	0.00	0.00
19	0.520		4000			4000.00	0.00	2080.62	0.00	0.00
20	0.503		48682			48682.00	0.00	24465.91	0.00	0.00
21	0.486					0.00	0.00	0.00	0.00	0.00

2.2 Assessment Scenarios

Two separate scenarios were originally considered for this economic assessment: The Do Nothing Baseline and the SMP6 Scenario. Following assessment of these scenarios, two further scenarios were considered: A Modified SMP6 Scenario and the SMP6 with Sediment Nourishment Scenario. These additional runs have been included in Sections 7 and 8 of this Report with a summary of the results presented in Section 9 to allow easy comparison.

- **The Do Nothing Baseline**. The Do Nothing Baseline is not a policy option but is required as a baseline against which all other options to Do Something are assessed and is required when undertaking economic assessment of the options. This allows comparison and contrasting of the costs of 'doing something' against the benefits arising from 'doing nothing'.
- **The SMP6 Scenario** considers the Do Something options in accordance with the adopted SMP6 2005 (Kelling Hard to Lowestoft) policies i.e. Hold the Line, Managed Realignment and No Active Intervention. The policy for each Unit considered within this economic assessment is outlined below in Table 1.2.
- **The Modified SMP6 Scenario.** See Section 7 for more detail.
- **The SMP6 with Sediment Nourishment Scenario.** See Section 8 for more detail.

Table 2.1: SMP6 policies for each Policy Unit for each of the three epochs

SMP6 Policy Unit	Short term (0-20 years)	Medium term (21-50 years)	Long term (51-100 years)
6.05 Cromer to Overstrand	Managed Realignment	No Active Intervention	No Active Intervention
6.06 Overstrand	Hold the Line	Managed Realignment	Managed Realignment
6.07 Overstrand to Mundesley	Managed Realignment	No Active Intervention	No Active Intervention
6.08 Mundesley	Hold the Line	Hold the Line	Managed Realignment
6.09 Mundesley to Bacton Gas Terminal	Managed Realignment	No Active Intervention	No Active Intervention
6.10 Bacton Gas Terminal	Hold the Line	Hold the Line	Hold the Line
6.11 Bacton Walcott and Ostend	Hold the Line	Managed Realignment	Managed Realignment
6.12 Ostend to Eccles	Managed Realignment	Managed Realignment	Managed Realignment

The SMP6 policies for each of the three epochs were first recommended in 2005 i.e. the baseline for year 0 was 2005. However in this Study the baseline for year 0 is 2013 and hence there is a 6 year difference. This is not considered to have a significant impact on the outcomes as the management activities assessed within this Study all fall within the three SMP6 epochs.

3. Benefits

Benefits (from erosion damages avoided by implementing a scheme) for each Policy Unit have been calculated using guidance from the Multi-Coloured Manual (MCM, 2010) and FCERM-AG (2010) over a 100 year period. Benefits have been discounted in accordance with the HM Treasury Green Book. The price date for the benefits is the same as for the costs (January 2013). The benefits were calculated from the value of the properties, recreation (tourism), impacts to flooding and other major infrastructure affected by predicted erosion rates during the 100 year time period.

3.1 Property benefits

3.1.1 Erosion benefits

The erosion benefits were calculated from the value of the houses that are at risk from erosion over 100 years for each Policy Unit (base date = January 2013). The erosion rates were calculated using the SCAPE model based on the residual life of the defences. The SCAPE model units are 500m lengths along this 35km of coastline and broadly match the Policy Units, sufficient for this high level Coastal Management Study. The model aims to consider the coastal dynamics of the 'system' including sediment transport between sub-cells.

A shapefile was downloaded from the Environment Agency National Receptor Database (NRD) and loaded into ArcMAP to enable identification of the properties along the frontage. The erosion rates (as indicated by the 2013 SCAPE model runs) for the short term (0-20 years), medium term (21-50 years) and long term (51-100 years) under both a Do Nothing Baseline and SMP6 Scenario were mapped within GIS. The data were overlayed with the property data to enable calculation of the number of properties at risk of erosion within each erosion zone (summarised in Table 3.1 and Table 3.2) over the next 100 years. This process was completed for both the Do Nothing Baseline and the SMP6 Scenarios.

The year in which an asset is considered to be at risk from erosion is dependent on both the location of the property and/or when services or infrastructure to the property are lost. Therefore the properties are considered to be at risk when the seaward edge of the property, or the road needed for access to the property comes within 5 m of an erosion line. This is more representative of the year of loss of a property than taking the year of loss of the central point of a property. Therefore in reality some properties may be 'lost' in the assessment before actually falling into the sea. The timing of the loss of property is important because it determines the discount value applied during the valuation of assets.

Key assumptions in calculating property erosion and values are:

- Counting of properties at risk from erosion includes a 5 m search distance – assuming that once a property is 5 m from the edge of the cliff it is too dangerous to inhabit.
- The erosion year value of halfway between the erosion lines (0-20=10; 20-50=35; 50-100=75) has been given to average out effect of discounting. Sensitivity testing has been carried out on the data to assess the impact this method may have on the overall benefit calculations. Due to the discounting factors applied, the values given through this method proved to be a conservative estimate (falling nearer the minimum potential benefits rather than the maximum potential benefits) when compared with the potential maximum and minimum benefit values (i.e. if all the properties within the 0-20 erosion band fall are eroded at year 0 or year 20 respectively).
- Comparison of properties and erosion lines within the GIS were also checked manually – if part of a property or access to property goes early (i.e. before the 'point' for the property in GIS), the erosion year of the property was adjusted accordingly.

- Values of properties have been taken from the North Norfolk Coastal Strategy (HR Wallingford, 2004). These values have been updated to 2013 values using the Halifax property index which is a regional evaluation of house prices (accessed January 2013).

There were a few properties included in this Study which had not been included in the North Norfolk Coastal Strategy (HR Wallingford, 2004). Where these properties were adjacent and similar to valued properties (particularly in the case of residential properties) a value was inferred. However, Cromer Country Club and Royal Cromer Golf Club had no values and therefore were taken from the Valuation Office Agency data base (accessed January 2013). This gives a rateable value of the property, which can be multiplied by ten (as recommended in the MCM) to give an approximate value for these commercial properties.

The values of properties that were affected by erosion under a 'Do nothing' scenario during each temporal band were calculated and entered into the FCRM–AG spreadsheets (EA, 2012) under the relevant Policy Unit (sheet: PV losses, column: erosion losses). The discount rate was then applied to each year to determine the Present Value (PV) of the properties lost to erosion. The value of properties lost under the SMP6 Scenario was also calculated. The SMP6 Scenario damages were then subtracted from the Do Nothing Baseline damages to calculate the SMP6 Scenario damages avoided/ benefits for each Policy Unit. This provides a measure of the benefit of Doing Something rather than Doing Nothing.

The erosion rates indicate that under the Do Nothing Baseline a total of 1,042 commercial and residential properties (1,1012 and 30 residential/commercial properties respectively) will be lost across all Policy Units by year 100 (excluding other infrastructure) and 1,175 commercial and residential properties (1,137 and 38 residential/commercial properties respectively) lost over 100 years under the SMP6 Scenario. The results are summarised below in Table 3.1 and show overall that the loss of properties under the SMP6 Scenario are more than under the Do Nothing Baseline. This can be explained through the impact of implementing management policies on other Policy Units (for more detail see Section 2 of the Study Report). There are differences between Policy Units which will be explored later.

Variability in loss of residential and commercial properties between epochs is due to varying property locations in relation to erosion predictions. For example it may be possible for no properties to be affected in years 0-20 as they are not situated close to the cliff edge, a few be lost in years 21-50 as the cliff edge retreats and then no losses are experienced between years 51 and 100, for example at Policy Unit 6.12. This is probably due to the spatial distribution of properties in relation to the cliff edge.

Table 3.1: Summary of residential properties (in bold) and commercial properties (in brackets) at risk over 100 years over all Policy Units under both a Do Nothing Baseline and SMP6 Scenario according to the SCAPE Model

Policy Unit	Do Nothing Baseline	SMP Policy	Do Nothing Baseline	SMP Policy	Do Nothing Baseline	SMP Policy	Do Nothing Baseline	SMP Policy
		0-20 years		21-50 years		51-100 years		Total
6.05 Cromer to Overstrand	0(0)	0(0)	0(0)	0(0)	0(3)	0(2)	0(3)	0(2)
6.06: Overstrand	**1**(0)	0(0)	**63** (1)	0(0)	**131**(3)	**240**(5)	**195**(4)	**240**(5)
6.07 Overstrand to Mundesley	**0** (4)	**7**(0)	**35** (3)	**31**(0)	**74**(0)	**52**(3)	**109**(7)	**90**(3)
6.08 Mundesley	**132** (6)	**6**(0)	**155**(2)	**10**(0)	**181**(2)	**396** (10)	**468**(10)	**412** (10)
6.09 Mundesley to Bacton Gas Terminal	**18**(0)	**3**(0)	0(0)	**23**(1)	**24**(1)	**15**(0)	**42**(1)	**41**(1)
6.10 Bacton Gas Terminal	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
6.11 Bacton Walcott and Ostend	**94** (0)	**14**(0)	**51**(1)	**253**(13)	**51**(4)	**85**(4)	**196**(5)	**352**(17)
6.12 Ostend to Eccles	**2**(0)	**2**(0)	0(0)	0(0)	0(0)	0(0)	**2**(0)	**2**(0)
Total	**247** (10)	**32**(0)	**304**(7)	**317**(14)	**461**(13)	**788** (24)	**1,012**(30)	**1,137**(38)

The total number of properties under a Do Nothing Baseline can be compared to the SMP6 evaluation and a recent evaluation – the North Norfolk Coastal Management Plan Evidence Gathering Study (undertaken by RPA, 2008) (Table 3.2 below).

Table 3.2: Comparison of residential and commercial properties at risk of coastal erosion over 100 years over all Policy Units under a Do Nothing/No Active Intervention Scenario

	0-20 years	21-50 years	51-100 years	Total
This Study (2013)	257	311	474	1,042
North Norfolk Coastal Management Plan Evidence Gathering Study (2008)	55	289	674	1,018
SMP6 (2005)	Up to 190	Up to 260	Up to 440	Up to 890

The total number of properties at risk of coastal erosion over the next 100 years under the Do Nothing Baseline in this Study is similar to the North Norfolk Coastal Management Plan Evidence Gathering Study (2008). However the distribution of when properties are lost over the three epochs is slightly different, with slightly more in the first 20 and 50 years but less in the last 50 years for this Study.

The loss of properties predicted by the SMP6 is broadly similar but slightly lower than in this Study. This is likely to be due to the use of the recent 2011 sea level rise guidance (EA) in this Study which includes acceleration in sea level rise and hence increased erosion rates. The property distribution over the Policy Units is different with higher loss of properties to the northwest (Cromer to Mundesley) and lower loss of properties to the south east (Bacton to Winterton) than the SMP assessment.

