Economics Report

Hayling Island FCERM Strategy

Havant Borough Council

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Quality information

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1. Introduction

1.1 Background

AECOM has been commissioned by Coastal Partners (CP) on behalf of Havant Borough Council (HBC) to develop a Flood and Coastal Erosion Risk Management Strategy for the coastal frontage of Hayling Island (herein referred to as 'the Strategy'). As part of the Strategy AECOM has undertaken an economic appraisal which will form a key part of determining the economic viability of implementing FCERM options within the Strategy.

Hayling Island is located off the south coast of England, within the jurisdiction of HBC, with Langstone Harbour to the west and Chichester Harbour to the east. The study area and spatial boundaries of the economic appraisal are shown in Figure 1-1.

Based on the latest modelling undertaken as part of this study, for the present day (with existing defences in place) there are 243 residential properties at risk from a 1 in 200 year (0.5% AEP) tidal flood event. There are also 92 non-residential properties at risk of flooding from the same return period event. Due to sea level rise, in 100 years' time, and with the failure of the existing defences, 2166 residential properties and 986 non-residential properties are expected to be at risk from a 1 in 200 year (0.5% AEP) event.

In addition to the FCERM context of Hayling Island, the A3023 represents a critical piece of transport infrastructure forming the link to the mainland via Langstone. There is a requirement to consider the need to protect access on to and off the island during extreme flood events, with particular reference to the requirement to maintain access for emergency services.

1.2 Economic appraisal

The economic appraisal undertaken supports the Strategy development and feeds into the wider option appraisal process in line with the HM Treasury Green Book (2020) and Environment Agency FCERM Appraisal Guidance (FCERM-AG, 2020). The appraisal is an integral part of building a robust flood and erosion risk management strategy for the island. It also provides evidence to facilitate discussions over potential contributions with major beneficiaries.

This report provides an update to the previous iteration of the economic appraisal, which established the baseline Do Nothing economic damages. Following confirmation of the short list options, the economic benefits of the options have been determined as well as the whole life costs. The benefits have then been compared to the costs to determine the benefit cost ratios (BCRs) and the economic case for the options.

Costs associated with the options include design, construction, and maintenance of the option over its design life. Benefits are based on the direct damages avoided (reduced flooding to property, people, assets and infrastructure) and a number of indirect damages avoided (e.g. health and wellbeing impacts of flooding). This economic comparison is known as cost benefit analysis (CBA) and provides a rational and systematic framework for assessing the advantages and disadvantages of the leading options.

The CBA has been undertaken using the framework of the FCERM-AG (2020). FCERM-AG represents the latest standard of cost-benefit analysis for all flood and coastal erosion risk projects in England. In this part of the assessment only FCERM eligible damages (and potential benefits) have been considered, although a separate Gross Value Added assessment and Economic footprint study has been undertaken alongside this appraisal and is presented in the GVA Assessment and Economic Footprint Study Report (AECOM, 2019).

Figure 1-1: Study site

1.3 Do Nothing (baseline) scenario

The Do Nothing scenario represents a hypothetical 'walk away' situation where no action is taken to manage the flood risk or maintain the existing structures in the study area. This scenario is an essential part of an appraisal because it provides the baseline from which the 'Do Something' options can be compared against to demonstrate the economic benefits.

With this approach the existing defences would be abandoned in terms of maintenance and repair, and no remedial or additional works would be carried out. In addition, adaptation to sea level rise or other climate change responses would not be addressed. Under this scenario, the existing defences along the frontage would fail at the end of their residual life and the properties in the erosion zones behind the defences would be at increased risk of erosion. Flood risk would be unmanaged and would increase significantly over time, resulting in significant parts of the study area becoming uninhabitable in the future. Stopping the existing beach management activities at Eastoke (south east corner of the island) would lead to a risk of breaching of the defences in this location and a greater flood risk in the future (see section 2.4 for more details).

The flood and erosion risk mapping for the Do Nothing scenario is shown in Figure 1-1. The erosion zones were developed by Coastal Partners (see Coastal Processes Report, 2021) and are based on a No Active Intervention scenario. The flood mapping shown on the figure is for a 1:200 year event in present day with the existing defences, and in 2121 when the existing defences will have failed. For the erosion zones, it is noticeable that on the south west corner of the island the erosion zones are moving seaward. This is in fact the opposite of erosion and is caused by sediment accretion in this area. For the remainder of the island's shoreline, the dominant process is erosion and land is expected to be lost to the sea over time (most noticeably in the south east corner of the island).

The Do Nothing damages are presented in Section 3 island-wide and for each of the Option Development Units (ODU). The coastline has been divided into ODUs to provide the flexibility to develop coastal management options on an area by area basis, ensuring the options are appropriate at a local scale. Understanding the damages for each ODU has supported the option appraisal process. Figures 1-2 and 1-3 present the locations of each ODU.

Figure 1-2: Locations of ODUs (North Hayling Island)

Figure 1-3: Locations of ODUs (South Hayling Island)

2. Methodology

2.1 Time epochs

To facilitate the economic appraisal, three time periods, known as epochs, have been developed for the study. These time epochs span the next 100 years and are as follows:

- Epoch 1: 2021 to 2041
- Epoch 2: 2041 to 2071
- Epoch 3: 2071 to 2121

2.2 Supporting hydraulic modelling

To determine the required flood depths, a range of return periods for various extreme events were simulated using the East Solent Hayling Island model. Refer to the Hayling Island Model Review (AECOM, 2019) for more details of this model. For more information on the return periods and modelling approach, refer to Appendix A of this report.

Flood mapping results (depth and extent) for the following return periods were included in the economic appraisal calculations: 50% AEP (1:2yr), 20% AEP (1:5yr), 5% AEP (1:20yr), 3.33% AEP (1:30yr), 1.33% AEP (1:75yr), 0.67% AEP (1:150yr), 0.5% AEP (1:200yr) and 0.2% AEP (1:500yr). With minor exceptions, flood mapping for each return period was used for the following years; 2021, 2041, 2071 and 2121. To determine the extreme water levels for each event, the latest Coastal Flood Boundary dataset (Environment Agency Coastal Design Sea Levels, 2018) and climate change projections (UKCP18) were used. The sea level rise projections for the UKCP18 Representative Concentration Pathway (RCP) 8.5 70th percentile was used as per the latest Environment Agency guidance for flood and coastal risk projects.

The maximum depth grids (5x5m resolution) from the flood model results were output into GIS to facilitate the inspection and attribution of flood depths for assets within the study area.

2.3 Identifying flood depths and properties at risk from erosion

To identify individual properties at risk an address point dataset (National Receptor Database, 2014) was used. The National Receptor Database (NRD) includes the property address, post code, property type (e.g. detached residential, semi-detached residential, factory, office, shop etc.) and property coordinates for all assets within the study area. The NRD data points were matched with the relevant building outlines from the OS Mastermap dataset.

Flood depths for each individual property were obtained in GIS by determining the flood depth for each return period that intercepts the Mastermap building outline.

The risk of erosion for each property was determined in GIS by spatially comparing the erosion zones with the Mastermap building outlines. The erosion zones were developed by Coastal Partners, using the SMP erosion zones and updating them with the latest information on sea level rise, residual life, average annual erosion, rebound from removal of defences and the latest baseline of the coast. The erosion zones are available for three time periods; year 0-20, year 20-50, and year 50-100 and assume a No Active Intervention policy. Where the Mastermap building outline intercepts or is contained within an erosion zone, the epoch of the erosion was designated to that property. Properties outside of the erosion zones are not considered to be at direct risk from erosion, although may be impacted indirectly (see section 2.7.1).

2.3.1 Data filtering

The NRD database contains a number of properties and assets which cannot be included in the valuation of Do Nothing damages. Once the flood depths for each property had been assigned, the database was checked to remove duplicate address points. Upper floor properties were removed from the dataset where there was not a risk of erosion and were not counted in flooding damages.

Assets with no NRD classification description ('Awaiting classification' and 'Blank') were excluded from the analysis as were the following classifications with negligible susceptibility to flooding as per the guidance in the MCM Technical Note (2016)[1]:

- Advertising Hoarding
- Bus Shelter
- Caravan
- CCTV
- Development
- Development Site
- Hopper / Silo / Cistern / Tank
- Mausoleum / Tomb / Grave
- Postal Box
- Property Shell
- Street Record
- Static Water
- Unused Land
- Utility

In the NRD dataset for Hayling Island there were over 1050 NRD 999 classified properties. The 999 classification represents properties where the land use is unknown. A similar approach to that recommended in MCM Technical Note (2016)[2] for reclassifying a large number of MCM 999 properties was adopted. For the MCM 999 properties with a floor area greater than 150m^2 (approximately 100 properties), a manual inspection on google street view was carried out to reclassify the properties into the appropriate MCM code. For the remaining MCM 999 properties (i.e. < 150m2 floor area), 90% of the non-residential sector average damages were applied.

No basement areas have been allowed for in the economic analysis. This was informed by a high level inspection of the area in Google Street View which suggested that the majority of properties do not have basements.

2.3.2 Property thresholds

For both residential and non-residential properties, a threshold value of 0.05m was applied. This is considered appropriate for a strategic level economic assessment, and given modelling and climate change uncertainties, however, if schemes are pursued following the Strategy it is recommended that threshold surveys are undertaken in the scheme areas to refine the threshold value on a property by property basis.

2.4 Breach of defences at Eastoke

The Eastoke Peninsula in the Southeast corner of the island has a history of flooding and beach erosion events, particularly bi-modal storm events. It is also exposed to extreme long period swell events, with two events occurring in early 2021. Historic evidence from this area suggests that if the ongoing beach management activities in this location were to stop, it is likely that the majority of the beach could be lost, which would lead to the hard defences at the back of the beach becoming exposed and would fail over time. The hard defences at the back of the beach were constructed in the 1950s and some have an estimated residual life of less than 10 years. The Eastoke Peninsula is also an area where there is a high concentration of properties, both residential and non-residential and therefore should the beach be lost during a storm event, and the hard defences at the back of the beaches fail, there is a risk that a breach could lead to significant economic damages on the island.

This risk has been incorporated into the economic assessment by including a breach of the defences at Eastoke into the economic calculations. To identify properties at risk from a breach at Eastoke, a GIS analysis was used to determine the NRD properties below the extreme water level for each return period event included in the economics. The Digital Terrain Model (DTM) for Hayling Island was then used to calculate the flood depth from the breach for each return period at each individual property. This GIS based approach is considered acceptable for a Strategic level project such as this, but for an economic assessment and design at the scheme level it is recommended that more detailed and specific breach modelling using the hydraulic model is undertaken.

In the economic calculations, there was assumed to be no risk of a breach in the Present Day, increasing to a 100% risk in Year 20. For Years 20, 50 and 99, for properties where the flood depths were greater from the breach assessment than from the hydraulic modelling (hydraulic modelling with no breach), the breach flood depths have been used to calculate damages.

[1] Chatterton, J.B. (2016) National Receptor Dataset: Property codes with prefix "9". Version 1, May 2016 © Flood Hazard Research Centre, Middlesex University
[2] Chatterton, J.B. (2016) National Receptor Dataset: Property codes with prefix "9". Version 1, May 2016 © Flood Hazard Research Centre, Middlesex University

2.5 Residential flood damages

Flood damages were obtained from the latest version of the Multi-Coloured Manual (MCM, 2021). The value of flood damage was based on the residential property type (detached, semi-detached, terrace, flat) and the depth of flooding for each flood scenario.

Damage values for 'Short duration, salt water, major flooding' were adopted and were then adjusted by a factor of 1.056 to allow for emergency costs (as recommended in the MCM, 2021). The direct flood damages values for different depths are summarised in Table 2-1.

2.6 Non-residential flood damages

Non-residential flood damages were also obtained from the MCM (2021). The property damages are based on the non-residential property type, the footprint area (m^2) and the depth of flooding for each of the modelled return periods. For NRD 999 properties which were not reclassified, the property damages are based on the 'Non-Residential Property Sector Average' with a 10% reduction.

Damage values for 'salt water, short duration major flood' were used. The direct flood damages values for different depths are summarised in Table 2-2.