The reasons for the differences between this Study and both the 2008 Study and the SMP Study are likely to be because the SCAPE model is able to provide a more sophisticated assessment of the coastal morphodynamics and sediment transport processes and considers the wider 'system'. The model captures the ability for sediment released from erosion in the north of the 'system' to be transported southwards by

longshore drift in time and will therefore provide enhanced protection against erosion for a short time for the frontages further south (for more detail see Appendix C: SCAPE Modelling of Shore Evolution: Cromer to Cart Gap). However the north will be more sediment starved as defences at Cromer prevent erosion and therefore sediment being brought into the system. The value for the northern frontages are more likely to be similar to the SMP6 and North Norfolk Coastal Management Plan studies, which have taken a more localised approach to shoreline retreat assessment (i.e. the assessment of erosion is done at a smaller scale and does not take into account the changes along the longer stretch of coastline included within this Study).

It should be noted that some results in the calculated SMP6 Scenario avoided damages/ benefits were different to expected for Policy Unit 6.06: Overstrand and Policy Unit 6.10 Bacton Gas Terminal (see Section 3 of the main Study Report for more details).

In the case of Policy Unit 6.06: Overstrand, the benefits of Doing Nothing appear to be higher than would be expected from Doing Something due to the outputs of the SCAPE model (for more detail see Appendix C: SCAPE Modelling of Shore Evolution: Cromer to Cart Gap). At Overstrand, within the SCAPE model, it has been assumed that the release and transport of sediments (from the frontage and from updrift) under a Do Nothing Baseline provides coast protection benefits thus reducing the overall extent of erosion over the 100 years. Under the SMP6 Scenario, by the time the cliffs are exposed to wave action (from year 20), there is less sediment on the frontage (in addition to less sediment being supplied to the frontage due to a Hold the Line management at Cromer) and therefore less 'buffering' of erosion and more houses at risk from coastal erosion. In addition, the proposed coastal defence options at Overstrand provide an improvement on the current defences in place. As the SCAPE model works on the assumption that the defences are what is currently in place, the cost of improving the defences is not realised in the results of the SCAPE model. Therefore, the economic assessment in this Policy Unit has added a delay to the erosion of properties under the SMP6 Scenario of 20 years (to represent the minimum likely residual life of the Options) to allow a more realistic benefit assessment.

At Bacton Gas Terminal under the SMP6 Scenario, where the policy is Hold the Line for 100 years, erosion appears to occur early in the model. There are three reasons for early recession: (1) cliffs may fail by geotechnical failure even when the toe is defended from wave action (2) palisades along the Norfolk coast are designed to allow some small recession, so as to not starve the system too strongly of sediment and (3) the defence failure years are defined at the 5% and 95% probability levels (and so approx. 5% of simulations involve failure before the earliest date). The third option probably isn't causing this recession, but (1) and (2) are probably more likely to have produced this anomaly. It is important to note that the Recession Upper Limit data does not indicate that this recession will occur, but a 5% chance that it will. As additional defences are likely to be put in place along this Policy Unit to ensure failure of defences does not occur, it has been assumed there will be no erosion in this Unit and therefore the economic assessment has taken the Do Nothing damages as the SMP6 Scenario benefits.

3.1.2 Flooding benefits

Walcott, in Policy Unit 6.11, is potentially vulnerable to flooding. The flood damages in the cost benefit analysis are based on the damages that HR Wallingford obtained for the North Norfolk Coastal Strategy (2004) which has been updated in this Study. The flood damages are assumed to occur up to the year that the sea wall fails, with increased flood damages after this year. Flood damages have only been calculated up until the first property is eroded, after this there are no flood damages assumed (only erosion losses). The damages to the properties from the 2004 study were increased by 30% based on the latest RPI.

3.2 Recreational benefits

The North Norfolk coastline is a popular area for local visitors, day visitors and tourists. The tourism benefits has been included within this economic report to allow a consideration of these benefits, however the values have been excluded from the economic assessment due to the large influence the tourism figures have on cost benefit scores. A more up to date and local (rather than regional) assessment using Contingent Valuation (CV) method (as is recommended in MCM, 2010) is required to increase the accuracy of the tourism benefits. It should be noted that tourism may make a significant difference to deciding the preferred schemes going forward. Previous strategy studies in the UK (with more specific and localised tourism data available) have successfully included tourism benefits as part of the recreational benefits.

The number of tourists visiting Cromer to Winterton Ness was estimated based on the figures from the 'Economic Impact of Tourism – North Norfolk 2010' (Tourism South East, 2010). For the purpose of this assessment, similar to the Economic Impact of Tourism report, tourists have been divided into overnight visitors (hereafter 'staying') and day visitors (hereafter 'day'). Figures from the Economic Impact of Tourism report suggested an annual number of 693,000 staying visitors and 5,426,000 day visitors to this area of North Norfolk. This equated to an average spend of £187.29/£37.72 per visitor per visit for staying/day visitors respectively.

Annual tourist numbers were divided along the frontage. It was recommended (by the NNDC Economic Development Team) that 70% of visitors are concentrated in the area Cromer to Mundesley. Visitor numbers were then further subdivided between the Policy Units using the Project Team's knowledge of the local area and resources from previous studies along the frontage. It has been assumed that the majority of visitors will focus their visits to towns and villages along the frontage (where there is car parking, shops and easier access to the beach) rather than to more isolated sections of the coastline. When analysing staying visitors, the location of holiday parks, caravan parks, hotels and B&Bs have been taken into account. Table 3.3 summarises the suggested distribution of visitors along the frontage.

Table 3.3: Summary of tourism numbers used for the different SMP policy Units

Policy Unit	Number Staying Visitors	Number Day Visitors
70 % Cromer to Mundesley = 485100 staying and 3,798,200 day visitors		
6.04 Cromer	194,040	1,519,280
6.05 Cromer to Overstrand	24,255	379,820
6.06: Overstrand	72,765	759,640
6.07 Overstrand to Mundesley	97,020	189,910
6.08 Mundesley	97,020	949,550
30 % Southeast of Mundesley = 207,900 staying and 1,627,800 day visitors		
6.09 Mundesley to Bacton Gas Terminal	10,395	0
6.10 Bacton Gas Terminal	0	0
6.11 Bacton Walcott and Ostend	62,370	325,560
6.12 Ostend to Eccles	10,395	162,780
6.13 Eccles to Winterton	124,740	1,139,460

In this Study, there are no options suggested to directly improve amenities and therefore tourism values have been calculated through evaluating 'damages avoided'. This is the difference between tourism losses calculated under a Do Nothing Baseline and losses calculated under the SMP6 Scenario. Percentage decrease in visitor numbers within each Policy Unit were determined by assessing each area individually and considering the dominant assets provided by the area. Additionally, out of a suspected loss of tourism, only a small number were included in the benefit analysis as visitors who would just go elsewhere within the country are not counted as they do not contribute to an overall national economic loss. This number who would visit elsewhere tended to be very high for staying visitors and slightly lower for day visitors, as it

is assumed that a higher number of day visitors includes local visitors. With the information available it is not possible to assess the implications of this further.

Discount factors were applied to the annual values of economic loss (calculated from number of visitor decline multiplied by average spend per visitor). Where erosion (onset of erosion was taken from the SCAPE model outputs) commenced at a later date in the SMP6 Scenario compared to the Do Nothing Baseline (where a Hold the Line management is implemented), the damages avoided over 100 years could be calculated. Positive tourism benefits were therefore only applicable to three Policy Units: 6.06 Overstrand, 6.08 Mundesley and 6.11 Bacton, Walcott and Ostend. Table 3.4 summarises the economic benefit from tourism (from damages avoided) in these three Policy Units.

Table 3.4: Summary of tourism values for a benefit cost analysis

SMP Policy Unit	Benefits (i.e. damages avoided) over 100 years (£k)
6.06: Overstrand	47,777
6.08 Mundesley	103,460
6.11 Bacton Walcott and Ostend	25,059

Other recreational benefits need further assessment. The SMP did not consider recreational benefits as part of its assessment but following this Study further detailed studies would be beneficial to support more detailed economic assessments at the scheme stage.

3.3 Other benefits

In addition to property and tourism benefits, infrastructure and service amenities will also be lost over the next 100 years under a Do Nothing Baseline. The assumptions and values of these are outlined below in Table 3.5. Wider socio-economic implications of the Do Nothing Baseline e.g. people, businesses (and jobs) moving away to other areas, is not considered as it is very difficult to apply a monetary value to these benefits.

Table 3.5: Other benefits along the North Norfolk frontage (values are before discounting has been applied)

Benefit	Description	Value
Bacton Gas Terrminal	Bacton Gas Terminal is a national asset for energy security in the UK and therefore has considerable importance.	Damage costs at the Bacton Gas site are suggested to have a value of £283 million
Erosion of roads.	Erosion of the B1159 at Trimingham, Mundesley and Walcott represents the loss of the main road which runs along the coast. As all other nearby roads are much smaller, there would not be the opportunity for diversion and therefore new sections of road would need to be built. The sections have been used from the 2004 Strategy. However, the costs have been calculated using figures from Spon's Architects' and Builders' Price Book (2012).	Erosion of B1159 in Policy Unit 6.11 = £1.2 million Erosion of B1159 in Policy Unit 6.08 = £1.2 million Erosion of B1159 in Policy Unit 6.07 = £2.3 million
Anglian Water wastewater treatment	Both at Overstrand and Mundesley the cliff-top pumping stations are at risk of erosion. As many sewage networks flow towards the pumping stations, landwards retreat of the pumping stations would not be a simple reconstruction. The values for re-siting and re-routing the works at each site were calculated within the 2004 Strategy and have been updated for this economic assessment using the latest RPI figures.	£1.8 million for Policy Unit 6.08 £2.1 million for Policy Unit 6.06

3.4 Summary of benefits

Each table below summarises the benefits for each Policy Unit. Please note that these values do not include tourism or recreation benefits. The results show that even in Policy Units where there are a higher number of properties at risk under the SMP6 Scenario when compared with the Do Nothing Baseline, positive overall benefits are shown. This is explained through the impact of delaying erosion of properties

and infrastructure. Due to the discounting applied to the value of the asset at risk from coastal erosion (see Section 2.1), those properties at risk in years 51-100 are worth less than those at risk in the short and medium terms (years 0-50). Therefore, although overall more properties are at risk from coastal erosion under the SMP6 Scenario, because they are mainly at risk only in the long term (51-100 years) due to defences being implemented in the short term (0-20 years), the value of the properties are reduced significantly enough to provide overall positive benefits.