Table 2-1: Flood damages for residential properties adopted from the MCM (2021). Values adjusted to account for emergency uplift and latest available CPI (June 2021)

Short Duration, salt water, major flood. Adopted from MCM (2021) (£)																	
MCM Code	Property Type / Age / Social Grade	Component	Depth (m)														
			-0.3	0	0.05	0.1	0.2	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3
11	Detached	Total Damage	2417	2417	9938	16129	27421	34548	40976	45147	49807	55495	61994	67612	72651	82586	87071
12	Semi-detached	Total Damage	3210	3210	8114	11658	17957	21589	24916	27014	29878	33611	37755	41637	46027	53893	57014
13	Terrace	Total Damage	2921	2921	7354	10644	16270	19717	23182	25148	27615	30624	33987	37178	40662	48148	50709
14	Bungalow	Total Damage	2332	2332	10230	15862	24077	29576	35052	39415	44351	50471	57512	63380	69205	80124	84376
15	Flat	Total Damage	2247	2247	7073	10799	16777	20385	24184	26596	28816	31448	34453	36880	38973	45430	47347

Table 2-2: Flood damages for non-residential properties from the MCM (2021). Values adjusted to account for latest available CPI (June 2021)

Short Duration, warning, salt water, no cellar. MCM (2021) (£)														
MCM Code	Property Type	Depth (m)												
		0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3
2	Retail	72	336	506	675	846	966	1091	1218	1397	1516	1608	1651	1711
3	Offices	78	360	524	652	783	876	984	1114	1278	1402	1504	1555	1619
4	Warehouses	23	323	557	726	881	1000	1092	1191	1242	1266	1303	1317	1352
6	Public buildings	50	236	323	394	475	532	606	689	792	879	929	951	978
8	Industry	14	79	119	154	195	226	257	294	344	377	414	439	470
51	Leisure	345	825	965	1074	1200	1292	1413	1537	1693	1820	1918	1965	2021
521	Playing Field	5	11	23	24	25	26	27	29	30	31	32	33	34
523	Sports Centre	45	199	278	331	386	421	490	569	656	733	765	778	792
525	Sports Stadium	10	47	71	88	110	122	142	157	185	199	209	214	220
526	Marina	21	58	75	103	125	142	158	176	208	237	264	282	306
960	Substation	39	1337	1779	2213	3440	4263	5485	5921	7611	7640	7661	7680	7685
	NRP Sector Average (-10%)	56	394	553	701	952	1125	1354	1490	1812	1893	1955	1987	2028

2.7 Write off and capping damages

2.7.1 Property write-off

Flooding write-off

It is stated in FCERM-AG, that for the purposes of the economic appraisal, properties should be assumed from an accounting perspective to be written-off once flooded by an event of 1 in 3 year return period (33% AEP) or less, as the property would no longer be habitable or functional. Once written off the present day value of the property is taken as an economic damage, but it can no longer accrue flood damages after that point.

The numerical model simulations undertaken for the study included a 1:2 year event (50% AEP). This event is a lower return period that the 1:3 year event and was used in the assessment to determine property write-off. The total number of properties written off due to flood risk by 2121 is 1446.

Direct erosion write-off

In addition to write-off from flooding, in the coastal environment property write off can also occur as a result of erosion or property loss due to collapse of supporting land, access or defences in front of a structure. On Hayling Island there are many properties located within the erosion zones. To provide an estimate of the damages, it has been assumed that the properties at risk from erosion in a particular epoch, were written off at the mid-point of that time epoch. For example, if a property was located in the epoch 3 erosion zone, it has been written off at the middle of this epoch in year 75 (2095). The middle of the epoch has been used because in reality some properties would erode towards the start of the epoch, whilst others would erode towards the end. For discounting purposes, it was therefore considered most reasonable to assume the mid-point of each epoch to provide an average discounting value and reduce the risk of under or overestimating the overall erosion present value PV damages.

Indirect erosion write-off

In the southeast of the Island, Southwood Road is predicted to erode by year 35 (see Figure 2-1). The road currently acts as the only travel route to approximately 1755 properties to the east. Should this road be lost then safe access and egress to the properties will not be possible and they will be uninhabitable. Due to the layout of the streets and shoreline, there is a lack of space in this area to construct an alternative roadway. Therefore, when Southwood Road erodes these properties would essentially be ‘cut-off’ from the rest of Hayling Island, would be uninhabitable and it is therefore appropriate to write-off the properties in the economics to reflect this.

A proportion (567 properties) of the properties in the south east corner of the island affected by the loss of access are at risk from frequent flooding and direct erosion to the buildings before Southwood Road erodes. These properties have been written-off as usual as a result of the direct erosion and flood risk. For the remainder of the properties in the area affected by erosion of Southwood Road (811 properties), these properties have been written-off in year 35, when the road is expected to erode.

Figure 2-1: Southwood Road erosion

2.7.2 Property capping

FCERM-AG also states that the total PV flood damages for a property over the duration of the appraisal period must not exceed the property market value. The cumulative damages were monitored for each property and once they exceeded the property value, further flood damages were capped and the property did not accrue any more damages.

2.7.3 Property values

The value of each property was required to incorporate write off and capping within the economic assessment. For residential properties, average house sale prices for the Hampshire region were obtained from The HM Land Registry Price Paid Dataset. The values were averaged for residential property type (detached, semi, terraced, flat) and were used in the assessment. This dataset was last updated in January 2021.

The commercial property values were valued on the rateable value for their business type (provided by the valuation office). Average values for retail, workshops, industry, warehouses and offices between £35/m^2 and £164/m^2 were estimated and then multiplied by the building floor space to estimate the rateable value of the business. In accordance with FCERM-AG, the rateable values were then divided by the business yield (6%) to provide an estimate of the market value for flood damage and capping purposes.

2.8 Discount rate

Discounting is a technique used to compare benefits (and costs) that occur at different points in time over the appraisal period (i.e. the next 100 years). Standard discount rates have been used to convert all cash damages to PV. This enables the whole life damages, benefits and costs of the options to be compared and also leads to a realistic assessment of the cost implications in today's terms. According to FCERM-AG, the following variable discount rates have been used within the economic appraisal; 3.5% for the years 0 to 30,3% for the years 31 to 75, and 2.5% for the years 76 to 99 resulting in a PV factor over 100 years at 29.9 (HM Treasury Green Book, 2003).

The annual average (non-discounted, cash) damages were discounted over the appraisal period to calculate the discounted whole life Do Nothing PV damages.

As an example of discounting applied to the economics assessment, if a property values at £100k (in cash terms) was to be written off in year 10 (i.e. towards the start of the appraisal period) the discount factor applied in year 10

is 0.71 so therefore the economic damage associated with loss of the property (in PV terms) would be £71k. If the property was instead written off in year 80 (towards the end of the appraisal period), the discount applied in year 80 is 0.08 so therefore the economic damage would be £8k (in PV terms).

For Loss of Life and Mental Health damages, a different discount rate has been applied using recent EA guidance[3] based on the revised Green Book (published in 2018). The following discount rates have been used: 1.5% for the years 0 to 30, 1.286% for the years 31 to 75 and 1.071% for the years 76 to 99 resulting in a PV factor over 100 years at 54.4%.

The annual average (non-discounted, cash) damages for Loss of Life and Mental Health were discounted over the appraisal period to calculate the discounted whole life Do Nothing PV damages.

2.9 Indirect flood damages

In addition to the direct flood damages to residential and non-residential properties, indirect flood losses have been considered. Indirect flood losses reflect deviations from the economic theory that suggests in a perfectly competitive world, all sales or production would simply transfer to a competitor with no financial loss to the nation as a whole. In reality, deviations from the competitive model exist and trade cannot simply be transferred, leading to indirect flood damages. Indirect flood damages are included within the Present Value (PV) Total Damages and equate to approximately 9% of the total damages for Hayling Island (for a breakdown of the indirect damages refer to Table 3-10). The areas of indirect flood damages that have been included in the assessment are discussed further below.

2.9.1 Intangible damages / benefits

Intangible damages associated with flooding to social health impacts, loss of personal items, disruption to the community etc. were included in the assessment at a rate of £250 per residential property (MCM, 2021). Intangible health damages / benefits are not applicable to non-residential properties.

2.9.2 Mental Health damages

The costs of flooding associated with mental health have been assessed according to recent the EA guidance[4]. These damages are calculated per adult per flood event, dependent on the depth of flooding. The average depth of flooding for each return period varies between 0.25 and 0.4 metres, therefore a conservative depth of 0.3 metres has been assumed giving damages of £1,878 per adult per flood event. The average number of adults per property is 1.85, therefore the total damage per residential property per flood event is £3,475.

2.9.3 Damages to vehicles

Flood damage to vehicles was considered at a rate of £6,776 per vehicle (MCM, 2021). For the Do Nothing scenario this damage was applied to 100% of residential properties at risk of flooding because it represents a theoretical walk away scenario where it was assumed people would not move their vehicles. It was assumed that each property at risk of flooding owned one vehicle. Vehicle damages are not applicable to non-residential properties.

2.9.4 Evacuation / temporary accommodation

Damages associated with the costs of evacuation / temporary accommodation after flood events have been included. These are based on evacuation costs provided in the MCM (2021) which estimate temporary accommodation and alternative accommodation costs for each residential property at £1,304 and £3,731 respectively. At the strategic scale the distribution of properties requiring temporary or longer term accommodation is unknown there it has assumed that 50% of the residential properties affected by flooding will require temporary accommodation, and 50% will require alternative accommodation. Evacuation damages are not applicable to non-residential properties.

2.9.5 Traffic disruption

Flooding can affect roads by leading to traffic disruption and increased journey durations. Traffic disruption depends on the duration of a road closure, length of diversion and volume of traffic. Under the Do Nothing scenario, flooding

[3] Environment Agency (2020) Advice for flood and coastal erosion risk management authorities: Discount rates, price indices and capping.
[4] Environment Agency (2020) Mental health costs of flooding and erosion. Available from: https://www.gov.uk/government/publications/partnership-funding-supporting-documents/mental-health-costs-of-flooding-and-erosion [Accessed 25 August 2021]

of the following major roads is expected; the A3023, Havant Road, Northney Road and West Lane. Furthermore, Southwood Road (at the southern frontage of the Island) is expected to experience flooding. Traffic disruption damages have been included for each of these roads except for the A3023. The damages for the A3023 have been counted by the Langstone FCERM scheme economic assessment because this road floods on the mainland from similar return period events, and therefore cannot be included in the appraisal for this Strategy.

To estimate the damages generated through traffic disruption to these roads, The Delayed-Hour Method (Method 1) of the MCM (2021) was adopted. Traffic disruption damages were considered at a rate of £13.20 per vehicle per hour, where the indicative delay durations were determined according to each return period. A traffic count study undertaken by Hampshire County Council over a two-week period in June 2017 was used to determine the average number of vehicles passing through the roads in any given hour.

2.9.6 Road damages

Flooding can damage the integrity of a road surface which will need to be repaired to ensure the safety of vehicle users. Road reconstruction costs following flooding have been obtained from the MCM (2021); £15/m^2 for a quiet road and £50/m^2 for a busier road (busier roads typically require a thicker surface layer and road works may need to occur at night or off-peak and thus incurring overtime costs).

The areas of flooding on the major roads on the Island were obtained from a GIS inspection for the range of return period events and time epochs. The major roads inspected included the A3023 (on Hayling Island itself), the Sea Front, Northney Road, West Lane and Southwood Road.

2.9.7 Education Service Closure

Direct damages from flooding occur due to the flooding of school buildings, the cost of temporary classroom accommodation and additional costs such as student counselling. Indirect damages may arise from a school closure leading to the loss of parents earning (or number of staff days lost to look after their children), the loss of a pupil's education or additional travel costs to alternative schools or locations. The MCM (2021) provides a number of methodologies for estimating the indirect damages to schools.

The grounds and buildings of Mill Rythe Infant School and Junior School are expected to flood from the Do Nothing Scenario from year 50 for events of 1 in 2 year return period (50% AEP) and 1 in 20 year (5% AEP) respectively. For the purpose of this assessment, indirect flood damages to the school have been estimated based on the loss of education days for students. The loss of parent earnings has also been calculated as both schools are primary schools therefore it is expected that the majority of the students would not be suitable to be left at home without supervision.

For the valuation of lost education days the number of full time students at both Mill Rythe Infant School and Junior School (194 and 294 respectively)[5] has been multiplied by the cost of a lost education day, based on values of pupil expenditure for each school (£26.49 and £25.41)[2], and then by the number of days the school is expected to be closed following a flood event. It is stated in the MCM (2021) that the disruption time for a school to be closed should be assessed as a maximum of five days.

For the valuation of loss of parent earnings, it is recommended that the number of full time students losing education days is divided by three to account for the following conditions: siblings within a school population, one parent may already be at home looking after younger siblings, one parent may be unemployed, some parents may choose to take annual leave and some may have alternative childcare arrangements. This is then multiplied by the national average daily wage (£90.49) provided in Table 6.20 of the MCM (2021) and then by the number of days the school is expected to be closed for a flood event.

Together, these assessments produce a damage of approximately £55,000 for Mill Rythe Infant School and £81,700 for Mill Rythe Junior School per daily closure.

2.9.8 Agricultural Land

The impacts of flooding on agricultural productivity have been assessed using guidance from the MCM, providing an estimate of the economic loss of the market value of agricultural land.

Table 9.7 of the MCM (2021) provides average annual costs of flooding per hectare, dependent on the drainage condition of the land and the type of agricultural land. Due to the lack of data available to determine the type of agricultural land on the island, an average cost per hectare based on all of the types of agricultural land and

[5] https://www.compare-school-performance.service.gov.uk/

drainage conditions has been estimated at £300.60.The areas of flooding of agricultural land were obtained from a GIS inspection for the range of return period events and time epochs.

2.9.9 Loss of life

The indirect damages associated with potential loss of life from a flood event have been estimated by following the Defra Flood and Coastal Defence appraisal guidance; Social Appraisal, Supplementary Notice to Operating Authorities – Assessing and Valuing the Risk to Life from Flooding for the Use in Appraisal of Risk Management Measures (2008).