Table 3.6: Summary of Present Value (PV) Damages

Policy Unit	PV erosion damages (£k)		PV flood damages (£k)		Total PV damages (£k)	
	Do Nothing	SMP6	Do Nothing	SMP6	Do Nothing	SMP6
6.05 Cromer to Overstrand	165	118	0	0	165	118
6.06 Overstrand	7,673	4,201	0	0	7,673	4,201
6.07 Overstrand to Mundesley	4,803	4,333	0	0	4,803	4,333
6.08 Mundesley	20,393	5,048	0	0	20,393	5,048
6.09 Mundesley to Bacton Gas Terminal	2,824	1,726	0	0	2,824	1,726
6.10 Bacton Gas Terminal	201,219	0	0	0	201,219	0
6.11 Bacton Walcott and Ostend	10,364	11,679	4,968	2,104	15,332	13,783
6.12 Ostend to Eccles	145	145	0	0	145	145
Total	247,586	27,250	4,968	2,104	252,554	29,354

Table 3.7:Summary of Present Value (PV) Damages and Benefits (£k)

Policy Unit	Do Nothing Baseline Damages (PV Damages) (£k)	Damage from applying the SMP6 Scenario (PV Damages) (£k)	SMP6 Scenario Damages Avoided/ Benefits (PV Benefits) (£k)
6.05 Cromer to Overstrand	165	118	47
6.06 Overstrand	7,673	4,201	3,472
6.07 Overstrand to Mundesley	4,803	4,333	469
6.08 Mundesley	20,393	5,048	15,345
6.09 Mundesley to Bacton Gas Terminal	2,824	1,726	1,098
6.10 Bacton Gas Terminal	201,219	0	201,219
6.11 Bacton Walcott and Ostend	15,332	13,783	1,549
6.12 Ostend to Eccles	145	145	0
Total	252,554	29,354	223,199

The results show that the Do Nothing Baseline total PV damages in this Study are less than those used in the SMP6 study (2005). This is likely to be due to the fact that the SMP6 was a high level document and this Study has taken a relatively more detailed assessment; therefore the damages are likely to be lower and more accurate. The most significant differences between the Do Nothing total PV damages and those in the SMP6 (2005) are for Policy Unit 6.12 (Ostend to Eccles). This is because the SCAPE model takes into account the wider area and includes sediment transport from north west to the south east. This sediment accumulates in front of the Happisburgh frontage and provides some short term protection to the coastline, thus reducing the extent of erosion and the total damages incurred.

4. Costs

The Present Value costs of the options were determined by combining the capital and maintenance costs correct as of January 2013 and discounting to the year of implementation. Costs have been estimated and optimised using contractor information and recent costs of construction of similar works. Costs have been reviewed and re-assessed as more details and construction information has been obtained. Option costs include £70,000 'other costs' for the Project Appraisal Report (PAR) stage, two years before construction is due to start. Detailed design costs have already been included within the material costs for each option.

4.1 Optimism Bias

Costs have been estimated as realistically as possible considering the high-level nature of the study, with an Optimism Bias of 60% (as typical in the FCERM-AG guidance, 2010), which naturally increases estimated prices and reduces derivative benefit cost ratios. As designs are subsequently refined and specific contractor methods, materials and working practices are gained through potential Early Contractor Involvement through Project Appraisal and Detailed Design Stages, the Optimism Bias can be reduced. For understanding of the potential costs at the Project Appraisal and Detailed Design Stages, an assessment allowing Optimism Bias of 30% has also been included for comparison.

4.2 Present Value Costs

The capital and maintenance costs for the each of the proposed options for each Policy Unit are presented in the tables below. Option 1 is the baseline Do Nothing option and has not been included in the tables below. Capital costs include significant works or upgrades to defences. Maintenance costs can either be annual or periodic. Annual maintenance consists of regular yearly spend whereas period maintenance is undertaken every 10 to 20 years depending on the type and condition of the structures. Increased sea level rise and potential increases in storm frequency and intensity suggest the maintenance required may be more frequent and more laborious than currently. Assuming that no funding was available and therefore no works could go ahead over the next 100 years then the maintenance burden on NNDC would be significantly increased. The proposed options represent a range of options that may be feasible along the frontage from Cromer to Winterton Ness, where an option can be completed alongside another option if deemed necessary.

Policy Unit 6.05 Cromer to Overstrand

Table 4.1: PV costs (with no optimism bias) for each short-listed option for Cromer to Overstrand

	Option	PV Costs (£k)		Notes
		0-5 years	6-100 years	
Capital cost (£k)	Option 2: Monitor and make groynes safe	0	0	No capital expenditure.
	Option 3: Rock placement	504	0	Assume 1:2 slope with 3m height by 6m width. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne). Required from 2015 for SCAPE Unit 65 only (200m).
Maintenance cost (£k)	Option 2: Monitor and make groynes safe	22	61	Surveys every year at cost of £4,000 over 20 years. Removal of groynes once residual life expired= £44,682. Length of defence=2000m.
	Option 3: Rock placement	0	3	Rock maintenance for rock groynes = £,1000 every 10 years (groyne of 70m average).Therefore for rock placement = £2,857 every 10 years (until year 20 when policy is NAI). 200m of defence length.

Policy Unit 6.06: Overstrand

Table 4.2: PV costs (with no optimism bias) for each short-listed option at Overstrand

	Option	PV Costs (£k)		Notes
		0-5 years	6-100 years	
Capital cost (£k)	Option 2: Rock placement	0	1,181	Assume 1:2 slope with 3m height by 6m width. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne). 900m length of rock.
	Option 3: Rock groynes	0	1,246	Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne).
	Option 4: Timber groyne maintenance	288	0	No capital expenditure.
	Option 5: New piles	0	1,255	Assume 15m length piles (10m below ground and 5m above). Steel Sheet piles AZ-18 700 supply.
	Option 6: New piles and rock placement	0	2,310	£2,497/m for supply and place piles. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne.
Maintenance cost (£k)	Option 2: Rock placement	0	6	Rock maintenance is £14/m. Taking 50 % of this value. 900m of rock =£6,429 every 10 years. This is then decreased by £1000 after year 50 every 10 years until 2113.
	Option 3: Rock groynes	0	8	Rock maintenance for rock groynes = £1000 every 10 years (groyne of 70m average). Rock groynes maintenance £8,000 for 8 groynes then decreasing by £1,000 every 10 years after year 50.

	Option 4: Timber groyne maintenance	44	149	Values based on 41 timber groynes requiring £1000/ groyne/10 years (average from the information presented in the Performance Review of Rock and Timber Groynes Report by Mott MacDonald, 2009 (250927/010)). Assume 25% needs replacement (1 in 4 timber planks).
	Option 5: New piles	0	0	No capital expenditure.
	Option 6: New piles and rock placement	0	8	Same as options 2 and 5.

Policy Unit 6.07 Overstrand to Mundesley

Table 4.3: PV costs (with no optimism bias) for each short-listed option for Overstrand to Mundesley

	Option	PV Costs (£k)		Notes
		0-5 years	6-100 years	
Capital cost (£k)	Option 2: Monitor and maintain /make safe.	0	0	No capital expenditure.
Maintenance cost (£k)	Option 2: Monitor and maintain /make safe	557	516	Surveys every year at cost of £4,000 over 20 years. Maintenance on timber revetment: 100% of £49,500 in Year 0 and then 50% in 10. Groynes maintenance in year 0 = £40,006. Then 50% in year 10.

Policy Unit 6.08 Mundesley

Table 4.4: PV costs (with no optimism bias) for each short-listed option for Mundesley

	Option	PV Costs (£k)		Notes
		0-5 years	6-100 years	
Capital cost (£k)	Option 2: Monitor and maintain	0	0	No capital expenditure.
	Option 3: Monitor, maintain and rock placement	261	0	Assume 1:2 slope with 3m height by 6m length. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne).
Maintenance cost (£k)	Option 2: Monitor and maintain	481	1,036	Length of timber revetment=500m. Assume 25% of £1,800/m for a new timber groyne/revetment. Then 10% every 10 years afterwards. Length of Steel cage armour=400m. Length of sea wall= 600m. Assume £66/m for repointing of seawall.
	Option 3: Monitor, maintain and rock placement	481	1,039	Rock maintenance for rock groynes = £1,000 every 10 years (groyne of 70m average). So in this case =100m of rock = £1,429 every 10years.

Policy Unit 6.09 Mundesley to Bacton Gas Terminal

Table 4.5: PV costs (with no optimism bias) for each short-listed option for Overstrand to Mundesley

	Option	PV Costs (£k)		Notes
		0-5 years	6-100 years	
Capital cost (£k)	Option 2: Monitor and maintain /make safe.	0	0	No capital expenditure.

Maintenance cost (£k)	Option 2: Monitor and maintain /make safe	140	207	Surveys every year at cost of £4,000 over 20 years. Maintenance on timber revetment: 100% of £21429 in Year 0 and 50% in year 10. Length of defence=1,100m.

Policy Unit 6.10 Bacton Gas Terminal

Table 4.6: PV costs (with no optimism bias) for each short-listed option for Bacton Gas Terminal

	Option	PV Costs (£k) 0-5 years	PV Costs (£k) 6-100 years	Notes
Capital cost (£)	Option 2: Maximise life of timber defences then high level rock revetment.	0	3,867	Installation of high level rock revetment at £6,600/m (assume 6m high).
	Option 3: Maximise life of timber defences then low level rock revetment.	0	3,222	Installation of low level rock revetment at £5,500/m. Assume 6m high.
Maintenance cost (£)	Option 2: Maximise life of timber defences then high level rock revetment.	450	0	Maintenance for timber revetment = 25% of price for new one (=£1,800/m). Length of defence=1000m.
	Option 3: Maximise life of timber defences then low level rock revetment.	450	0	Maintenance for timber revetment = 25% of price for new one (=£1,800/m). Length of defence=1000m.

Policy Unit 6.11 Bacton, Walcott and Ostend

Table 4.7: PV costs (with no optimism bias) for each short-listed option for Bacton, Walcott and Ostend

	Option	PV Costs (£k) 0-5 years	PV Costs (£k) 6-100 years	Notes
Capital cost (£)	Option 2: Rock placement	1,261	6,415	Assume 1:2 slope with 3m height by 6m length. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne).
	Option 3: Heavy maintenance of timber revetment and groynes and seawall	0	0	No capital expenditure.
	Option 4: Rock groynes	985	4,820	Assume 8 rock groynes, 80 m length over 1000m =640 length of groynes. From 2045 for MU64 - 500m length of frontage = 3 groynes. From 2075 for MU63 - 400m length of frontage = 5 groynes.
Maintenance cost (£)	Option 2: Rock placement	0	72	Rock maintenance for rock groynes = £1,000 every 10 years (groyne of 70m average).
	Option 3: Heavy maintenance of timber revetment and groynes and seawall	1,454	2,601	4,350m of groyne length = £62,143 every 10 years. £66/m for repointing and recladding of the sea wall (taken from recent Strategy work at Hartlepool) Assume cost of timber revetment would be £1,800/m.
	Option 4: Rock groynes	0	31	Assume rock groyne maintenance is broadly the same as rock placement.

Policy Unit 6.12 Ostend to Eccles

Table 4.8: PV costs (with no optimism bias) for each short-listed option for Ostend to Eccles

	Option	PV Costs (£k) 0-5 years	PV Costs (£k) 6-100 years	Notes
Capital cost (£k)	Option 2: Monitor and sweat the assets	1,134	0	Assume cost of new timber revetment and groynes would be £1,800/m.
	Option 3: Rock placement	1,958	0	Assume 1:2 slope with 3m height by 6m length. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne). MU31 and bit of MU30 gives a total of 750m length of defence.
Maintenance cost (£k)	Option 2: Monitor and sweat the assets	0	1,884	Maintenance of timber revetment and timber groynes assumed as 25 % of £1,800 per m. 100% in year 0, 90% in year 10, 80% in year 20, etc (over 100 years).
	Option 3: Rock placement	0	17	Rock maintenance = £14/m every ten years (from previous work). 90% in year 10, 80% in year 20 etc (over 100 years).

4.3 Summary of costs

A summary of the total calculated Present Value costs over the 100 years for each Policy Unit are presented in Table 4.9.

Table 4-9 Summary of options Present Value (PV) Costs (£K) NB numbers are rounded up to the nearest thousand for presentation but actual numbers and year of implementation of works can be found in the economic spreadsheets in the back of this Report.

Policy Unit	Option	Initial Implementation PV Cost (Year 0-5) (£k)			Future PV Costs (Year 6-100) (£k)			Total PV Cost (£k)	PV other (£k appraisal cost)	Total PV Cost (£k including appraisal costs)	Total PV Cost (£k) (30% bias)	Total PV Cost (£k) (60% bias)
		Capital (£k)	Maintenance (£k)	Sub Total (£k)	Capital (£k)	Maintenance (£k)	Sub Total (£k)					
6.05 Cromer to Overstrand	Option 2: Monitor and make groynes safe	0	22	22	0	61	61	83	0	83	108	133
	Option 3: Rock placement	504	0	504	0	3	3	507	70	578	751	924
6.06: Overstrand	Option 2: Rock placement	0	0	0	1,181	6	1,187	1,187	37	1,225	1,591	1,959
	Option 3: Rock groynes	0	0	0	1,246	8	1,254	1,254	38	1,292	1,679	2,067
	Option 4: Timber groyne maintenance	288	44	332	0	149	149	481	70	551	717	882
	Option 5: New sheet piling	0	0	0	1,255	0	1,255	1,255	38	1,293	1,680	2,068
	Option 6: New sheet piling and rock placement	0	0	0	2,310	8	2,318	2,318	38	2,356	3,062	3,769
6.07 Overstrand to Mundesley	Option 2: Monitor, maintain and make safe	0	557	557	0	516	516	1,073	0	1,073	1,395	1,717
6.08 Mundesley	Option 2: Monitor and maintain	0	481	481	0	1,036	1,036	1,517	0	1,517	1,971	2,427
	Option 3: Monitor, maintain and rock placement	261	481	742	0	1,039	1,039	1,781	70	1,851	2,406	2,961
6.09 Mundesley to Bacton Gas Terminal	Option 2: Monitor, maintain and make safe	0	140	140	0	207	207	347	0	347	451	556
6.10 Bacton Gas Terminal	Option 2: maximise defences life then high level rock revetment.	0	450	450	3,867	0	3,867	4,317	38	4,354	5,660	6,967
	Option 3: maximise defences life then low level rock revetment.	0	450	450	3,222	0	3,222	3,672	38	3,710	4,823	5,936

Policy Unit	Option	Initial Implementation PV Cost (Year 0-5) (£k)			Future PV Costs (Year 6-100) (£k)			Total PV Cost (£k)	PV other (£k appraisal cost)	Total PV Cost (£k including appraisal costs)	Total PV Cost (£k) (30% bias)	Total PV Cost (£k) (60% bias)
		Capital (£k)	Maintenance (£k)	Sub Total (£k)	Capital (£k)	Maintenance (£k)	Sub Total (£k)					
6.11 Bacton Walcott and Ostend	Option 2: Rock placement	1,261	0	1,261	6,415	72	6,487	7,748	70	7,818	10,163	12,509
	Option 3: Timber revetment and groyne and seawall maintenance	0	1,454	1,454	0	2,601	2,601	4,055	0	4,055	5,271	6,487
	Option 4: Rock groynes	985	0	985	4,820	31	4,851	5,836	70	5,906	7,677	9,449
6.12 Ostend to Eccles	Option 2: Monitor and sweat the assets	1,134	0	1,134	0	1,884	1,884	3,018	0	3,018	3,924	4,830
	Option 3: Rock placement	1,958	0	1,958	0	17	17	1,974	70	2,044	2,657	3,271

5. Benefit cost ratios

In order to compare the different options it is useful to consider the benefit cost ratios for each Policy Unit. The benefit cost ratio compares the cost of each option over the next 100 years (including design, build and ongoing maintenance), against the benefits (properties that are not eroded or flooded and increased tourism for example) over the same period and are presented in Table 5.1.

Table 5.1: Benefit cost ratios for each Policy Unit (NB those options highlighted in red are unlikely to achieve FDGiA funding as they have benefit cost ratios less than one)

Policy Unit	Option	PV Costs (£k) 60% bias	PV Benefits (excluding tourism) (£k)	Av. BCR (excluding tourism)
6.05 Cromer to Overstrand	Option 2: Monitor and make groynes safe	133	47	0.4
	Option 3: Rock placement	924	47	0.1
6.06: Overstrand	Option 2: Rock placement	1959	3,472	1.8
	Option 3: Rock groynes	2,067	3,472	1.7
	Option 4: Timber groyne maintenance	882	3,472	3.9
	Option 5: New sheet piling	2,068	3,472	1.7
	Option 6: New sheet piling and rock placement	3,769	3,472	0.9
6.07 Overstrand to Mundesley	Option 2: Monitor, maintain and make safe	1,717	469	0.3
6.08 Mundesley	Option 2: Monitor and maintain	2,427	15,345	6.3
	Option 3: Monitor, maintain and rock placement	2,961	15,345	5.2
6.09 Mundesley to Bacton Gas Terminal	Option 2: Monitor, maintain and make safe	556	1,098	2.0
6.10 Bacton Gas Terminal	Option 2: maximise life defences then high level rock revetment.	6,967	201,219	28.9
	Option 3: maximise life defences then low level rock revetment.	5,936	201,219	33.9
6.11 Bacton Walcott and Ostend	Option 2: Rock Placement	12,509	1,549	0.1
	Option 3: Timber revetment and groyne and sea wall maintenance	6,487	1,549	0.3
	Option 4: Rock groynes	9,449	1,549	0.2
6.12 Ostend to Eccles	Option 2: Monitor and sweat the assets	4,830	0	0
	Option 3: Rock placement	3,271	0	0

Sensitivity testing was also undertaken to consider the business case put forward for all preferred options on the following aspects:

- Increased cost by 10%
- Reduce optimum bias to 30%
- Minimum erosion – taking the year at the beginning of each erosion period (e.g. Year 0 for all going within Years 0-20) (see section 3.1.1 of this Economic Assessment Report).
- Maximum erosion – taking the year at the end of each erosion period (e.g. Year 20 for all going within Years 0-20) (see section 3.1.1 of this Economic Assessment Report).

A summary of this sensitivity testing is presented in Table 5.2. Results show little significant changes in benefit cost ratios as result of sensitivity analysis. Those Policy Units with a benefit cost ratio above 1.0 generally stay above 1.0 during the sensitivity.

Table 5-2: Summary of benefit cost ratio sensitivity tests relative to 60% optimum bias basecase (all calculations exclude tourism benefits). (NB those options highlighted in red are unlikely to achieve FDGiA funding as they have benefit cost ratios less than one)

Policy Unit	Preferred option	Basecase (60% optimum bias)	Reducing optimum bias to 30%	Option cost increased by 10%*	Maximum erosion	Minimum erosion
6.05 Cromer to Overstrand	Option 2: Monitor and make groynes safe	0.4	0.4	0.3	0.2	0.8
	Option 3: Rock placement	0.1	0.1	0.0	0.0	0.1
6.06: Overstrand	Option 2: Rock placement	1.8	2.2	3.9	1.1	2.7
	Option 3: Rock groynes	1.7	2.1	4.8	1.1	2.6
	Option 4: Timber groyne maintenance	3.9	1.5	3.6	2.5	6.0
	Option 5: New sheet piling	1.7	1.1	2.5	1.1	2.6
	Option 6: New sheet piling and rock placement	0.9	2.6	6.0	0.6	1.4
6.07 Overstrand to Mundesley	Option 2: Monitor, maintain and make safe	0.3	0.3	0.2	0.2	1.2
6.08 Mundesley	Option 2: Monitor and maintain	6.3	7.8	5.7	4.5	8.5
	Option 3: Monitor, maintain and rock placement	5.2	6.4	4.7	3.7	7.3
6.09 Mundesley to Bacton Gas Terminal	Option 2: Monitor, maintain and make safe	2.0	2.4	1.8	1.6	2.3
6.10 Bacton Gas Terminal	Option 2: maximise life defences then high level rock revetment.	28.9	35.5	26.3	20.5	40.0
	Option 3: maximise life defences then low level rock revetment.	33.9	41.7	30.8	24.0	46.9
6.11 Bacton Walcott and Ostend	Option 2: Rock Placement	0.1	0.2	0.1	0.2	0.0
	Option 3: Timber revetment and groyne and sea wall maintenance	0.3	0.3	0.2	0.4	0.0
	Option 4: Rock groynes	0.2	0.2	0.1	0.3	0.0
6.12 Ostend to Eccles	Option 2: Monitor and sweat the assets	0.0	0.0	0.0	0.0	0.0
	Option 3: Rock placement	0.0	0.0	0.0	0.0	0.0

6. Flood and Coastal Resilience Partnership Funding

The 'Flood and Coastal Resilience Partnership Funding' approach allows a proportion of Government funding to be made available to any scheme. The amount of funding is assessed relative to the benefits delivered by the scheme including the number of households protected, and the damages being prevented. The 'number of houses protected' within the calculations include the difference between residential properties at risk in a Do Nothing Baseline compared with the number of residential properties at risk under the SMP6 Scenario (Table 6.1) (i.e. the number of properties 'saved' by implementing the SMP6 Scenario, compared to the Do Nothing Baseline).