By utilising this guidance and following the 'Risks to people' method, the loss of life (£) per magnitude of flood event was estimated. This calculation was based upon a number of variables for the appraisal area that included the flood hazard rating (variables include the depth and flow of water, and the debris factor), the area vulnerability rating (variables include a flood warning system, speed of flood onset and the nature of the area), and the people vulnerability rating (age of population, health of population). The loss of life (£) for each magnitude of flood event was then factored by the probability of the flood event occurring to determine an annual damage per year associated with loss of life.

2.9.10 Other infrastructure damages

Other infrastructure damages relating to outage to electricity, gas and water supply have been assumed to be minimal at the site and therefore these potential damages have not been quantified.

2.9.11 Recreation

The Land, Environment, Economics and Policy institute (LEEP) at the University of Exeter have developed the Outdoor Recreation Valuation Tool (ORVal). The tool is used to measure the value of currently available greenspace to the economy at various locations across the whole of the UK, including Hayling Island.

The value of outdoor recreation is provided as a welfare value per year, with other information including the number of visitors per year, and transport modes of visitors to the site. The welfare value is defined as the monetary equivalent of the welfare enjoyed by individuals as a result of having access to the green space, which can also correspond to a willingness to pay value for the site.

The ORVal tool has been interrogated to determine the key green space and recreation locations on the island and their annual value to the local economy. There are a number of outdoor spaces which are used for recreation on Hayling Island. These include the Billy Trail footpath, a number of nature reserves and environmentally designated areas, and the large beach along the south waterfront. The ORVal tool estimates that there are approximately 1,885,000 recreation visitors to these sites per annum, generating a total Welfare value of £9.5 million per year.

In GIS the flood and erosion risk to the ORVal sites under a Do Nothing scenario has been established by comparing the site areas to the flood mapping and erosion zones. Given that the majority of the sites are located on the coast, a significant proportion of the sites are at risk from either flooding or erosion (or both). Based on the onset and severity of risk, a PV damage for the Do Nothing scenario (2021-2121) has been estimated for these sites.

The PV damage was estimated by determining the return period flood events from which each site floods. A flood event is likely to cause damage to the recreation sites and is likely to lead to temporary disruption or closure due to H&S concerns. It was necessary to assume the duration of disruption; it was assumed that flooding from a 1:2 year event would lead to 1 week of disruption/closure, for a 20yr flood event a 2 week period, for a 75yr flood event a 3 week period and for a 200yr event or greater a 4 week period.

During each disruption / closure period it has been assumed that no visitors will access the site. However, it would be likely that a proportion of these visitors would visit another site (thus transferring the economic benefits). As a proxy for how many visitors are likely to visit another site, the total number of sites on Hayling Island that are likely to be disrupted has been considered. Using this information and the data from the ORVal tool the loss of recreation visitors has been quantified and an Annual Average Damage has been estimated.

Annual Average Damages (AAD) from flooding for each site were taken up until the point in time at which the recreation site is expected to be substantially lost to erosion. No erosion damages were considered for the sites because it was considered that in the event of a permanent loss of a site due to erosion, all the recreational visitors to the site would find an alternative site in the long term.

2.9.12 Contaminated Land

There are a number of potentially contaminated land areas adjacent to the shoreline around Hayling Island, including the area adjacent to the Oyster Beds, at Northney, Copse Lane, Mill Rythe Lane, Mengham Lane, Lakeside and at Selsmore and Mengham. The majority of these sites are currently undefended, or have defences in a poor condition and are therefore at risk of erosion in the Do Nothing scenario. Should these sites erode there is potential for environmental damage and therefore it would be expected that ongoing clean-up / remediation would be required to prevent or reduce the environmental damage.

Remediation costs were estimated using information from both the UK Government Homes and Communities Agency's (HCA) guidance on Dereliction, demolition and remediation costs (March, 2015) and project example waste removal and remediation costs provided by Coastal Partners

The project example costs indicate that the cost for waste extraction and removal is likely to be an order of magnitude greater than remediation, however, the costs are likely to be sensitive to a range of factors, such as type of material, burial depth and distance to be moved offsite. For the sites on Hayling Island there is significant uncertainty for each of these factors and without further information it was considered conservative / prudent to apply the generic remediation costs available from the UK Government Homes and Communities Agency's guidance. However, as part of future scheme development it is recommended that further investigations are carried out on the potentially contaminated sites to better understand the potential costs of remediation / waste removal and to incorporate this into the economic case of the management options. At scheme development level a more detailed assessment of the environmental damages associated with the erosion or leaching of coastal landfill into European designations is likely to be needed, including investigation into the costs of infraction.

Using the updated erosion zones,, the area of potentially contaminated land at risk at each site over the next 100 years was estimated using GIS. An average remediation cost per hectare of £90k / Ha was multiplied by the area of potentially contaminated land at risk and discounted at the appropriate rate to provide the economic damage associated with the erosion of the sites.

2.9.13 Loss of employment days

Coastal Partners undertook a public survey to determine the number of Hayling Island residents who work off of the island. Should a flood event occur and the access route off the island be blocked, this would prevent these residents from going to work, which can be counted as a national loss to the economy. The national loss to the economy has been estimated but has instead been included in the Langstone economic appraisal given that the main road off the island floods at Langstone from a lower / similar return period event.

3. Do Nothing Damages

The Do Nothing damages were established for the appraisal period between years 0-99.

3.1 Properties at risk

The number of properties expected to be at risk from flooding for a range of return period events under the Do Nothing scenario is presented in Table 3-1 below. These property counts are based on the hydraulic modelling and do not include those properties which are likely to flood from a breach event at Eastoke in 2041. The number of properties which may be at risk from the breach event are presented in brackets in the table, and these have been considered in the damages assessment probabilistically.

Table 3-1: Total number of properties at risk under the Do Nothing scenario, assuming a property threshold of 0.05m and 0.05m for residential and non-residential properties.

Year	Return period event	Residential properties at risk (in a breach event)	Non-Residential properties at risk (in a breach event)	Total properties at risk of flooding (in a breach event)
2021	1:2	61	8	69
	1:5	69	17	86
	1:20	83	27	110
	1:30	106	35	141
	1:75	148	56	204
	1:150	187	75	262
	1:200	243	92	335
	1:500	336	128	464
2041	1:2	480 (264)	146 (60)	626 (324)
	1:5	486 (323)	146 (70)	632 (393)
	1:20	486 (381)	146 (108)	632 (489)
	1:30	502 (392)	153 (112)	655 (504)
	1:75	645 (412)	200 (121)	845 (533)
	1:150	754 (430)	237 (126)	991 (556)
	1:500	873 (473)	297 (141)	1170 (614)
2071	1:2	649 (393)	349 (116)	998 (509)
	1:5	714 (414)	379 (121)	1093 (535)
	1:20	823 (455)	470 (134)	1293 (589)
	1:30	876 (467)	476 (137)	1352 (604)
	1:75	975 (529)	507 (153)	1482 (682)
	1:150	1067 (600)	533 (164)	1600 (764)
	1:200	1143 (635)	559 (170)	1702 (805)
	1:500	1283 (730)	601 (205)	1884 (935)
2121	1:2	1474 (800)	782 (221)	2256 (1021)
	1:5	1571 (860)	819 (242)	2390 (1102)
	1:20	1778 (957)	893 (257)	2671 (1214)
	1:30	1864 (974)	913 (261)	2777 (1235)
	1:75	1991 (1016)	953 (269)	2944 (1285)
	1:150	2115 (1063)	986 (273)	3101 (1336)
	1:200	2166 (1088)	992 (276)	3158 (1364)

Table 3-2 below shows the distribution of properties at risk of flooding across the Option Development Units (ODUs) from the 1:20, 1:75 and 1:200 year events, in 2021 and in 2121.

Table 3-2: Number of properties at risk of flooding by ODU (2021 and 2121)

ODU	1:20 year: Residential	1:20 year: Non-Residential	1:75 year: Residential	1:75 year: Non-Residential	1:200 year: Residential	1:200 year: Non-Residential
Present Day (2021)						
1: Hayling Bridge to Northney Farm	3	1	4	1	14	2
2: Northney Marina	0	1	0	1	0	2
3: Northney Farm to Chichester Road	5	1	7	2	7	4
4: Chichester Road to Mill Rythe Junior School	3	4	5	7	5	14
5: Mill Rythe Junior School to Salterns Lane	2	2	2	7	3	14
6: Salterns Lane to Wilsons Boat Yard	0	2	6	2	9	4
7: Wilsons Boat Yard to Fishery Creek	1	3	1	7	2	26
8: Eastoke	59	10	60	18	76	35
9: Eastoke Corner to Inn on the Beach	1	1	7	4	60	9
10: Inn on the Beach to North Shore Road	9	0	13	3	20	4
11: North Shore Road	0	0	1	1	1	2
12: North Shore Road to Newtown	0	0	0	0	0	0
13: Newtown	0	0	0	0	0	1
14: Newtown to Stoke	0	0	0	0	0	0
15: Stoke to Langstone Bridge Carpark	0	2	1	3	21	9
16: Langstone Bridge Carpark to Langstone Bridge	0	0	0	0	0	0
Total	**83**	**27**	**148**	**56**	**243**	**92**

ODU	1:20 year: Residential	1:20 year: Non-Residential	1:75 year: Residential	1:75 year: Non-Residential	1:200 year: Residential	1:200 year: Non-Residential
2121						
1: Hayling Bridge to Northney Farm	49	28	58	29	62	31
2: Northney Marina	0	5	0	13	0	13
3: Northney Farm to Chichester Road	23	35	37	42	45	45
4: Chichester Road to Mill Rythe Junior School	24	79	30	88	31	97
5: Mill Rythe Junior School to Salterns Lane	72	124	90	125	106	126
6: Salterns Lane to Wilsons Boat Yard	34	34	52	37	69	38
7: Wilsons Boat Yard to Fishery Creek	137	117	167	132	189	137
8: Eastoke	1062	285	1115	289	1176	296
9: Eastoke Corner to Inn on the Beach	38	38	58	43	76	47
10: Inn on the Beach to North Shore Road	63	43	65	45	65	46
11: North Shore Road	53	24	57	23	62	25
12: North Shore Road to Newtown	0	0	0	0	0	0
13: Newtown	59	7	65	9	72	9
14: Newtown to Stoke	3	1	3	1	3	1
15: Stoke to Langstone Bridge Carpark	161	74	194	75	210	78
16: Langstone Bridge Carpark to Langstone Bridge	0	2	0	2	0	3
Total	**1778**	**893**	**1991**	**953**	**2166**	**992**

The total number of properties at risk from erosion (non-cumulative) are presented in Table 3-3. Note that this excludes the additional 811 properties that would be written off from the loss of Southwood Road in the south east corner of the Island.

Table 3-3: Number of properties at risk from erosion under the Do Nothing scenario

Epoch	Properties at risk; residential	Properties at risk; non-residential	Properties at risk; total
Epoch 1; 2021 - 2041	34	3	37
Epoch 2; 2041- 2071	494	77	571
Epoch 3; 2071- 2121	690	105	795

Table 3-4 shows the distribution of properties at risk from erosion in each epoch across the ODUs. Similarly, the numbers of properties presented excludes the additional properties that would be written off from the loss of Southwood Road in the south east corner of the Island.

Table 3-4: Number of properties at risk of erosion by ODU

ODU	Epoch 1 Total number of properties at risk	Epoch 2 Total number of properties at risk	Epoch 3 Total number of properties at risk
1: Hayling Bridge to Northney Farm	0	0	1
2: Northney Marina	0	2	3
3: Northney Farm to Chichester Road	0	1	10
4: Chichester Road to Mill Rythe Junior School	1	5	9
5: Mill Rythe Junior School to Salterns Lane	0	2	15
6: Salterns Lane to Wilsons Boat Yard	0	0	12
7: Wilsons Boat Yard to Fishery Creek	0	6	11
8: Eastoke	34	513	562
9: Eastoke Corner to Inn on the Beach	0	10	137
10: Inn on the Beach to North Shore Road	2	30	11
11: North Shore Road	0	1	10
12: North Shore Road to Newtown	0	0	0
13: Newtown	0	0	4
14: Newtown to Stoke	0	0	0
15: Stoke to Langstone Bridge Carpark	0	1	10
16: Langstone Bridge Carpark to Langstone Bridge	0	0	0

Total	**37**	**571**	**795**

3.2 Damages

The Do Nothing damages for the appraisal period are presented below in Table 3-5 and Table 3-6 below. In the tables 'Cash' damages refer to the undiscounted damages (presented in today's cash terms) whereas the 'PV' damages are those which include discounting through time. The PV damages are those which are adopted in the benefit cost ratio and funding assessment. As in Table 3-1, the Do Nothing damages are for the properties in the study area whose flood risk is influenced by the Do Something options.

Table 3-5 presents the direct damages to properties associated with individual return period flood events. The damages presented in this table do not include erosion or indirect damages and do not consider the probability of each flood event occurring.

Table 3-5: Do Nothing cash damages (direct damages to properties only) for individual flood events

Return Period Event	Do Nothing Cash Damage for individual flood events (£k) by Year			
	2021	2041	2071	2121
1:2	1,161	17,566	39,574	103,764
1:5	1,911	17,682	44,548	111,058
1:20	2,497	17,797	56,419	127,135
1:30	3,561	18,847	59,219	133,199
1:75	5,145	24,791	64,591	14,553
1:150	6,768	32,319	71,729	153,876
1:200	8,733	N/A*	76,678	157,182
1:500	15,101	41,887	84,793	N/A*

** Annual Average Damage has not been calculated directly for these return period events, however the damages have been interpolated to calculate the overall cash damages.*

Table 3-6 presents the total damages over the duration of the appraisal period, considering the probabilities of the different flood events occurring and includes the erosion damages and also the indirect damages. The total Do Nothing undiscounted cash damages for the Island are estimated to be approximately £1.2 billion over the next 100 years. In discounted present value terms this equates to approximately £314 million.

Table 3-6: Total Do Nothing damages

Period	Do Nothing Cash Damages (£k)	Do Nothing PV Damages (£k)
Years 0-99	1,172,654	314,086

3.2.1 Distribution of damages - type

The distribution of damages between direct flood damages, direct erosion damages and indirect damages over the 100 year appraisal period is presented in Figure 3-1 below. In PV terms, the total direct flood damages are estimated to be approximately £128million (41%), the direct erosion damages are £164million (52%) and the indirect damages are £22million (7%). In undiscounted cash terms, the direct flood damages are estimated to be approximately £502million, the direct erosion damages are approximately £593million and the indirect damages are approximately £77million.

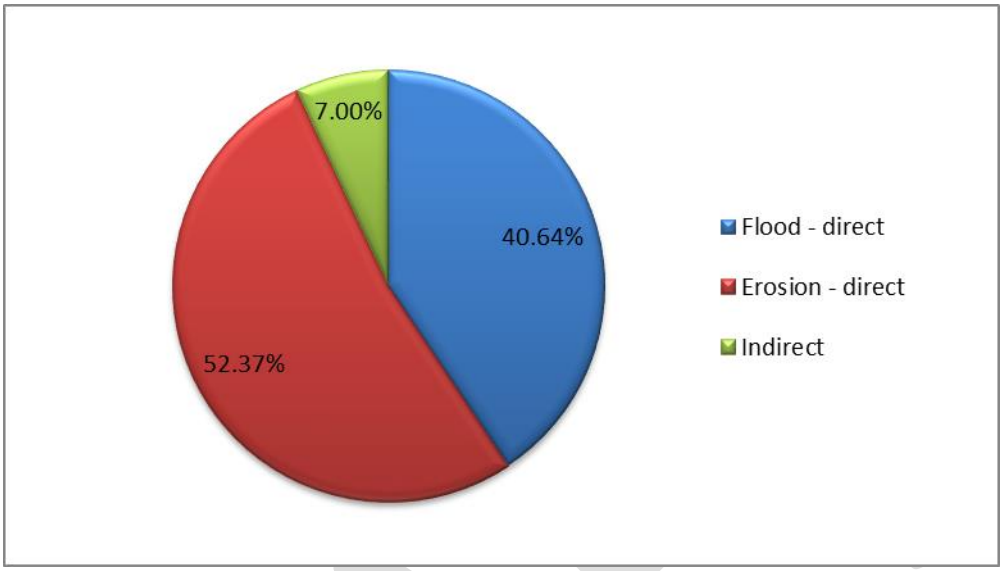

Figure 3-1: Distribution of damages by percentage

3.2.2 Distribution of damages - timing

The proportion of damages in each time epoch is presented in Table 3-7 below. As can be seen, the majority of the cash damages (53%) and PV damages (72%) are expected to occur in epoch 2 between 2041 and 2071. This is predominantly due to the majority of direct erosion damages occurring in epoch 2. The cash damages in epoch 1 are expected to be 3% of the total damages and the PV damages are expected to be 12% of the total damages.

Table 3-7: Distribution of damages by time epoch

Period	Do Nothing Cash Damages (£k)	Do Nothing PV Damages (£k)
Epoch 1; 2021-2041	40,148	35,808
Epoch 2: 2041-2071	626,985	225,889
Epoch 3; 2071-2121	505,520	52,388
Total	1,172,654	314,086

The distribution of PV damages over time is shown graphically in Figure 3-2 below, with the damages presented as cumulative.

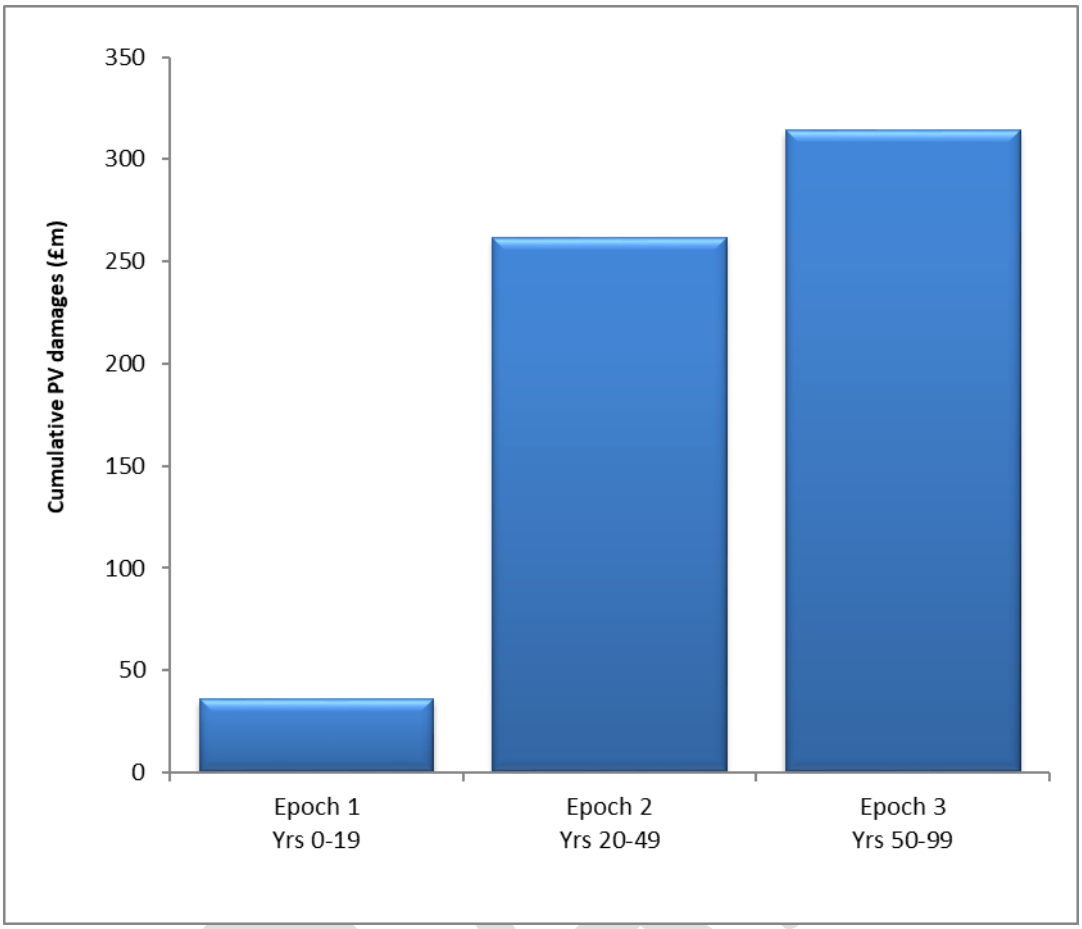

Figure 3-2: Distribution of damages through time

3.2.3 Distribution of damages – location

The distribution of Do Nothing damages between the various ODUs is presented in Table 3-8 below. As can be seen, more than two thirds of the total damages are in ODU 8 (Eastoke) which is expected given the high concentration of properties in this area which are at risk from both flooding and erosion.

Table 3-8: Do Nothing damages by ODU

ODU	PV damages (£k)	PV damages (% of total)	Cash damages (£k)	Cash damages (% of total)
1: Hayling Bridge to Northney Farm	4,380	1.4	27,400	2.3
2: Northney Marina	115	0.0	764	0.1
3: Northney Farm to Chichester Road	2,854	0.9	15,291	1.3
4: Chichester Road to Mill Rythe Junior School	5,913	1.9	29,920	2.6
5: Mill Rythe Junior School to Salterns Lane	6,123	2.0	50,365	4.3
6: Salterns Lane to Wilsons Boat Yard	2,218	0.7	18,948	1.6
7: Wilsons Boat Yard to Fishery Creek	9,856	3.2	81,418	7.0
8: Eastoke	244,434	78.6	685,891	58.8
9: Eastoke Corner to Inn on the Beach	7,935	2.6	66,803	5.7
10: Inn on the Beach to Ferryboat Inn	9,969	3.2	39,080	3.4
11: Ferryboat Inn to North Shore Road	3,278	1.1	30,430	2.6
12: North Shore Road to Stoke	62	0.0	142	0.0
13: Newtown	3,298	1.1	24,349	2.1
14: Newtown to Stoke	198	0.1	1,208	0.1
15: Stoke to Langstone Bridge Carpark	9,785	3.1	88,936	7.6
16: Langstone Bridge Carpark to Langstone Bridge	702	0.2	5,265	0.5
Total	**314,086**		**1,172,654**	

3.2.4 Distribution of damages – Annual average damage / write off

Table 3-9 below shows the distribution of damages associated with AADs (counted annually) and the damages associated with property write-off (counted as a lump sum at the time of write off). The AADs include flood damages and indirect damages. The write-off damages can be caused by both erosion and flooding.

Table 3-9: Distribution of damages between AAD / WO

Period	AAD PV Damages (£k)	AAD Cash Damages (£k)	Write off PV damages (£k)	Write off cash damages (£k)
Epoch 1; 2021-2041	208	300	28,641	30,540
Epoch 2: 2041-2071	134	358	217,527	605,411
Epoch 3; 2071-2121	2,350	28,602	43,242	430,564
Total	**2,692**	**29,260**	**289,411**	**1,095,775**

3.2.5 Distribution of indirect damages

Table 3-10 below shows the distribution of the indirect damages between the various categories and through time. The total of the indirect damages equates to approximately 9% of the overall Do Nothing damages (approximately £24million).

Table 3-10: Distribution of indirect damages

Indirect damage	PV Damages (£k)				Cash Damages (£k)			
	Epoch 1	Epoch 2	Epoch 3	Total	Epoch 1	Epoch 2	Epoch 3	Total
Intangible	37	39	35	111	51	124	347	522
Vehicle	999	1,076	951	3,026	1,398	3,422	9,493	14,313
Evacuation	371	400	353	1,124	519	1,271	3,527	5,318
Travel disruption	493	665	505	1,663	703	2,140	4,772	7,615
Road damage	2,437	2,358	1,616	6,411	3,385	7,447	15,299	26,131
School	93	237	263	593	143	780	2,650	3,273
Agriculture	99	92	88	279	138	290	904	1,332
Contaminated Land	17	44	44	105	27	146	435	608
Recreation	366	213	107	686	494	643	1,014	2,151
Loss of Life and Mental Health	2,047	3,101	2,833	7,981	2,449	4,951	7,910	15,309
Total	**6,959**	**8,227**	**6,797**	**21,983**	**9,308**	**21,216**	**46,354**	**76,878**

4. Costing

To compare the relative economic merits of the options and to generate the benefits cost ratios, the whole life costs for each of the different strategic options were estimated on an ODU by ODU basis.

For each option the whole life costs included capital costs, maintenance costs and operational costs. To inform the costing exercise an assumed defence structure, defence length/height and timing of capital works and maintenance was established as part of the option development. This information was then used to cost each of the strategic options.

4.1 Capital Construction Costs

The cost estimations for capital works were undertaken using a variety of sources and using the best available information. In the first instance, where actual defence costs were available from previous projects or published dataset, these costs have been used as a basis for relevant options for the Strategy e.g. beach recycling and beach replenishment.

In the absence of 'real' costs, values have been estimated from rates provided in civil engineering price books (e.g. SPONS, 2021) coupled with experience of costs from similar projects. The indicative costs are presented as of July 2021.

Typically, the cost of the coastal defences varies with the height of the defences. It was therefore necessary to estimate the height of the structure that was required and this information was attained by undertaking a GIS analysis. In GIS indicative defence alignments were created and using the Digital Terrain Model (DTM) for Hayling Island, the average shoreline elevation across the indicative alignments was identified to determine the necessary height of each defence structure. The unit costs of the defence height were then multiplied by the defence length required to estimate the capital construction costs. This was done for every defence type considered for each strategic option in each ODU.

For the 'Maintain' option, some capital construction costs were included with maintenance costs, to acknowledge that some of the existing defences are informal / are not expected to last throughout the whole Strategy period.

The following sections summarise the capital costing basis and assumptions for different defence structures which comprise the strategic options.

4.1.1 Floodwall

Unit rates per metre for flood defence walls were estimated using civil engineering price books (e.g. SPONS 2021) coupled with experience of costs from similar projects. A standard indicative cross section was adopted to cost the structures.