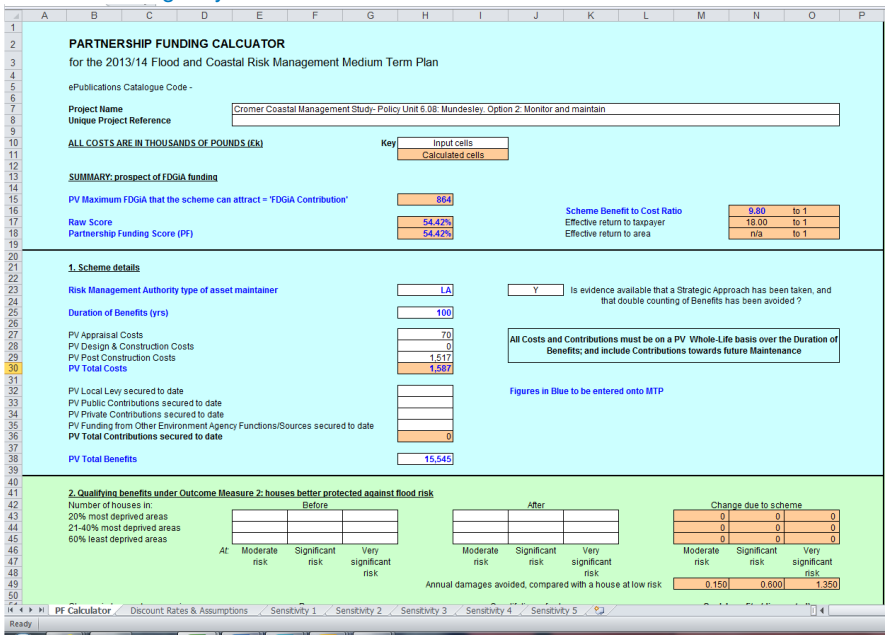
Table 6.1: Difference in number of residential properties protected from risk of erosion over 100 years under Do Nothing Baseline and SMP6 Scenarios. NB just those Policy Units with a SMP6 policy recommendation of Hold the Line and benefit cost ratios above 1.0 have been included.

SMP Policy Unit	Properties protected (0-20 years)	Properties protected (20-100 years)	Properties protected total
6.06:Overstrand	1	0[1]	1
6.08 Mundesley	126	0[1]	126
Total			**127**

1Where the properties protected are shown as a '0' in this table is where the number of properties eroded under the SMP6 Scenario is greater than the number of properties eroded under the Do Nothing Baseline.

The funding allocations are based on the FDGiA Calculator. This tool identifies the maximum amount of funding available based on Partnership Funding Scores. An example of the spreadsheet tool used is presented in Figure 6.1.

Figure 6.1: Example of the Partnership Funding Calculator used to identify the maximum amount of funding a Environment Agency towards a scheme.



Partnership Funding Scores have been calculated for each Policy Unit and are presented below in Table 6.2.

Table 6.2: FDGiA Calculator outputs excluding tourism (NB Policy Units with benefit cost ratios less than one are unlikely to achieve FDGiA funding and hence have been excluded)

Policy Units	Option	Benefit Cost Ratio	PV Total Costs without Optimism Bias (£k)	Raw Partnership Funding Score (PFS) (%)	Maximum Partnership Funding Allocation (£k)	External contributions required to achieve 100% PFS (£k)	External contributions required to achieve 150% PFS (£k)	External contributions required to achieve 200% PFS (£k)
6.06 Overstrand	Option 2: Rock placement	1.8	1,225	17	206	1,019	1,629	2,242
	Option 3: Rock groynes	1.7	1,292	16	206	1,086	1,731	2,377
	Option 4: Timber groyne maintenance	Maintenance project – not eligible for funding						
	Option 5: New sheet piling	1.7	1,293	16	206	1,087	1,660	2,379
	Option 6: New sheet piling and rock placement	Benefit cost ratio below 1 and therefore unlikely to achieve FDGiA funding						
6.08 Mundesley	Option 2: Monitor and maintain	Maintenance project – not eligible for funding						
	Option 3: Monitor, maintain and rock placement	5.2	1,851	196	1,851	0	0	74

7. Modified SMP6 Scenario

Following the results from the initial economic assessment, it was agreed to assess the impact of extending the Hold the Line policies, both in terms of technical impacts (discussed in the main report and Appendix C: SCAPE report) and economic impacts.

The SCAPE model was re-run with the residual life of the current defences extended to beyond year 100 in three Policy Units (6.06, 6.08 and 6.11) to represent a change to a Hold the Line policy in the long term (0-100 years) (Table 7.1). These Policy Units were chosen as they have a higher density of assets at risk from coastal erosion in addition to the only Policy Units with a Hold the Line management recommendation in the short term (0-20 years) from the SMP6 (excluding 6.10 where the management recommendation is already Hold the Line over the long term (0-100 years)). To assess the economic impacts, the benefits, costs and benefit cost ratios were re-calculated under this different scenario.

Table 7.1: Table to show polices for Run 3. Ones in red show where it has been changed.

SMP6 Policy Unit	Area of frontage	Short term (0-20 years)	Medium term (21-50 years)	Long term (51-100 years)
6.05	Cromer to Overstrand	Managed Realignment	No Active Intervention	No Active Intervention
6.06	Overstrand	Hold the Line	Hold the Line	Hold the Line
6.07	Overstrand to Mundesley	Managed Realignment	No Active Intervention	No Active Intervention
6.08	Mundesley	Hold the Line	Hold the Line	Hold the Line
6.09	Mundesley to Bacton Gas Terminal	Managed Realignment	No Active Intervention	No Active Intervention
6.10	Bacton Gas Terminal	Hold the Line	Hold the Line	Hold the Line
6.11	Bacton Walcott and Ostend	Hold the Line	Hold the Line	Hold the Line
6.12	Ostend to Eccles	Managed Realignment	Managed Realignment	Managed Realignment

Unless otherwise stated in the following sections, the methodology followed to calculate benefits and costs follows the same as has been described in Sections 3 to 6.

7.1 Benefits

7.1.1 Properties

Although the management policy has been altered in only three Policy Units, the potential coastline recession shown by the SCAPE model changes due to the impact of these policy changes on sediment movement along the frontage.

Erosion lines were therefore re-drawn in GIS with properties at risk from erosion recalculated (Table 7.2). Under this Modified SMP6 Scenario only 265 commercial and residential properties are at risk, compared to 1,045 under the Do Nothing Baseline.

Table 7.2: Table to show residential properties at risk from erosion under the Do Nothing Baseline and Modified SMP6 Scenarios (brackets show commercial properties). The final column displays the properties better protected from coastal erosion (compared to the Do Nothing Baseline) over 100 years under the Modified SMP6 Scenario.

Policy Unit	Do Nothing Baseline	Modified SMP6 Scenario	Do Nothing Baseline	Modified SMP6 Scenario	Do Nothing Baseline	Modified SMP6 Scenario	Total properties better protected
	0-20 years		21-50 years		51-100 years		Total
6.05 Cromer to Overstrand	0(0)	0(0)	0(0)	0(0)	**0** (3)	0(2)	**0(1)**
6.06: Overstrand	**1**(0)	0(0)	**63** (1)	0(0)	**131**(3)	**3**(0)	**192(4)**
6.07 Overstrand to Mundesley	**0** (4)	**11**(4)	**35** (3)	**24**(0)	**74**(0)	**62**(5)	**12(-2)**
6.08 Mundesley	**132** (6)	**6**(0)	**155**(2)	0(0)	**181**(2)	**17**(0)	**445(10)**
6.09 Mundesley to Bacton Gas Terminal	**18**(0)	**17**(0)	0(0)	0(1)	**24**(1)	**13**(0)	**12(0)**
6.10 Bacton Gas Terminal	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	**0(0)**
6.11 Bacton Walcott and Ostend	**94** (0)	**19**(2)	**51**(1)	**34**(0)	**51**(4)	**41**(0)	**102(3)**
6.12 Ostend to Eccles	**2**(0)	**2**(0)	0(0)	0(0)	0(0)	**1**(1)	**-1(-1)**
Total	**247** (10)	**55**(6)	**307**(7)	**58**(1)	**461**(13)	**137**(8)	**762(15)**

7.1.2 Other benefits

Despite the potentially important influence of tourism for this area of coastline, it was considered that the current data available is not sufficient to include within the economic assessment as discussed in Section 3.2. The tourism values have therefore not been recalculated for the Modified SMP6 Scenario. However, it is likely that the benefits from tourism would increase the benefit cost ratios in Policy Units 6.06, 6.08 and 6.11 where the Hold the Line policy has been extended.

Value of benefits from major infrastructure have been kept the same as the previous assessment however the year they are exposed to risk of erosion may have changed:

- Bacton Gas Terminal – no change from SMP6 Scenario
- Roads – Roads at risk from erosion in Policy Units 6.08 and 6.11 are **not** at risk under the Modified SMP6 Scenario and therefore benefits are calculated as the 'damages avoided'. In 6.07 the road is still at risk of erosion and therefore the benefits are the same as under the SMP6 Scenario
- Anglian Water assets – Anglian Water assets at risk from erosion in Policy Units 6.06 and 6.08 are **not** at risk under the Modified SMP6 Scenario and therefore the benefits are calculated as the 'damages avoided'.

7.1.3 Summary of benefits

Table 7.3: Table to show Present Value (PV) damages and benefits (this does not include recreation benefits)

Policy Unit	Do Nothing Baseline PV Damage (£k)	PV Damage from applying Modified SMP6 Scenario (£k)	PV Damages Avoided/ Benefits (£k)
6.05 Cromer to Overstrand	165	118	47
6.06 Overstrand	7,673	481	7,192
6.07 Overstrand to Mundesley	4,803	5,525	-723[1]
6.08 Mundesley	20,393	474	19,919
6.09 Mundesley to Bacton Gas Terminal	2,824	3,072	-247[1]
6.10 Bacton Gas Terminal	201,219	0	201,219
6.11 Bacton Walcott and Ostend	15,332	8,649	6,683
6.12 Ostend to Eccles	145	224	-79[1]
Total	252,554	18,543	234,011

[1]Further detail explaining where the negative benefits have arisen can be found in Section 3 of the main Study Report.

7.2 Costs

7.2.1 Options

The options for coastal defences have only been reconsidered for the three Policy Units which have been changed: Policy Units 6.06, 6.08 and 6.11. The coastal defence options have been kept broadly similar to recommended under the SMP6 Scenario, however small changes have been made to ensure the defences have an estimated life of 100 years. The changes when compared to the SMP6 Scenario are summarised in Table 7.4.

Table 7.4: Table summarising changes in the coastal defence options when compared between the Modified SMP6 Scenario and the SMP6 Scenario.

Policy Unit	SMP6 Option	Modified SMP6 Option	Comments
6.06 Overstrand	Option 2: Rock placement	Option 2: Rock placement and maintenance of timber revetment/seawall	Same principles but additional maintenance on the timber revetment and sea wall is needed to ensure 100 year life of the defences.
	Option 3: Rock groynes	Option 3: Rock groynes and maintenance of timber revetment/seawall	Same principles but additional maintenance on the timber revetment and sea wall is needed to ensure 100 year life of the defences.
	Option 4: Timber groyne maintenance	Option 4: Timber groynes, timber revetment and seawall cladding	Timber groyne maintenance is not considered enough to hold the line over 100 years and therefore also need to replace and maintain the timber revetment and re-clad the sea wall.
	Option 5: New piles	Option 5: New piles, timber revetment and seawall cladding	Same principles but additional maintenance on the timber revetment and sea wall is needed to ensure 100 year life of the defences.
	Option 6: New piles and rock placement	Option 6: New piles, rock placement, timber revetment and seawall cladding	Same principles but additional maintenance on the timber revetment and sea wall is needed to ensure 100

Policy Unit	SMP6 Option	Modified SMP6 Option	Comments
			year life of the defences.
6.08 Mundesley	Option 2: Monitor and maintain	Option 2: Monitor and maintain	Same as under the SMP policy however re-clad the sea wall in year 0 and year 50 and maintenance stays at maximum level throughout the 100 years.
	Option 3: Monitor, maintain and rock placement	Option 3: Monitor, maintain and rock placement	
6.11 Bacton, Walcott and Ostend	Option 2: Rock placement	Option 2: Rock placement	Same as under the SMP policy however maintenance stays at maximum level throughout the 100 years.
	Option 3: Heavy maintenance of timber revetment and groynes and seawall	Option 3: Heavy maintenance of timber revetment and groynes and seawall	
	Option 4: Rock groynes	Option 4: Rock groynes	

7.2.2 Option Costs

The option costs under the three Policy Units listed above are presented in more detail in Tables 7.5, 7.6 and 7.7, with a summary presented in Table 7.8.

Policy Unit 6.06: Overstrand

Table 7.5: PV costs for each short-listed option at Overstrand. Notes give more details on how the costs have been calculated.

	Option	PV Costs (£k)		Notes
		0-5 years	6-100 years	
Capital cost (£k)	Option 2: Rock placement and maintenance of timber revetment/seawall	0	1,181	Assume 1:2 slope with 3m height by 6m width. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne). 900m length of rock.
	Option 3: Rock groynes and maintenance of timber revetment/seawall	0	1,243	Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne).
	Option 4: Timber groynes, timber revetment and seawall cladding	0	1,200	Replace timber revetment and groynes in year 20 and year 70 – assume a total length of timber to replace as 1,090m at £1,800 per m.
	Option 5: New piles, timber revetment and seawall cladding	0	1,870	Assume 15m length piles (10m below ground and 5m above). Steel Sheet piles AZ-18 700 supply. Replaced in year 20 and year 70. Replace timber revetment in years 20 and 70 – 450m at £1800/m.
	Option 6: New piles, rock placement, timber revetment and seawall cladding	0	2,717	Same as Option 5 with rock placement from Option 2.
Maintenance cost (£k)	Option 2: Rock placement and maintenance of timber revetment/seawall	0	156	Rock maintenance is £14/m. Taking 50 % of this value. 900m of rock =£6,429 every 10 years. Sea wall cladding and timber revetment maintenance in year 20 and year 70.
	Option 3: Rock groynes and maintenance of timber revetment/seawall	0	154	Rock maintenance for rock groynes = £1,000 every 10 years (groyne of 70m average). Sea wall cladding and timber revetment maintenance in year 20 and year 70.
	Option 4: Timber groynes, timber revetment and seawall cladding	0	571	Values based on 41 timber groynes requiring £1000/ groyne/10 years (average from the information presented in the Performance Review of Rock and Timber Groynes Report by Mott MacDonald, 2009 (250927/010)). Assume 25% needs replacement (1 in 4 timber planks) every 10 years. Sea wall cladding in year 20 and year 70.
	Option 5: New piles, timber revetment and seawall cladding	0	24	Sea wall cladding in years 20 and 70.
	Option 6: New piles, rock placement, timber revetment and seawall cladding	0	28	Same as option 5 with rock maintenance = £7/m every 10 years.

Policy Unit 6.08 Mundesley

Table 7.6: PV costs for each short-listed option at Mundesley. Notes give more details on how the costs have been calculated.

	Option	PV Costs (£k)		Notes
		0-5 years	6-100 years	
Capital cost (£k)	Option 2: Monitor and maintain	0	0	No capital expenditure.
	Option 3: Monitor, maintain and rock placement	261	0	Assume 1:2 slope with 3m height by 6m length. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne).
Maintenance cost (£k)	Option 2: Monitor and maintain	669	1,539	Length of timber revetment=500m. Assume 25% of £1,800/m for a new timber groyne/revetment. Then 10% every 10 years afterwards. Length of Steel cage armour=400m. Length of sea wall= 600m. Assume £66/m for repointing of seawall.
	Option 3: Monitor, maintain and rock placement	669	1,541	Rock maintenance for rock groynes = £1,000 every 10 years (groyne of 70m average). So in this case =100m of rock = £1,429 every 10years.

Policy Unit 6.11 Bacton, Walcott and Ostend

Table 7.7: PV costs for each short-listed option at Bacton, Walcott and Ostend. Notes give more details on how the costs have been calculated.

	Option	PV Costs (£k)		Notes
		0-5 years	6-100 years	
Capital cost (£)	Option 2: Rock placement	1,261	6,415	Assume 1:2 slope with 3m height by 6m length. Assume £2,610/m for rock armour (this assumes 45 tonnes of rock at a cost of £58/tonne).
	Option 3: Heavy maintenance of timber revetment and groynes and seawall	0	0	No capital expenditure.
	Option 4: Rock groynes	985	4,820	Assume 8 rock groynes, 80 m length over 1000m =640 length of groynes. From 2045 for MU64 - 500m length of frontage = 3 groynes. From 2075 for MU63 - 400m length of frontage = 5 groynes.
Maintenance cost (£)	Option 2: Rock placement	0	112	Rock maintenance for rock groynes = £1,000 every 10 years (groyne of 70m average).
	Option 3: Heavy maintenance of timber revetment and groynes and seawall	1,454	3,538	4,350m of groyne length = £62,143 every 10 years.
	Option 4: Rock groynes	0	48	Assume rock groyne maintenance is broadly the same as rock placement.

7.2.3 Summary of costs for Policy Units 6.06, 6.08 and 6.11

Table 7-8 Summary of options Present Value (PV) Costs (£K) NB numbers are rounded up to the nearest thousand for presentation but actual numbers and year of implementation of works can be found in the economic spreadsheets in Appendix A.

Policy Unit	Option	Initial Implementation PV Cost (Year 0-5) (£k)			Future PV Costs (Year 6-100) (£k)			Total PV Cost (£k)	PV other (£k appraisal cost)	Total PV Cost (£k including appraisal costs)	Total PV Cost (£k) (30% bias)	Total PV Cost (£k) (60% bias)
		Capital (£k)	Maintenance (£k)	Sub Total (£k)	Capital (£k)	Maintenance (£k)	Sub Total (£k)					
6.06: Overstrand	Option 2: Rock placement and maintenance of timber revetment/seawall	0	0	0	1,181	156	1,337	1,337	38	1,374	1,786	2,199
	Option 3: Rock groynes and maintenance of timber revetment/seawall	0	0	0	1,243	154	1,396	1,396	38	1,434	1,864	2,294
	Option 4: Timber groynes, timber revetment and seawall cladding	0	0	0	1,200	571	1,771	1,771	38	1,809	2,351	2,894
	Option 5: New piles, timber revetment and seawall cladding	0	0	0	1,870	24	1,895	1,895	38	1,932	2,512	3,092
	Option 6: New piles, rock placement, timber revetment and seawall cladding	0	0	0	2,717	28	2,745	2,745	38	2,782	3,617	4,452
6.08 Mundesley	Option 2: Monitor and maintain	0	669	669	0	1,539	1,539	2,208	0	2,208	2,870	3,532
	Option 3: Monitor, maintain and rock placement	261	669	930	0	1,541	1,541	2,470	70	2,540	3,302	4,065
6.11 Bacton Walcott and Ostend	Option 2: Rock placement	1,261	0	1,261	6,415	112	6,527	7,788	70	7,858	10,216	12,573
	Option 3: Timber revetment and groyne and seawall maintenance	0	1,454	1,454	0	3,538	3,538	4,992	0	4,992	6,490	7,987
	Option 4: Rock groynes	985	0	985	4,820	48	4,867	5,853	70	5,923	7,700	9,476

7.3 Benefit cost ratios

The benefit cost ratios have been re-calculated to reflect the changes in benefits in all Policy Units under the Modified SMP6 Scenario.

Table 7.9: Benefit cost ratios for each Policy Unit (NB those options highlighted in red are unlikely to achieve FDGiA funding as they have benefit cost ratios less than one)

Policy Unit	Option	PV Costs (£k) 60% bias	PV Benefits (excluding tourism) (£k)	Av. BCR (excluding tourism)
6.05 Cromer to Overstrand	Option 2: Monitor and make groynes safe	133	47	0.4
	Option 3: Rock placement	924	47	0.1
6.06: Overstrand	Option 2: Rock placement and maintenance of timber revetment/seawall	2,199	7,192	3.3
	Option 3: Rock groynes and maintenance of timber revetment/seawall	2,294	7,192	3.1
	Option 4: Timber groynes, timber revetment and seawall cladding	2,894	7,192	2.5
	Option 5: New piles, timber revetment and seawall cladding	3,092	7,192	2.3
	Option 6: New piles, rock placement, timber revetment and seawall cladding	4,452	7,192	1.6
6.07 Overstrand to Mundesley	Option 2: Monitor, maintain and make safe	1,717	-723	-0.4
6.08 Mundesley	Option 2: Monitor and maintain	3,532	19,919	5.6
	Option 3: Monitor, maintain and rock placement	4,065	19,919	4.9
6.09 Mundesley to Bacton Gas Terminal	Option 2: Monitor, maintain and make safe	556	-247	-0.4
6.10 Bacton Gas Terminal	Option 2: maximise life defences then high level rock revetment.	6,967	201,219	28.9
	Option 3: maximise life defences then low level rock revetment.	5,936	201,219	33.9
6.11 Bacton Walcott and Ostend	Option 2: Rock Placement	12,573	5,843	0.5
	Option 3: Timber revetment and groyne and sea wall maintenance	7,987	5,843	0.7
	Option 4: Rock groynes	9,476	5,843	0.6
6.12 Ostend to Eccles	Option 2: Monitor and sweat the assets	4,830	-79	0.0
	Option 3: Rock placement	3,271	-79	0.0

Sensitivity testing was also undertaken to consider the business case put forward for all preferred options on the following aspects:

- Increased cost by 10%
- Reduce optimum bias to 30%
- Minimum erosion – taking the year at the beginning of each erosion period (e.g. Year 0 for all going within Years 0-20) (see section 3.1.1 of this Economic Assessment Report).
- Maximum erosion – taking the year at the end of each erosion period (e.g. Year 20 for all going within Years 0-20) (see section 3.1.1 of this Economic Assessment Report).

A summary of this sensitivity testing is presented in Table 7.10. Results show little significant changes in benefit cost ratios as result of sensitivity analysis. Those Policy Units with a benefit cost ratio above 1.0 generally stay above 1.0 during the sensitivity.