The costing of the walls included allowance for the following aspects and materials:

- Site clearance
- Excavation and disposal
- Concrete top – Design mix
- Reinforcement of concrete
- Formwork
- Placing of concrete
- Cladding
- Preliminaries and scaling of works
- Appraisal / Design cost

4.1.2 Seawall

Unit rates per metre for seawalls were estimated using civil engineering price books (e.g. SPONS 2021) coupled with experience of costs from similar projects. A standard indicative cross section was adopted to cost the structures.

The costing of the walls included allowance for the following aspects and materials:

- Site clearance
- Excavation and disposal
- Sheet pile installation
- Foundation fill / compaction
- Concrete top – Design mix
- Reinforcement of concrete
- Formwork
- Placing of concrete
- Preliminaries and scaling of works
- Appraisal / Design cost

4.1.3 Earth Embankment

Unit rates per metre for earth embankments were estimated using civil engineering price books (e.g. SPONS, 2021) coupled with experience of costs from similar projects.

The costing of the earth embankment included allowance for the following aspects and materials:

- Site clearance
- Excavation and disposal
- Re-use of excavation material
- Topsoil and fill
- Drainage
- Seeding
- Preliminaries and scaling of works
- Appraisal / Design cost

4.1.4 Revetment

Unit rates per metre were estimated for both rock and concrete revetments, using civil engineering price books (e.g. SPONS, 2021) coupled with experience of costs from similar projects.

The costing of the concrete revetment included allowance for the following aspects and materials:

- Site clearance
- Excavation and disposal
- Sheet pile driving
- Fill
- Concrete for wall
- Reinforcement of concrete
- Formwork
- Placing of concrete
- Preliminaries and scaling of works
- Appraisal / Design cost

The costing of the rock revetment included allowance for the following aspects and materials:

- Site clearance
- Reprofile slope
- Geotextile
- Rock armour core
- Rock armour
- Placement of rock
- Preliminaries and scaling of works
- Appraisal / Design cost

4.1.5 Gabions

Unit rates per metre were estimated for gabions, using civil engineering price books (e.g. SPONS, 2021) coupled with experience of costs from similar projects.

The costing of the gabions included allowance for the following aspects and materials:

- Site clearance
- Reprofile slope
- Geotextile
- Gabions
- Preliminaries and scaling of works
- Appraisal / Design cost

4.1.6 Groynes

Unit rates per metre were estimated for both rock and timber groynes, using civil engineering price books (e.g. SPONS, 2021) coupled with experience of costs from similar projects.

The costing of the rock groynes included allowance for the following aspects and materials:

- Site clearance
- Reprofile slope
- Geotextile
- Rock armour core
- Rock armour
- Placement of rock
- Preliminaries and scaling of works
- Appraisal / Design cost

The costing of the timber groynes included allowance for the following aspects and materials:

- Site clearance
- Excavation of beach material
- Timber piles
- Timber sheeters
- Bolted connections
- Preliminaries and scaling of works
- Appraisal / Design cost

4.1.7 Crest Raising

Crest raising is an option within the strategic options, where existing or new defences must be raised in the future to keep pace with sea level rise. To represent the cost of crest raising, the cost was taken as equivalent to that of a new concrete flood wall construction.

This is likely to represent an over-estimate of the cost of crest raising, but is considered suitable given the wide range of existing concrete structures within the Strategy frontage.

4.1.8 Road Raising

Unit rates per metre were estimated for road raising, using civil engineering price books (e.g. SPONS, 2021). The costing of the road raising included allowance for the following aspects and materials:

- Site clearance
- Excavation / breakout of old road surface
- Fill and compaction
- Road construction
- Preliminaries and scaling of works
- Appraisal / Design cost

4.1.9 Property Flood Resilience

Cost estimates for Property Flood Resilience (PFR) are based on the grant allowances available to properties which install these defence measures. The current grant allowance is £5,000 per property.

It should be acknowledged that additional costs associated with protection would have to come from other sources, such as homeowners. This could include an engineer fee for undertaking a pre-installation property survey.

Properties at risk of flooding from a 5% AEP flood event or higher were considered for PFR, as part of the strategic options. PFR has only been considered to protect properties up to a 5% AEP event, as it is not effective at providing protection from flooding at higher return period events.

4.1.10 Creek Barrier

The cost of a creek barrier for ODU 6 was estimated based on the 200 metre width of the creek entrance, based on costing experience from similar projects (Langstone Harbour Barrier, Bristol Tidal Flood Risk Management Strategy) and using civil engineering price books (e.g. SPONS, 2021).

A total cost of £4.5 million has been estimated, including costs for a rubble mound (based on a mixture of as built costs and design costs) and gates and utility connections (based on a SPONS (2021) build-up for tidal gates).

4.1.11 Historic Landfill Remediation

The cost of historic landfill remediation was estimated as an average between the guidance from the Environment Agency (provided by Coastal Partners) and the HCA guidance on Dereliction, demolition and remediation costs (March, 2015).

A total cost of £24.63 per m^3 has been estimated for in-situ remediation, which could include biological treatment, flushing, treatment of leachate, soil vapour extraction and stabilisation / solidification.

4.1.12 Billy Trail Relocation

Cost estimates for relocation of the Billy Trail are based on land purchase costs for relocation (estimated from various estate agents, based on arable land in the south east of England) and the creation of a footpath and cycleway further inland using civil engineering price books (e.g. SPONS, 2021). A cost of £26,329 has been used for site preparation (site clearance and land purchase) and a cost of £592,700 have been use for the creation of a footpath and cycleway.

The costing of the Billy Trail relocation included allowance for the following aspects and materials:

- Site clearance
- Land purchase
- Excavation for levelling
- Compaction
- Road construction
- Preliminaries and scaling of works
- Appraisal / Design cost

4.1.13 Habitat Creation

Cost estimates for habitat creation are based on land purchase costs for relocation (estimated from various estate agents, based on arable land in the south east of England) and the cost of creating new habitat from Environment Agency guidance[6]. A total cost of £7,414 per hectare has been estimated for habitat creation.

[6] Environment Agency (2015) Cost Estimation for Habitat Creation – Summary of Evidence. Available from: https://assets.publishing.service.gov.uk/media/6034ef5ee90e0766033f2ea7/Cost_estimation_for_habitat_creation.pdf [Accessed 30 September 2021].

4.1.14 Beach Management

Beach management costs were estimated for beach recycling and beach nourishment across ODU 8 and ODU 9. For both types of scheme, cost estimates were based on real life costs provided by Coastal Partners. Beach recycling and beach nourishment costs were based on recent beach recycling costs from Hayling Island, between October 2017 and March 2021. A cost of £295k was adopted for beach nourishment, and £50k for beach recycling.

Beach management is currently carried out at Hayling Island on an annual basis, therefore beach nourishment has been included every two years, and beach recycling every year, within the maintenance costs for ODU 8 and ODU 9.

4.1.15 Summary

Table 4-1 provides a summary of the estimated unit costs for the different defence structures used when producing the costs for each strategic option.

Table 4-1: Summary of unit costs (£) for defence measures (prior to optimism bias and risk contingency)

Defence Type	Unit	Cost (£)	Based on
Floodwall	10 Metre (Length)	3,100	0.5 metre (height)
		6,100	1.0 metre (height)
		9,100	1.5 metre (height)
Seawall	10 Metre (Length)	9,500	0.5 metre (height)
		17,500	1.0 metre (height)
		25,700	1.5 metre (height)
Earth Embankment	10 Metre (Length)	1,700	0.5 metre (height)
		3,600	1.0 metre (height)
		6,000	1.5 metre (height)
Gabions	10 Metre (Length)	1,000	0.5 metre (height)
		2,600	1.0 metre (height)
		5,500	1.5 metre (height)
Rock Groynes	50 Metre (Length)	49,600	Per groyne

Timber Groynes	50 Metre (Length)	75,400	Per groyne
Crest Raising	10 Metre (Length)	2,000	0.5 metre (height)
		3,800	1.0 metre (height)
		5,600	15 metre (height)
Road Raising	10 Metre (Length)	71,600	0.5 metre (height)
		73,300	1.0 metre (height)
		75,000	15 metre (height)
Property Flood Resilience	Per property	5,000	N/A
Creek Barrier	200 Metre (Length)	4,500,000	N/A
Historic Landfill Remediation	Per m^3	25	N/A
Billy Trail Relocation	10 Metre (Length)	619,000	N/A
Habitat Creation	Per hectare	7,400	N/A
Beach Management	Per nourishment	295,000	N/A
	Per recycling	50,000	N/A

4.2 Maintenance Costs

Maintenance costs also form part of the whole life costs for the strategic options and refer to the costs for periodic or annual maintenance works that are required to maintain the structural integrity of the defences.

For the maintenance of existing defences (as part of the 'Do Minimum', 'Maintain' and 'Do Something' options), costs were applied at a constant rate of £6.37 per metre of defence. This approximate value was derived from Environment Agency guidance[7]. This rate was then multiplied by the length of each ODU to calculate the total maintenance cost of existing defences.

For maintenance of new capital construction works, costs were applied annually in each ODU, as a 1% factor of the cost of the capital works. The exception to this was during the first 5 years after capital construction works are to be undertaken, when it was assumed that no maintenance would be required.

4.3 Discounting

Discounting is used to compare costs that occur at different points in time during the Strategy appraisal period on a relative present value (PV) basis. Discounting has been applied to the whole life costs using the same approach as used with the economic benefits and damages. Standard discount rates have been used to convert all cash costs to PV costs to compare whole life costs of the strategic options. As per to FCERM-AG, the following variable discount rates have been used within the economic assessment appraisal: 3.5% for years 0 to 30, 3% for years 31 to 75, and 2.5% for years 76 to 99.

Using these discount rates over the 100 years appraisal period, a total PV cost for each strategic option was determined for each ODU.

4.4 Preliminaries, Optimism Bias and Risk Contingency

An allowance for preliminary costs has been applied at 35% of the build up cost, as well as 20% to account for appraisal and design costs.

In line with FCERM-AG policy, an optimism bias of 60% was applied to the present value whole life costs for each strategic option. Optimism bias is included to account for the tendency for;

"appraisers to be overly optimistic in early assessment of project costs, timescales and benefits in comparison to the final values".

"To counter this, the HM Treasury issued guidance in the form of a percentage to increase the present value costs depending on the uncertainty surrounding the estimates. An optimism bias of 60% is typically used for projects at an early stage of consideration (including strategies)" (Flood and Coastal Erosion Risk Management appraisal guidance – environment agency, 2020).

In addition to the optimism bias allowance, a further risk contingency of 20% has also been applied, to account for other unknown risks.

4.5 Adaptation

High level cost estimates for property relocation have been included as part of the 'Adaptation' strategic option. Given the uncertainties associated with this option, the estimated costs are only indicative and have been calculated for illustration purposes only. Further costing work would be required should the adaptation option be taken forward in the future.

Given the uncertainties with the costs of adaptation, the option has not been included within the benefit cost ratio assessment. However, the costs may provide useful context for future management decisions if/when it is found to no longer be economically viable to defend the coastline with new coastal defences.

In the adaptation option, a total cost of £509,450 has been estimated for the relocation of an individual property. This cost is based on compensation for homeowners for moving out of the area, including property purchase costs, a home loss payment and reasonable costs for moving. To work out an overall cost for this option, the individual property cost has been applied to all properties in the future when they become at risk of flooding from a 0.5% AEP

[7] Environment Agency (2015) Cost Estimation for Fluvial Defences – Summary of Evidence. Available from: https://assets.publishing.service.gov.uk/media/6034ed2ed3bf7f264f23eb51/Cost_estimation_for_fluvial_defences.pdf [Accessed 30 September 2021].

event. As such, the total cost of relocating all properties on Hayling Island at risk of flooding from a 0.5% AEP event by 2121 is approximately £362,989k in PV terms, and £2,345,508k in cash terms.

5. Benefits

The benefits of the strategic options have been calculated for each ODU to enable a benefit cost ratios comparison to be undertaken.

5.1 Standards of Protection

For each strategic option, two different Standards of Protection (SoP) against flooding have been assessed in the benefit cost comparison. The onset of flooding varies across Hayling Island, therefore some ODUs may require a higher SoP to provide sufficient protection and reduce residual damages. This aligns with the decision rules outlined in FCERM-AG and a comparison of different standards enables the optimal SoP from an economic standpoint to be determined. The benefits for the following two SoPs have been calculated:

- 1.33% AEP Standard of Protection
- 0.5% AEP Standard of Protection

5.2 Benefits Calculations

For the 'Do Minimum' option, there are no flood related benefits because the option does not improve the standard of protection against flooding and therefore the flood damages are expected to be the same as the 'Do Nothing' damages. However there will be some minor erosion benefits with this option associated with the delayed onset of defence failure (due to patch-repair maintenance). The damages associated with erosion for this option have been calculated using the 'Do Minimum' erosion zones provided by Coastal Partners.