Table 7-10: Summary of benefit cost ratio sensitivity tests *relative to 60% optimum bias basecase (all calculations excluding tourism benefits). (NB those options highlighted in red are unlikely to achieve FDGiA funding as they have benefit cost ratios less than one)

Policy Unit	Preferred option	Basecase (60% optimum bias)	Reducing optimum bias to 30%	Option cost increased by 10%*	Maximum erosion	Minimum erosion
6.05 Cromer to Overstrand	Option 2: Monitor and make groynes safe	0.4	0.4	0.3	0.2	0.8
	Option 3: Rock placement	0.1	0.1	0.0	0.0	0.1
6.06: Overstrand	Option 2: Rock placement and maintenance of timber revetment/seawall	3.3	4.0	3.0	1.9	5.3
	Option 3: Rock groynes and maintenance of timber revetment/seawall	3.1	3.9	3.1	2.9	2.0
	Option 4: Timber groynes, timber revetment and seawall cladding	2.5	3.1	2.3	1.4	4.0
	Option 5: New piles, timber revetment and seawall cladding	2.3	2.9	2.1	1.3	3.8
	Option 6: New piles, rock placement, timber revetment and seawall cladding	1.6	2.0	1.5	0.9	2.6
6.07 Overstrand to Mundesley	Option 2: Monitor, maintain and make safe	-0.4	-0.5	-0.4	-0.3	-0.5
6.08 Mundesley	Option 2: Monitor and maintain	5.6	6.9	5.1	4.0	8.2
	Option 3: Monitor, maintain and rock placement	4.9	6.0	4.5	3.5	7.1
6.09 Mundesley to Bacton Gas Terminal	Option 2: Monitor, maintain and make safe	-0.4	-0.5	-0.4	-0.3	-0.6
6.10 Bacton Gas Terminal	Option 2: maximise life defences then high level rock revetment.	28.9	35.5	26.3	20.5	40.0
	Option 3: maximise life defences then low level rock revetment.	33.9	41.7	30.8	24.0	46.9
6.11 Bacton Walcott and Ostend	Option 2: Rock Placement	0.5	0.6	0.4	0.2	0.8
	Option 3: Timber revetment and groyne and sea wall maintenance	0.7	0.9	0.7	0.3	1.2
	Option 4: Rock groynes	0.6	0.8	0.6	0.3	1.0
6.12 Ostend to Eccles	Option 2: Monitor and sweat the assets	0.0	0.0	0.0	0.0	0.0
	Option 3: Rock placement	0.0	0.0	0.0	0.0	-0.1

7.4 Flood and Coastal Risk Partnership Funding

The Partnership Funding Scores were re-calculated for those Policy Units with a Hold the Line Policy with recommended capital works. These are summarised in Table 7.11.

Table 7.11: FDGiA Calculator outputs excluding tourism (NB Policy Units with benefit cost ratios less than one are unlikely to achieve FDGiA funding and hence have been excluded from this table)

Policy Units	Option	Benefit Cost Ratio	PV Total Costs without Optimism Bias (£k)	Raw Partnership Funding Score (PFS) (%)	Maximum Partnership Funding Allocation (£k)	External contributions required to achieve 100% PFS (£k)	External contributions required to achieve 150% PFS (£k)	External contributions required to achieve 200% PFS (£k)
6.06 Overstrand	Option 2: Rock placement and maintenance of timber revetment/seawall	3.3	1,374	101	1,374	0	673	1,360
	Option 3: Rock groynes and maintenance of timber revetment/seawall	3.1	1,434	97	1,388	43	760	1,477
	Option 4: Timber groynes, timber revetment and seawall cladding	2.5	1,809	77	1,388	416	1,321	2,225
	Option 5: New piles, timber revetment and seawall cladding	2.3	1,932	72	1,388	541	1,507	2,473
	Option 6: New piles, rock placement, timber revetment and seawall cladding	1.6	2,782	50	1,388	1,391	2,782	4,173
6.08 Mundesley	Option 2: Monitor and maintain	Maintenance project – not eligible for funding						
	Option 3: Monitor, maintain and rock placement	4.9	2,540	261	2,540	0	0	0

8. SMP6 with Beach Nourishment Scenario

Currently, the Environment Agency recharges the beach at Cart Gap (north west of Policy Unit 13) every four years. Through discussions with the Environment Agency, approximately 500,000m^3 of sediment is estimated as being placed along the frontage at Cart Gap approximately every four years.

Through discussions between the Project Team, North Norfolk District Council and the Environment Agency, the option of potentially moving the site of nourishment further updrift has been discussed, with the suggestion that this might benefit the whole of this study frontage. If the sediment was still transported down to Cart Gap through longshore drift it could be assumed that changing the location of the recharge even would not have negative impacts down drift (this has been further discussed in Section 2 of the main Study Report).

To test this possibility, the SMP6 with Sediment Nourishment Scenario looks at moving this recharge site to Policy Units 6.05, 6.06 and part of 6.07 (5km of frontage) to assess whether the impact of sediment movement along the frontage could benefit all Policy Units without negatively impacting the processes at Policy Unit 6.13. The residual life of the current defences has been kept the same as under the SMP6 Scenario. In addition, 100m^3 sediment per m length was added along 5km of the most north western part of the frontage every four years (and therefore 500,000m^3 sediment in total introduced every 5 years). This could be equivalent to an area of recharge of 4m by 50m which would give an appropriate slope for beach recharge material (1:12.5).

Unless otherwise stated in the following sections, the methodology followed to calculate benefits and costs follows the same as has been described in Sections 3 to 6.

8.1 Benefits

8.1.1 Properties

Erosion lines were re-drawn in GIS with properties at risk from erosion recalculated (Table 7.2). Under the SMP6 with Beach Nourishment Scenario 928 commercial and residential properties are at risk, compared to 1,045 under the Do Nothing Baseline.

Table 8.1: Table to show residential properties at risk from erosion under the Do Nothing Baseline and SMP6 with Beach Nourishment Scenarios (brackets show commercial properties). The final column displays the properties better protected from coastal erosion (compared to the Do Nothing Baseline) over 100 years under the SMP6 with Beach Nourishment Scenario.

Policy Unit	Do Nothing Baseline	SMP6 with Beach Nourishment Scenario	Do Nothing Baseline	SMP6 with Beach Nourishment Scenario	Do Nothing Baseline	SMP6 with Beach Nourishment Scenario	Total properties better protected
	0-20 years		21-50 years		51-100 years		Total
6.05 Cromer to Overstrand	0(0)	0(0)	0(0)	0(0)	**0** (3)	0(2)	**0**(1)
6.06: Overstrand	**1**(0)	0(0)	**63**(1)	0(0)	**131**(3)	**141**(1)	**54**(3)
6.07 Overstrand to Mundesley	**0**(4)	**2**(0)	**35**(3)	**1**(0)	**74**(0)	**28**(3)	**78**(4)
6.08 Mundesley	**132**(6)	**6**(0)	**155**(2)	**6**(0)	**181**(2)	**360**(10)	**96**(0)
6.09 Mundesley to Bacton Gas Terminal	**18**(0)	**1**(0)	0(0)	**16**(1)	**24**(1)	**19**(0)	**6**(0)
6.10 Bacton Gas Terminal	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
6.11 Bacton Walcott and Ostend	**94**(0)	**13**(0)	**51**(1)	**223**(9)	**51**(4)	**80**(2)	**-120**(-6)
6.12 Ostend to Eccles	**2**(0)	**2**(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Total	**247**(10)	**24**(0)	**304**(7)	**246**(10)	**461**(13)	**628**(18)	**117**(2)

8.1.2 Other benefits

Despite the potentially important influence of tourism for this area of coastline, it was considered that the current data available is not enough to include within economic assessment is Section 3.2 of this report. The tourism values have therefore not been recalculated for the SMP6 with Beach Nourishment Scenario.

Value of benefits from major infrastructure have been kept the same as the previous assessment however the year they are exposed to risk of erosion may have changed:

- Bacton Gas Terminal – same as SMP6 Scenario.
- Roads – Roads at risk from erosion in Policy Unit 6.07 are **not** at risk under the SMP6 with Beach Nourishment Scenario and therefore the Do Nothing damages are used as the benefits. In 6.11 the road is still at risk of erosion and therefore the benefits are the same as under the SMP6 Scenario. In 6,08 the road is not at risk until the long term (year 75) and therefore the damages under the SMP6 with Beach Nourishment Scenario for the erosion of the road is £115k.
- Anglian Water assets – Anglian Water assets at risk from erosion in Policy Units 6.06 is the same as under the SMP6 Scenario (at risk in the medium term (years 21-50). In Policy Unit 6.08, the Anglian Water assets are **not** at risk from erosion until the long term (year 75) and therefore the damages associated with the SMP6 with Beach Nourishment Scenario are reduced (compared to the Do Nothing Baseline and SMP6 Scenarios) to £176k.

8.1.3 Summary of benefits

Table 8.2: Table to show Present Value (PV) damages and benefits (this does not include recreation benefits)

Policy Unit	Do Nothing Baseline PV Damage (£k)	PV Damage from applying SMP6 with Beach Nourishment Scenario (£k)	PV Damages Avoided/ Benefits (£k)
6.05 Cromer to Overstrand	165	118	47
6.06 Overstrand	7,673	2,141	5,532
6.07 Overstrand to Mundesley	4,803	1,118	3,685
6.08 Mundesley	20,393	4,455	15,938
6.09 Mundesley to Bacton Gas Terminal	2,824	1,465	1,359
6.10 Bacton Gas Terminal	201,219	0	201,219
6.11 Bacton Walcott and Ostend	15,332	12,741	2,591
6.12 Ostend to Eccles	145	145	0
Total	252,554	22,183	230,371

8.2 Costs

8.2.1 Options

The management options for coastal defences have been kept the same as under the SMP6 Scenario. The cost of implement the beach recharge has not been incorporated into this assessment as it is considered that there would be no additional cost to the Environment Agency in moving the location of the recharge currently undertaken at Cart Gap.

As risk of coastal erosion decreases with the additional input of sediment, it is likely that the cost of building and maintaining defences would decrease, especially in Policy Unit 6.06 where the beach recharge occurs. This reduction in costs has not been accounted for within the assessment to allow a conservative assessment of how this option may alter benefit cost ratios of different future schemes.

If this scheme was taken through for further consideration at PAR stage, discussions between North Norfolk District Council and the Environment Agency would be needed to determine how the cost of the recharge would be managed and whether this could be included as a contribution to the PAR schemes.

8.3 Benefit Cost Ratios

The benefit cost ratios have been re-calculated to reflect the changes in benefits in all Policy Units under the SMP6 with Beach Nourishment Scenario.