For the 'Maintain' option, there are some flood benefits compared to 'Do Nothing' due to preventing flood defence failures, such as breaching at Eastoke. The flood benefits for the Maintain option were calculated using flood modelling results with the flood defences in place throughout the appraisal period. In the Maintain option there are significant erosion benefits as all erosion damages associated with 'Do Nothing' scenario have been removed.

The flood risk benefits of the 'Sustain' and 'Improve' strategic options have been determined by calculating the difference between the baseline 'Do Nothing' flood damages and the residual flood damages for each option. Residual damages are those damages that would still occur after the option has been implemented as a result of above design event flood events occurring or defences failing. For example, where a new flood defence with a 1.33% AEP SoP is constructed, residual damages would occur if a 0.5% AEP event or a 0.1% AEP event were to occur over the lifetime of the scheme. As both the sustain and improve options involve holding the line, there are significant erosion benefits as all erosion damages associated with the 'Do Nothing' scenario has been removed.

For the 'Property Flood Resilience' option, the flood damages for the 50%, 20% and 5% AEP events have been assumed to be zero. The residual damages for all return period events above 5% AEP are included, as well as all erosion damages. Property Flood Resilience has only been considered to protect properties up to a 5% AEP event, as it is not effective at providing protection from flooding at higher return period events.

5.3 Habitat Creation Benefits

Many of the Strategic Options include additional environmental benefits through habitat creation, which can be measured through Outcome Measure 4 (OM4) – environmental improvements. The partnership funding supporting guidance[8] has been used to estimate the benefits associated with habitat creation. Outcome Measure 4a (OM4a) measures benefits by hectares of habitats created or enhanced, by comparing the flow of ecosystem services the scheme provides against the current habitat condition. Table 5-1 displays the predefined OM4a values for habitats, per hectare per year.

DEFRA's Magic Maps application was used to determine the current habitat types for each ODU. Following this, a GIS analysis was used to estimate the number of hectares of habitat to be created or enhanced for each Strategic

[8] Environment Agency (2020) Partnership funding: Supporting guidance for Outcome Measure 4. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/895861/Partnership_funding_supporting_guidance_for_OM4.pdf [Accessed 19 October 2021].

Option, as well as the likely type of habitat after the enhancements. Habitat condition was assumed to be 'Moderate' both before and after enhancement, for all ODUs.

The benefits for each strategic option per year were calculated by the change in benefits from the current habitat to the future habitat. The annual benefits were then aggregated across the appraisal period to calculate PV benefits, using the FCERM-AG discount rates, and added to the benefits calculated in Section 6 to calculate the benefit cost ratios.

Table 5-1: Predefined OM4a Values for Habitats (2018 prices/ha/year)

Habitat	Condition		
	Poor	Moderate	Good
Intertidal	£1,860	£6,410	£10,970
Heathland	£1,100	£3,440	£6,450
Woodland	£1,100	£3,440	£6,450
Wet woodland	£670	£2,040	£3,410
Wetlands/wet grassland	£60	£110	£490
Grassland	£90	£1,400	£2,720
Pond/lakes	£670	£2,040	£3,410
Arable	£30	£50	£60

6. Benefit Cost Ratio

In each ODU the Benefit Cost Ratios were calculated for the strategic options to demonstrate their economic viability and to help inform the selection of the leading strategic option. Following the decision rules outlined in the FCERM-AG guidance, the identification of the leading FCERM option was based on the process outlined in Figure 6-1. The process makes use of the Average Benefit Cost Ratio (ABCR) and the Incremental Benefit Cost Ratio (IBCR) as key metrics.

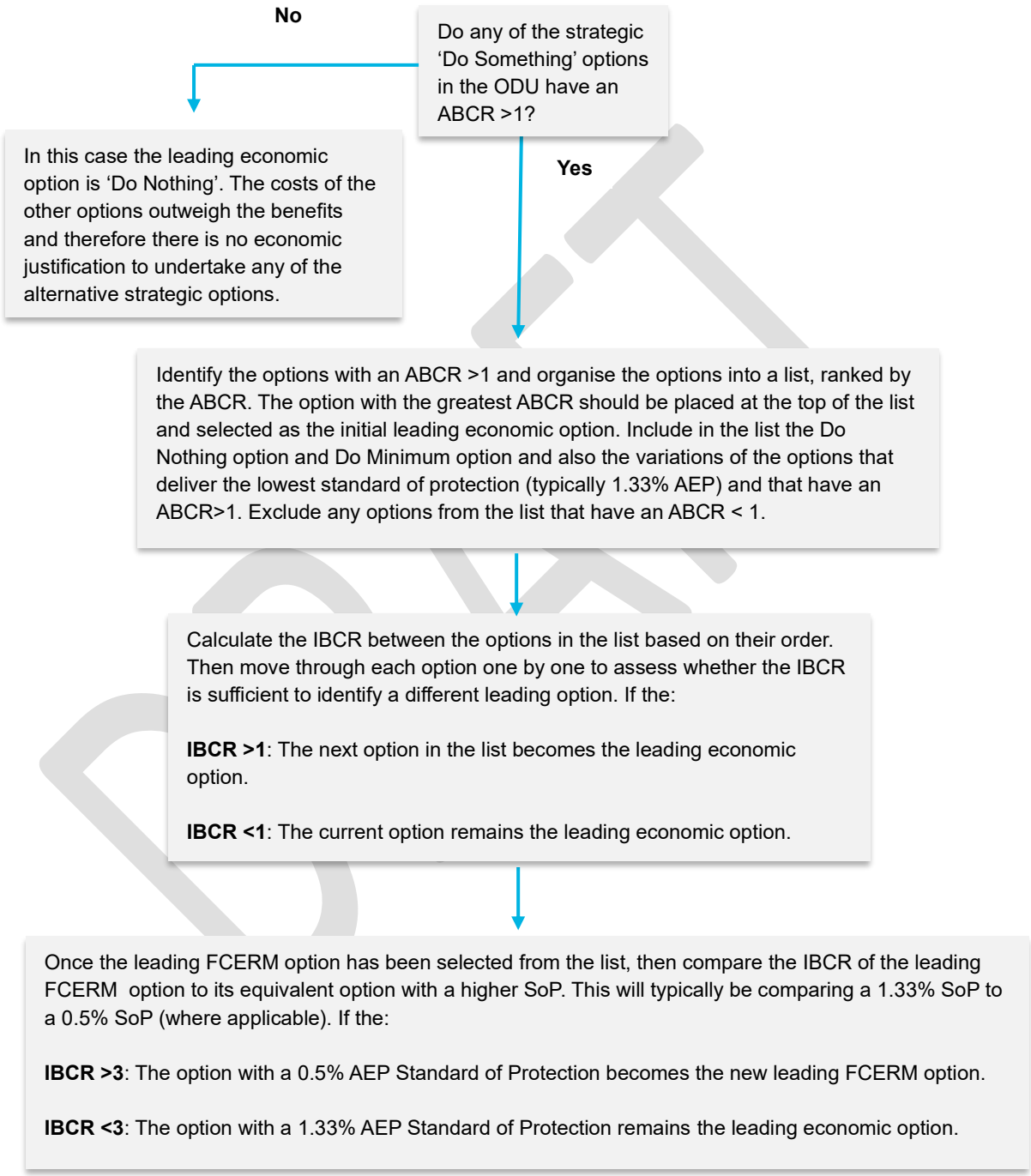

Figure 6-1: Process for the Identification of the Leading FCERM Option

The ABCR is calculated by dividing the whole life benefits of a strategic option by the whole life costs of the option. The benefits and costs used in the calculation are in present value terms. An ABCR > 1 indicates that there is an economic justification for an option (although other options may have a stronger economic case).

The IBCR is calculated between two strategic options. It is calculated by dividing the difference in the benefits between the options by the difference in costs between the options. If the IBCR >1 between the options, it indicates that there is an economic justification for proceeding with the option that delivers greater benefits, but at a higher

cost. The FCERM-AG option appraisal decision rules has a set of IBCR thresholds which are used to guide the selection of the optimal standard of protection of an option.

This process is presented in Appendix C for each ODU. Separate tables are presented to show:

1. A table showing the ABCR of all of the strategic options in an ODU. The strategic options with an ABCR <1 are highlighted in red as these options are not economically viable. Where there are no strategic options with an ABCR >1, the leading FCERM option is highlighted in green;

2. A table showing all of the strategic options in an ODU with a 1.33% SoP (excluding the 'Do Something' options with an ABCR <1). These options are organised by ABCR and the tables show the IBCR between options. The leading FCERM option based on the IBCR comparison is highlighted in green; and,

3. A table showing a comparison between the leading FCERM option with a 1.33% SoP and a 0.5% SoP. The IBCR between the two SoPs is shown and is used to select the optimal SoP of the option, based on a comparison with the FCERM-AG IBCR thresholds. The leading FCERM option is highlighted in green.

7. Leading Options

Table 7-1 presents the leading FCERM option for each ODU, including the whole life PV costs, cash costs, PV benefits and ABCR.

The selection of the overall leading option was not based solely on the economic score; further technical, social, environmental and sensitivity testing was carried to confirm the overall leading option for each ODU with wider objectives considered. Details of this approach can be found in the Short List to Leading Option Appraisal Report. Table 7-2 presents the overall leading option for each ODU, including the whole life PV costs, cash costs, PV benefits and ABCR.

Further to this, aspirational options were developed for some ODUs which could become feasible in the future if further financial contributions are made available through regeneration and redevelopment. These aspirational options are presented in Table 7-3.

Table 7-1: Leading FCERM Options

ODU	Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1	**Sustain 1.33% AEP with managed realignment -** Setback embankment on the east and west side, with habitat creation. Increasing length and height over time to keep pace with sea level rise	1,912	4,821	5,116	2.68
2	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0.00
3	**Sustain 0.5% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,287	7,535	6,140	2.68
4	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0.00
5	**Improve from 2071 (Maintain then Improve) 0.5% AEP with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	2,527	9,417	7,683	3.04
6	**Improve from 2071 (Maintain then Improve) 0.5% AEP Frontline –** Maximise the life of existing defences, then implement frontline floodwall	986	5,166	2,299	2.33
7	**Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	4,001	8,739	12,878	3.22

ODU	Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
8	**Sustain 0.5% AEP** – Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	54,840	132,001	250,085	4.56
9	**Sustain 0.5% AEP Replace Inn on the Beach -** Setback floodwall, increasing length and height over time to keep pace with sea level rise. Replacement of Inn on the Beach with a rock groyne. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	10,211	30,313	10,543	1.03
10	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	1,280	4,104	3,634	2.84
11	**Improve 0.5% AEP –** Floodwall around west side only. Full length and height from present day	1,303	2,322	3,278	2.52
12	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0.00
13	**Sustain from 2041 (Maintain then Sustain) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	342	1,045	3,298	9.65
14	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0.00
15	**Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	6,270	11,880	11,600	1.85
16	**Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	410	836	683	1.66

Table 7-2: Overall Leading Options

ODU	Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1	**Sustain 0.5% AEP with managed realignment hybrid -** Frontline floodwall on the west and setback embankment on the east and frontline embankment in front of historic landfill, with habitat creation. Increasing length and height over time to keep pace with sea level rise	5,353	10,613	5,483	1.02
2	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	318	1,050	67	0.21
3	**Sustain 0.5% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,287	7,535	6,140	2.68
4	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	1,181	3,857	937	0.79
5	**Sustain 1.33% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	4,671	9,113	7,116	1.52
6	**Improve from 2071 (Maintain then Improve) 0.5% AEP Frontline –** Maximise the life of existing defences, then implement frontline floodwall	986	5,166	2,299	2.33
7	**Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	4,001	8,739	12,878	3.22
8	**Sustain 0.5%** - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	76,843	167,042	250,085	3.25

ODU	Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
9	**Sustain 0.5% AEP Maintain Inn on the Beach** – Setback floodwall, increasing length and height over time to keep pace with sea level rise. Capital refurbishment of the defences in front of Inn on the Beach. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	10,324	30,635	10,543	1.02
10	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	1,280	4,104	3,634	2.84
11	**Sustain 1.33% AEP –** Floodwall around the west side, followed by a floodwall around the east side in 2041. Increasing length and height over time to keep pace with sea level rise	2,508	7,496	2,942	1.17
12	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0.00
13	**Sustain from 2041 (Maintain then Sustain) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	342	1,045	3,298	9.65
14	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0.00
15	**Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	6,270	11,880	11,600	1.85
16	**Sustain 0.5% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	445	868	702	1.58

Table 7-3: Aspirational Options

ODU	Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
2	**Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	942	2,225	108	0.11
10	**Improve 1.33% AEP –** North side defence, with raising of Ferry Road. Full length and height from present day	51,951	56,635	9,546	0.18
12	**Managed realignment –** Setback earth embankment with habitat creation	601	836	558	0.93
14	**Sustain 1.33% AEP with managed realignment and relocation of the Billy Trail –** Setback earth embankment around assets only, with habitat creation. Increasing length and height over time to keep pace with sea level rise	3,682	4,148	429	0.12

8. Sensitivity testing

A number of sensitivity tests have been carried out on the economic assessment. For the Do Nothing damages, two key sensitivity tests have been undertaken, relating to the assumed property threshold level and the breach of the defences at Eastoke. For the short list options, a sensitivity test has been carried out relating to the option costs.