Table 8.3: Benefit cost ratios for each Policy Unit (NB those options highlighted in red are unlikely to achieve FDGiA funding as they have benefit cost ratios less than one)

Policy Unit	Option	PV Costs (£k) 60% bias	PV Benefits (excluding tourism) (£k)	Av. BCR (excluding tourism)
6.05 Cromer to Overstrand	Option 2: Monitor and make groynes safe	133	47	0.4
	Option 3: Rock placement	924	47	0.1
6.06: Overstrand	Option 2: Rock placement	1,959	5,532	2.8
	Option 3: Rock groynes	2,067	5,532	2.7
	Option 4: Timber groyne maintenance	882	5,532	6.3
	Option 5: New sheet piling	2,068	5,532	2.7
	Option 6: New sheet piling and rock placement	3,769	5,532	1.5
6.07 Overstrand to Mundesley	Option 2: Monitor, maintain and make safe	1,717	3,685	2.1
6.08 Mundesley	Option 2: Monitor and maintain	2,427	15,938	6.6
	Option 3: Monitor, maintain and rock placement	2,961	15,938	5.4
6.09 Mundesley to Bacton Gas Terminal	Option 2: Monitor, maintain and make safe	556	1,359	2.4
6.10 Bacton Gas Terminal	Option 2: maximise life defences then high level rock revetment.	6,967	201,219	28.9
	Option 3: maximise life defences then low level rock revetment.	5,936	201,219	33.9
6.11 Bacton Walcott and Ostend	Option 2: Rock Placement	12,509	2,094	0.2
	Option 3: Timber revetment and groyne and sea wall maintenance	6,487	2,094	0.3
	Option 4: Rock groynes	9,449	2,094	0.2
6.12 Ostend to Eccles	Option 2: Monitor and sweat the assets	4,830	0	0
	Option 3: Rock placement	3,271	0	0

Sensitivity testing was also undertaken to consider the business case put forward for all preferred options on the following aspects:

- Increased cost by 10%
- Reduce optimum bias to 30%
- Maximum erosion – taking the year at the beginning of each erosion period (e.g. Year 0 for all going within Years 0-20) (see section 3.1.1 of this Economic Assessment Report).
- Minimum erosion – taking the year at the end of each erosion period (e.g. Year 20 for all going within Years 0-20) (see section 3.1.1 of this Economic Assessment Report).

A summary of this sensitivity testing is presented in Table 8.4. Results show little significant changes in benefit cost ratios as result of sensitivity analysis. Those Policy Units with a benefit cost ratio above 1.0 generally stay above 1.0 during the sensitivity.

Table 8-4: Summary of benefit cost ratio sensitivity tests *relative to 60% optimum bias basecase (all calculations excluding tourism benefits). (NB those options highlighted in red are unlikely to achieve FDGiA funding as they have benefit cost ratios less than one)

Policy Unit	Preferred option	Basecase (60% optimum bias)	Reducing optimum bias to 30%	Option cost increased by 10%*	Maximum erosion	Minimum erosion
6.05 Cromer to Overstrand	Option 2: Monitor and make groynes safe	0.4	0.4	0.3	0.2	0.8
	Option 3: Rock placement	0.1	0.1	0.0	0.0	0.1
6.06: Overstrand	Option 2: Rock placement	2.8	3.5	2.6	1.9	4.4
	Option 3: Rock groynes	2.7	3.3	2.4	1.8	4.2
	Option 4: Timber groyne maintenance	6.3	7.7	5.7	4.2	9.8
	Option 5: New sheet piling	2.7	3.3	2.4	1.8	4.2
	Option 6: New sheet piling and rock placement	1.5	1.8	1.3	1.0	2.3
6.07 Overstrand to Mundesley	Option 2: Monitor, maintain and make safe	2.1	2.6	2.0	1.4	3.5
6.08 Mundesley	Option 2: Monitor and maintain	6.6	8.1	6.0	4.9	8.7
	Option 3: Monitor, maintain and rock placement	5.4	6.6	4.9	4.0	7.2
6.09 Mundesley to Bacton Gas Terminal	Option 2: Monitor, maintain and make safe	2.4	3.0	2.2	2.0	2.9
6.10 Bacton Gas Terminal	Option 2: maximise life defences then high level rock revetment.	28.9	35.5	26.3	20.5	40.0
	Option 3: maximise life defences then low level rock revetment.	33.9	41.7	30.8	24.0	46.9
6.11 Bacton Walcott and Ostend	Option 2: Rock Placement	0.2	0.2	0.2	0.2	0.0
	Option 3: Timber revetment and groyne and sea wall maintenance	0.3	0.4	0.3	0.4	0.0
	Option 4: Rock groynes	0.2	0.3	0.2	0.3	0.0
6.12 Ostend to Eccles	Option 2: Monitor and sweat the assets	0.0	0.0	0.0	0.0	0.0
	Option 3: Rock placement	0.0	0.0	0.0	0.0	0.0

8.4 Flood and Coastal Risk Partnership Funding

The Partnership Funding Scores were re-calculated for those schemes with a Hold the Line Policy and therefore are recommended for capital works. These are summarised in Table 8.5.

Table 8.5: FDGiA Calculator outputs excluding tourism (NB options with benefit cost ratios less than one are unlikely to achieve FDGiA funding and hence have been excluded)

Policy Units	Option	Benefit Cost Ratio	PV Total Costs without Optimism Bias (£k)	Raw Partnership Funding Score (PFS) (%)	Maximum Partnership Funding Allocation (£k)	External contributions required to achieve 100% PFS (£k)	External contributions required to achieve 150% PFS (£k)	External contributions required to achieve 200% PFS (£k)
6.06 Overstrand	Option 2: Rock placement	2.8	1,225	48	591	634	1,250	1,862
	Option 3: Rock groynes	2.7	1,292	46	591	701	1,344	1,990
	Option 4: Timber groyne maintenance	Maintenance project – not eligible for funding						
	Option 5: New sheet piling	2.7	1,293	46	591	702	1,345	1,991
	Option 6: New sheet piling and rock placement	1.5	2,355	25	591	1,764	2,944	4,121
6.08 Mundesley	Option 2: Monitor and maintain	Maintenance project – not eligible for funding						
	Option 3: Monitor, maintain and rock placement	5..4	1,851	198	1,851	0	0	37

9. Summary of all economic assessments

This section presents tables of results from the different scenarios. These results are discussed further alongside the technical feasibility of the different scenarios within the main Study Report. PV costs and benefit cost ratios are calculated with 60% Optimism Bias applied. Information on Partnership Funding (PF) scores have only been included in Policy Units with benefit cost ratios above 1.0. The 'properties better protected from erosion' are compared with the Do Nothing Baseline for all management scenarios. There is no difference in the PV costs between the SMP6 and SMP6 with Sediment Nourishment Scenario as the cost of implementing the sediment recharge has not been included (see 8.2.1). The highest benefit cost ratio and partnership funding scores between the different Scenarios in each Option has been highlighted red.

9.1 6.05 Cromer to Overstrand

		SMP6 Scenario	Modified SMP6 Scenario	SMP6 with Beach Nourishment Scenario
Properties better protected from erosion		**1**	**1**	**1**
Total benefits (£k)		**47**	**47**	**47**
Option 2: Monitor and make groynes safe	PV Cost (£k)	133	133	133
	Benefit cost ratio	0.4	0.4	0.4
Option 3: Rock placement	PV Cost (£k)	924	924	924
	Benefit cost ratio	0.1	0.1	0.1

9.2 6.06 Overstrand

		SMP6 Scenario	Modified SMP6 Scenario	SMP6 with Beach Nourishment Scenario
Properties better protected from erosion		**-46**	**196**	**57**
Total benefits (£k)		**3,472**	**7,192**	**5,532**
Option 2: Rock placement	PV Cost (£k)	1,959	2,199	1,959
	Benefit cost ratio	1.8	3.3	2.8
	Partnership Funding Score (%)	17	101	48
Option 3: Rock groynes	PV Cost (£k)	2,067	2,294	2,067
	Benefit cost ratio	1.7	3.1	2.7
	Partnership Funding Score (%)	16	97	46
Option 4: Timber groyne maintenance	PV Cost (£k)	882	2,894	882
	Benefit cost ratio	3.9	2.5	6.3
	Partnership Funding Score (%)	37	77	107
Option 5: New sheet piling	PV Cost (£k)	2,068	3,092	2,068
	Benefit cost ratio	1.7	2.3	2.7
	Partnership Funding Score (%)	16	72	46
Option 6: New sheet piling and rock placement	PV Cost (£k)	3,769	4,452	3,769
	Benefit cost ratio	0.9	1.6	1.5
	Partnership Funding Score (%)	8	50	25

9.3 6.07 Overstrand to Mundesley

		SMP6 Scenario	Modified SMP6 Scenario	SMP6 with Beach Nourishment Scenario
Properties better protected from erosion		**23**	**10**	**82**
Total benefits (£k)		**469**	**-723**	**3,685**
Option 2: Monitor, maintain and make safe	PV Cost (£k)	1,717	1,717	1,717
	Benefit cost ratio	0.3	-0.4	2.1

9.4 6.08 Mundesley

		SMP6 Scenario	Modified SMP6 Scenario	SMP6 with Beach Nourishment Scenario
Properties better protected from erosion		**56**	**455**	**96**
Total benefits (£k)		**15,345**	**19,919**	**15,938**
Option 2: Monitor and maintain	PV Cost (£k)	2,427	3,532	2,427
	Benefit cost ratio	6.3	5.6	6.6
	Partnership Funding Score (%)	239	301	241
Option 3: Monitor, maintain and rock placement	PV Cost (£k)	2,961	4,065	2,961
	Benefit cost ratio	5.2	4.9	5.4
	Partnership Funding Score (%)	196	261	198

9.5 6.09 Mundesley to Bacton Gas Terminal

		SMP6 Scenario	Modified SMP6 Scenario	SMP6 with Beach Nourishment Scenario
Properties better protected from erosion		**1**	**12**	**6**
Total benefits (£k)		**1,098**	**-247**	**1,359**
Option 2: Monitor, maintain and make safe	PV Cost (£k)	556	556	556
	Benefit cost ratio	2.0	-0.4	2.4

9.6 6.10 Bacton Gas Terminal

		SMP6 Scenario	Modified SMP6 Scenario	SMP6 with Beach Nourishment Scenario
Properties better protected from erosion		**0**	**0**	**0**
Total benefits (£k)		**201,219**	**201,219**	**201,219**
Option 2: maximise life defences then high level rock revetment.	PV Cost (£k)	6,967	6,967	6,967
	Benefit cost ratio	28.9	28.9	28.9
Option 3: maximise life defences then low level rock revetment.	PV Cost (£k)	5,936	5,936	5,936
	Benefit cost ratio	33.9	33.9	33.9

9.7 6.11 Bacton, Walcott and Ostend

		SMP6 Scenario	Modified SMP6 Scenario	SMP6 with Beach Nourishment Scenario
Properties better protected from erosion		**-168**	**105**	**-126**
Total benefits (£k)		**1,549**	**6,683**	**2,591**
Option 2: Rock Placement	PV Cost (£k)	12,509	12,573	12,509
	Benefit cost ratio	0.1	0.5	0.2
Option 3: Timber revetment and groynes and sea wall maintenance	PV Cost (£k)	6,487	7,987	6,487
	Benefit cost ratio	0.3	0.8	0.3
Option 4: Rock groynes	PV Cost (£k)	9,449	9,476	9,449
	Benefit cost ratio	0.2	0.7	0.2

9.8 6.12 Ostend to Eccles

		SMP6 Scenario	Modified SMP6 Scenario	SMP6 with Beach Nourishment Scenario
Properties better protected from erosion		**0**	**-2**	**0**
Total benefits (£k)		**0**	**-79**	**0**
Option 2: Monitor and sweat the assets	PV Cost (£k)	4,830	4,830	4,830
	Benefit cost ratio	0	0	0
Option 3: Rock placement	PV Cost (£k)	3,270	3,271	3,271
	Benefit cost ratio	0	0	0