8.1 Property threshold levels

A key uncertainty in the valuation of the Do Nothing damages is the values that have been assumed for the property thresholds. Residential and non-residential property threshold levels have been assumed to be 0.05m. The threshold level for residential and non-residential properties has been sensitivity tested with alternative thresholds of 0.01m, 0.15m and 0.1m. Table 8-1 presents the changes to the total PV damages with varying values of threshold for the residential properties which were not surveyed.

The sensitivity test indicates that the overall Do Nothing damages are not overly sensitive to the assumed property threshold level; an increase in property threshold to 0.15m (from 0.05m) decreases the Do Nothing damages by approximately 6%. A reduction in the property threshold to 0.01m increases the Do Nothing damages by approximately 6%. Given the absence of further information on the property threshold, the use of 0.05m is considered to be most acceptable for this strategic level appraisal as it is towards the middle of the range tested and the sensitivity tests demonstrate a comparatively even % change by increasing or decreasing the threshold.

It is not considered necessary to obtain more information on the threshold level of properties for the Strategy. However, when schemes are progressed, the damages may be more sensitive to variations in threshold at the local level, so this sensitivity should then be reanalysed.

Table 8-1: Sensitivity test of residential threshold levels in relation to the total PV damages (£k)

Option	Property threshold Level			
	0.01m	**0.05m (original)**	**0.10m**	**0.15m**
Do Nothing	£333,438k	£314,086k	£303,384k	£292,233k
Percentage change from original	6%	N/A	3%	6%

This sensitivity test has not been carried out on the strategic options, as the test indicates the Do Nothing damages are not sensitive to change in property threshold levels. As such, it is likely that the option benefits and costs would not be sensitive to these changes. If the threshold levels of properties are found to be significantly different during individual scheme appraisal, causing the benefit cost ratio of the overall leading options to be below unity, the FCERM decision making process (outlined in the Short List to Leading Option report) should be followed. In this scenario, the FCERM leading option could be favoured over the overall leading option.

8.2 Breach of defences at Eastoke

There is uncertainty in the likely timing of the breach of the defences at Eastoke. In the economic appraisal it has been assumed that there would be no risk of a breach at Year 0, increasing to a 100% risk in Year 20 under the Do Nothing Scenario. This timing has been sensitivity tested with an alternative scenario which assumes no risk of a breach at Year 0, increasing to a 50% risk at Year 20 and a 100% risk at Year 50. Table 8-2 presents the changes to the total PV damages with a change in the year of the breach at Eastoke.

The sensitivity test indicates that the overall Do Nothing damages are not overly sensitive to the timing of the breach at Eastoke. Reducing the risk of the breach to 50% in Year 20 decreases the Do Nothing damages by approximately 3%. Given that the difference in the damages between the two scenarios is relatively low, including the breach at Year 20 is considered an acceptable approach for this strategic level appraisal.

Damages may be more sensitive to variations in the breach year at a local level, therefore this sensitivity should be reanalysed when developing schemes for ODU 8.

Table 8-2: Sensitivity test of the breach of the defences at Eastoke in relation to the total PV damages (£k)

Option	Timing of breach occurring	
	100% risk in 2041 (original)	50% risk in 2041, 100% risk in 2071
Do Nothing	£314,026k	£319,411k
Percentage change from original	N/A	3%

This sensitivity test has not been carried out on the strategic options, as the test indicates the Do Nothing damages are not sensitive to a change in the year of breach at Eastoke. As such, it is likely that the option benefits and costs would not be sensitive to these changes. Furthermore, both the overall leading and FCERM leading options for Eastoke (ODU 8) have a benefit cost ratio above 2 and it is unlikely that changing the timing of the breach would reduce this below unity. Any changes to the timing of the breach should be re-assessed as part of the detailed scheme appraisal. If changes result in benefit cost ratio of the overall leading option being below unity, the FCERM decision making process (outlined in the Short List to Leading Option report) should be followed. In this scenario, the FCERM leading option could be favoured over the overall leading option.

8.3 Phased Management Approach

The Strategy has adopted the recommended UKCP18 Representative Concentration Pathway (RCP) 8.5 70th percentile as the allowance for sea level rise. However, there is still some uncertainty in future sea level rise predictions.

To accommodate this uncertainty into the Strategy, the leading options incorporate a phased management approach whereby works are phased over time, depending on the risk of flooding and coastal erosion. For example, if sea levels rise more slowly than anticipated, the implementation of new defences can be delayed. Alternatively, if sea levels rise more rapidly than predicted, defence implementation can be brought forward or defences can be built to a higher SoP.

This approach provides the most adaptability to the Strategy, and allows decision makers to use an evidence based approach in the future by monitoring sea level rise over time, ensuring that the maximum benefits are generated. This also avoids the early implementation of works which may not be needed in the future. This adaptive capacity of the Strategy allows the flexibility to ensure that the economic case remains sound in the future, despite uncertainties.

8.4 Option costs

There is some uncertainty in the costing of the shortlisted options, as values for capital costs, maintenance costs and operational costs have been estimated using rates provided in civil engineering price books (e.g. SPONS, 2021) coupled with experience of costs from similar projects.

These costs have been sensitivity tested by applying an uplift of 25% to the whole life PV costs for each option. Table 8-3 and Table 8-4 present the changes to the whole life PV costs and benefit cost ratios for the FCERM leading and overall leading options respectively.

The sensitivity test for the overall leading options indicates that the costs are not overly sensitive to a 25% increase in costs, as the benefit cost ratio falls below unity for only three ODUs; ODU 1, ODU 9 and ODU 11. The FCERM decision making process within the Short List to Leading Option Report (AECOM, 2022) indicates that in this scenario the FCERM leading option should be selected as the overall leading option instead. This approach should be followed as part of the detailed scheme appraisal for these ODUs (following on from the Strategy), should the costs of the overall leading options increase.

The sensitivity test for the FCERM leading options selection indicates that the costs are not overly sensitive to a 25% increase in costs, as only the benefit cost ratio for ODU 9 falls below unity. If the costs for ODU 9 increase as part of the detailed scheme appraisal, it may be necessary to look at adaptation as an alternative option for management here. This is also highlighted within the FCERM decision making process, in the Short List to Leading Option Report (AECOM, 2022). Section 6 of that report also discusses the potential for adaptation to be explored when the FCERM leading and overall leading options are no longer economically viable.

Table 8-3: Sensitivity test of the FCERM leading options costs

ODU	Strategic Option	Whole Life PV Benefits (£k)	Whole Life PV Cost (£k) (original)	ABCR (original)	Whole Life PV Cost (£k) (25% uplift)	ABCR (25% uplift)
1	**Sustain 1.33% AEP with managed realignment -** Setback embankment on the east and west side, with habitat creation. Increasing length and height over time to keep pace with sea level rise	5,116	1,912	2.68	2,390	2.14
2	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0.00	0	0.00
3	**Sustain 0.5% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	6,140	2,287	2.68	2,859	2.15
4	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0.00	0	0.00
5	**Improve from 2071 (Maintain then Improve) 0.5% AEP with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	7,683	2,527	3.04	3,159	2.49
6	**Improve from 2071 (Maintain then Improve) 0.5% AEP Frontline –** Maximise the life of existing defences, then implement frontline floodwall	2,299	986	2.33	1,233	1.87
7	**Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	12,878	4,001	3.22	5,001	2.57
8	**Sustain 0.5% AEP** – Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	250,085	54,840	4.56	68,550	3.65

ODU	Strategic Option	Whole Life PV Benefits (£k)	Whole Life PV Cost (£k) (original)	ABCR (original)	Whole Life PV Cost (£k) (25% uplift)	ABCR (25% uplift)
9	**Sustain 0.5% AEP Replace Inn on the Beach -** Setback floodwall, increasing length and height over time to keep pace with sea level rise. Replacement of Inn on the Beach with a rock groyne. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	10,543	10,211	1.03	12,764	0.83
10	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	3,634	1,280	2.84	1,600	2.27
11	**Improve 0.5% AEP –** Floodwall around west side only. Full length and height from present day	3,278	1,303	2.52	1,629	2.01
12	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0.00	0	0.00
13	**Sustain from 2041 (Maintain then Sustain) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	3,298	342	9.65	428	7.71
14	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0.00	0	0.00
15	**Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	11,600	6,270	1.85	7,838	1.48
16	**Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	683	410	1.66	513	1.33

Table 8-4: Sensitivity test of the overall leading options costs

ODU	Strategic Option	Whole Life PV Benefits (£k)	Whole Life PV Cost (£k) (original)	ABCR (original)	Whole Life PV Cost (£k) (25% uplift)	ABCR (25% uplift)
1	**Sustain 0.5% AEP with managed realignment hybrid -** Frontline floodwall on the west and setback embankment on the east and frontline embankment in front of historic landfill, with habitat creation. Increasing length and height over time to keep pace with sea level rise	6,749	5,353	1.26	6,691	1.01
2	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	67	318	0.21	398	0.17
3	**Sustain 0.5% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	6,140	2,287	2.68	2,859	2.15
4	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	937	1,181	0.79	1,476	0.63
5	**Sustain 1.33% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	7,116	4,671	1.52	5,839	1.22
6	**Improve from 2071 (Maintain then Improve) 0.5% AEP Frontline –** Maximise the life of existing defences, then implement frontline floodwall	2,299	986	2.33	1,233	1.87
7	**Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	12,878	4,001	3.22	5,001	2.57
8	**Sustain 0.5%** - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	250,085	76,843	3.25	96,054	2.60

ODU	Strategic Option	Whole Life PV Benefits (£k)	Whole Life PV Cost (£k) (original)	ABCR (original)	Whole Life PV Cost (£k) (25% uplift)	ABCR (25% uplift)
9	**Sustain 0.5% AEP Maintain Inn on the Beach** – Setback floodwall, increasing length and height over time to keep pace with sea level rise. Capital refurbishment of the defences in front of Inn on the Beach. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	10,543	10,324	1.02	12,905	0.82
10	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	3,634	1,280	2.84	1,600	2.27
11	**Sustain 1.33% AEP –** Floodwall around the west side, followed by a floodwall around the east side in 2041. Increasing length and height over time to keep pace with sea level rise	2,942	2,508	1.17	3,135	0.94
12	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0.00	0	0.00
13	**Sustain from 2041 (Maintain then Sustain) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	3,298	342	9.65	428	7.71
14	**Do Nothing –** No Active Intervention. Baseline scenario	0	0	0.00	0	0.00
15	**Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	11,600	6,270	1.85	7,838	1.48
16	**Sustain 0.5% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	702	445	1.58	556	1.26

9. Indicative Partnership Funding Calculator

An indicative partnership funding assessment has been completed to determine the potential funding levels from FCERM GiA of the FCERM leading options, as well as the overall leading options and aspirational options. This also indicates the scale of contributions which may be needed to implement the options over the duration of the Strategy. The assessment has been carried out in accordance with the Environment Agency funding guidance for FCERM Strategies and utilises the latest Partnership Funding Calculator (Spring 2020 version).

9.1 Partnership Funding Overview

The DEFRA Flood and Coastal Resilience Partnership Funding arrangement defines the level of flood risk management Grant-in Aid (GiA) a project could achieve based on a series of DEFRA Outcome Measure (OM) targets. There are four OMs under which projects can attract GiA:

- **OM1**: All benefits arising as a result of the investment, less than those valued under the other outcome measures;
- **OM2**: Households moved from one category of flood risk to a lower category;
- **OM3**: Households better protected against coastal erosion; and,
- **OM4**: Statutory environmental obligations met through flood and erosion risk management.

A full table of the OMs and benefits under each that will qualify for national funding is provided in the latest DEFRA GiA guidance. The table is reproduced in Table 9-1. The assumed flood and erosion risk categories and probabilities are in Table 9-2 and Table 9-3 respectively.

Table 9-1: Outcome Measures Summary (Environment Agency, 2021)

OM no.	Outcome Measure definition	Benefits and outcomes qualifying for national funding	Payment rate	Examples of funding levels from Government
OM1	Average benefit to cost ratio of schemes *OM1a relates to overall benefits of a scheme* *OM1b is a subset of 1a, people related benefits*	Under OM1, present value of whole-life benefits of the current investment, less benefits paid for or payments made under the other outcome measures.	OM1a: 6p per £1 of qualifying benefit OM1b: 20p per £1 of qualifying benefit	These include avoidance of damages to e.g. business, agriculture, local government, communications, infrastructure, utilities and public health
OM1a				
OM1b				
OM2	Households moved from one category of flood risk to a lower category *OM2a are measured as households at risk today, better protected by the investment* *OM2b are measured as additional households at risk up to 2041 that are better protected by the investment*	Under OM2, present value of direct damages to residential properties and their contents avoided, in the: -20% most deprived areas -21-40% most deprived areas -60% least deprived areas	45p per £1 30p per £1 20p per £1	Based on moving a single household from a higher risk category to a lower risk for the duration of the project appraisal period
OM2a				
OM2b				
OM3	Households better protected against coastal erosion	Under OM3, present value of direct damages to residential properties and their contents avoided, in the: -20% most deprived areas -21-40% most deprived areas -60% least deprived areas	20p per £1	Based protecting a household from erosion risk for the duration of the project appraisal period

OM no.	Outcome Measure definition	Benefits and outcomes qualifying for national funding	Payment rate	Examples of funding levels from Government
OM4a	Habitats enhanced – habitat conditions restored and enhanced	OM4a is for habitat improvements, based on the type and condition of the habitat 'before' compared to 'after'	20p per £1 qualifying benefit.	Based on hectares of habitat by condition and type restored or enhanced

Table 9-2: Flood Risk Categories and Assumed Flood Probabilities (Environment Agency, 2021)

Risk category	Annual chance of flooding
Very significant	5% or greater (standard of protection less than or equal to 1:20)
Significant risk	Greater than 2% but less than 5% (standard of protection 1:21 to 1:49
Intermediate risk	Greater than 1% but less than 2% (standard of protection 1:50 to 1:99)
Moderate risk	Greater than 0.5 % but less than or equal to 1% (standard of protection 1:100 to 1:199)
Low risk	0.5% or less (standard of protection 1:200 or above)

Table 9-3: Erosion Risk Categories (Environment Agency, 2021)

Risk category	Timescale
Medium Term Loss	<=20 years
Longer Term Loss	>20 years

The Environment Agency has prepared a standard spreadsheet calculator (2020 version) to calculate the level of FCERM GiA based on a series of input parameters. These include whole life option costs, benefits (OM1) and the number of properties moving from one flood risk band to another (OM2s). The partnership funding calculator provides a GiA contribution (£) and an initial 'Raw' OM score which can be used to assess the likelihood of a scheme attracting partnership funding. The GiA contribution represents a theoretical maximum funding value that could be available based upon the outcomes delivered by the scheme.

The DEFRA policy statement puts forward a minimum OM threshold of 100% to receive national funding, but notes that any contributions secured towards projects scoring 100% or above can either a) reduce the cost of the scheme to the national taxpayer, making it more likely to go ahead sooner rather than later or b) be used to help fund other local schemes in the local strategy. For more details and definitions of each term used in the Partnership Funding calculator please refer to the Partnership Funding guidance documents (2021).

9.2 Indicative Partnership Funding Calculations

Indicative Partnership Funding calculations have been undertaken for the overall leading options, the FCERM leading options and the aspirational options in each unit (see Appendix B). However, it should be noted that the Partnership Funding calculator is not strictly intended to be used in this manner (to work out funding for long term strategic options such as this). Instead the funding calculator should only really be used to assess the funding score for individual schemes, where future maintenance / upgrades do not exceed 20% of the original capital cost (see Partnership Funding Guidance[9]).

Consequently, the funding calculations presented here and in Appendix B should be treated as purely an illustration of the potential amount of GiA available for the strategic options across their lifespans, based on the benefits delivered. The scores are not representative of the individual schemes that make up the options and therefore should not be used to indicate how much funding may be available at the scheme level.

[9] Environment Agency (2014) Calculate Grant in Aid funding for flood and coastal erosion risk management projects: Guidance for risk management authorities. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1026853/Calculate_grant-in-aid__GIA__funding_for_FCERM_projects__2014_.pdf [Accessed 29 November 2021]

The scores have been generated by assuming a benefit and cost duration of 100 years (to match the strategic option lifespan). New partnership funding calculators will be required when delivering the individual schemes in the future and these should be calculated over the individual scheme's duration of benefits (e.g. 20 or 50 years).

Table 9-4 below summarises the amount of GiA that will likely be available over the lifespan of each of the strategic options based on the calculations undertaken. As can be seen, ODU 8 (Eastoke) is expected to attract the largest amount of GiA due to the concentration of benefits in this location.

As can be seen in Appendix B, the Partnership Funding scores for the strategic options all fall below the 100% threshold for full GiA funding. As a result, it is likely that the Partnership Funding scores for the individual schemes that form part of each strategic option will also fall below the 100%. Therefore, in order to obtain the GiA amount, further contributions for each scheme will be required from non-GiA sources.

It should also be recognised that for a certain strategic option, the Partnership Funding score presented in Appendix B may not be representative of the funding score for each scheme within that option. It is likely that the scores will vary between schemes within an option, depending on the timing of the scheme and when the majority of benefits are realised. For example, at Eastoke (ODU 8), the funding scores for the schemes in epoch 2 and 3 are likely to be significantly greater than the initial scheme in epoch 1. This is because the majority of benefits with the FCERM and overall leading strategic option for this unit do not come until epoch 2 and therefore the initial scheme will therefore have fewer associated benefits and outcome measures.

Table 9-4: Indicative GiA availability for the strategic options over their 100 year lifespan

ODU	Strategic Option	Estimated amount of GiA available (£k)	Notes
FCERM leading options			
1	Sustain 1.33% AEP with managed realignment	429	
2	Do Nothing	-	No GiA for Do Nothing
3	Sustain 0.5% AEP with managed realignment	1,315	
4	Do Nothing	-	No GiA for Do Nothing
5	Improve from 2071 (Maintain then Improve) 0.5% with managed realignment	1,017	
6	Improve from 2071 (Maintain then Improve) 0.5% Frontline	216	
7	Sustain 0.5% AEP	721	
8	Sustain 0.5% AEP	33,210	
9	Sustain 0.5% AEP Replace Inn on the Beach	1,982	
10	Resilience	424	
11	Improve 0.5% AEP	229	
12	Do Nothing	-	No GiA for Do Nothing
13	Sustain from 2041 (Maintain then Sustain) 0.5% AEP	222	
14	Do Nothing	-	No GiA for Do Nothing
15	Sustain 0.5% AEP	662	
16	Sustain 1.33% AEP	41	
Overall leading options			
1	Sustain 0.5% AEP with managed realignment hybrid	-	BCR < 1, No GiA likely to be available
2	Resilience	-	Separate funding available for resilience*
3	Sustain 0.5% AEP with managed realignment	125	
4	Resilience	-	Separate funding available for resilience*
5	Sustain 1.33% AEP with managed realignment	1,006	

6	Improve from 2071 (Maintain then Improve) 0.5% Frontline	216	
7	Sustain 0.5% AEP	721	
8	Sustain 0.5%	33,169	
9	Sustain 0.5% AEP Maintain Inn on the Beach	1,982	
10	Resilience	424	
11	Sustain 1.33% AEP	236	
12	Do Nothing	-	No GiA for Do Nothing
13	Sustain from 2041 (Maintain then Sustain) 0.5% AEP	222	
14	Do Nothing	-	No GiA for Do Nothing
15	Sustain 0.5% AEP	662	
16	Sustain 0.5% AEP	42	
Aspirational options			
2	Sustain 1.33% AEP	-	BCR < 1, No GiA likely to be available
10	Improve 1.33% AEP	-	BCR < 1, No GiA likely to be available
12	Managed realignment	-	BCR < 1, No GiA likely to be available
14	Sustain 1.33% AEP with managed realignment and relocation of the Billy Trail	-	BCR < 1, No GiA likely to be available

As outlined in Table 9-4, there is a separate funding pot available for resilience schemes whereby flood hit homes and businesses are eligible for up to £5,000 to help protect from future flooding. The grants are available through local authorities and are intended to be used to help pay for a range of property improvements to improve resilience against flooding.

Appendix A Modelling Approach

The economic appraisal used results from the East Solent modelling which showed the flood depth and extent for a range of return periods. Model results provided by the Environment Agency from the original modelling project were used, in addition to new simulations undertaken by AECOM in 2019 and 2021.

The East Solent model requires extensive computing time (a typical simulation takes 48-72 hours) and therefore the project team rationalised in a proportionate manner then number of additional simulations that were required, considering the project program and budget. To do this an equivalencies and substitution approach was adopted, whereby certain model simulations were used to represent different return periods across the various time epochs. This approach was appropriate given the strategic nature of the project. However, more detailed modelling may be required to support scheme level appraisal at a later stage.

Table A 1 below provides a summary of the equivalencies approach for the baseline Do Nothing scenario. The first three columns show the return periods for which flood mapping was needed (see section 2.2 in main report for details on how the extreme water levels were determined). The next three columns to the right show which model simulation was used to produce the flood mapping for each return period. For each return period, the difference between the extreme still water level in the model equivalency and the calculated level based on the original model boundaries adjusted for sea level rise is ±0.08m (calculated at model boundary 1). This is a suitable level of accuracy to inform the option appraisal and economic appraisal of a strategic level study such as this.

Table A 1: Summary of equivalencies approach. Still water levels presented are found at Boundary 1 location

Required flood mapping for project			Model simulation used as equivalency			Difference in water level (m)	Simulation origin
Year	Return period	Still water level (m ODN)	Year	Return period	Still water level (m ODN)		
2021	50% AEP (1:2yr)	2.95	New simulation – no equivalency			0	AECOM 2021
	20% AEP (1:5yr)	3.04	2015	20% (1:5yr)	3.12	+0.08	AECOM 2019
	5% AEP (1:20yr)	3.18	2015	10% (1:10yr)	3.19	+0.01	ESM
	3.33% AEP (1:30yr)	3.21	New simulation – no equivalency			0	AECOM 2021
	1.33% AEP (1:75yr)	3.31	New simulation – no equivalency			0	AECOM 2021
	0.67% AEP (1:150yr)	3.38	New simulation – no equivalency			0	AECOM 2021
	0.5% AEP (1:200yr)	3.41	2015	1% (1:100yr)	3.44	+0.03	ESM
	0.2% AEP (1:500yr)	3.51	2015	0.5% (1:200yr)	3.51	0	ESM
2041	50% AEP (1:2yr)	3.08	2015	20% (1:5yr)	3.12	+0.04	AECOM 2019
	20% AEP (1:5yr)	3.17	2015	10% (1:10yr)	3.19	+0.02	ESM
	5% AEP (1:20yr)	3.31	2015	4% (1:25yr)	3.29	-0.02	ESM
	3.33% AEP (1:30yr)	3.34	2015	3.33% (1:30yr)	3.30	-0.04	ESM
	1.33% AEP (1:75yr)	3.44	2015	1% (1:100yr)	3.44	0	ESM
	0.67% AEP (1:150yr)	3.51	2015	0.5% (1:200yr)	3.51	0	ESM
	0.5% AEP (1:200yr)	3.54	No simulation – interpolated in economics			-	-
	0.2% AEP (1:500yr)	3.64	2015	0.2% (1:500yr)	3.61	-0.03	EMS
2071	50% AEP (1:2yr)	3.35	New simulation – no equivalency			0	AECOM 2021
	20% AEP (1:5yr)	3.44	New simulation – no equivalency			0	AECOM 2021
	5% AEP (1:20yr)	3.58	2031	0.5% (1:200yr)	3.60	+0.02	ESM
	3.33% AEP (1:30yr)	3.62	2071	5% (1:20yr)	3.63	+0.01	AECOM 2019
	1.33% AEP (1:75yr)	3.71	2015	0.1% (1:1000yr)	3.68	-0.03	ESM
	0.67% AEP (1:150yr)	3.78	2071	1.33% (1:75yr)	3.77	-0.01	AECOM 2019
	0.5% AEP (1:200yr)	3.81	2065	0.5% (1:200yr)	3.83	+0.02	ESM
	0.2% AEP (1:500yr)	3.91	2121	20% (1:5yr)	3.91	0	AECOM 2019

Required flood mapping for project			Model simulation used as equivalency			Difference in water level (m)	Simulation origin
Year	Return period	Still water level (m ODN)	Year	Return period	Still water level (m ODN)		
2121	50% AEP (1:2yr)	3.98	2065	0.1% (1:1000yr)	4.00	+0.02	ESM
	20% AEP (1:5yr)	4.07	2121	5% (1:20yr)	4.06	-0.01	AECOM 2019
	5% AEP (1:20yr)	4.21	2121	1.33% (1:75yr)	4.20	-0.01	AECOM 2019
	3.33% AEP (1:30yr)	4.24	2115	0.5% (1:200yr)	4.25	+0.01	ESM
	1.33% AEP (1:75yr)	4.34	New simulation – no equivalency			0	AECOM 2021
	0.67% AEP (1:150yr)	4.41	2115	0.1% (1:1000yr)	4.42	+0.01	ESM
	0.5% AEP (1:200yr)	4.44	New simulation – no equivalency			0	AECOM 2021
	0.2% AEP (1:500yr)	4.54	No simulation – interpolated in economics			-	-

Defended / Undefended modelling

For the Do Nothing scenario both the 2021 and 2041 modelling simulations were based on the 'Defended' model setup. This includes the presence of the existing coastal defences in the model. In 2071 and 2121, the modelling simulations were based on the 'Undefended' model setup, in which the existing defences are removed from the model. The justification for this approach is provided in the points below:

- The defence condition assessment report (AECOM, 2019) identifies the estimated residual lives of the defences around the island. The residual life estimates are variable, with some defences in poor condition having estimated residual lives of 5-10 years. However, many of the defences around the island have estimated residual lives of 15-20 years, with some defences having residual lives 20+ years. These residual life estimates assume no maintenance is undertaken in the future.
- When undertaking the modelling simulations, an island wide assumption on whether the simulation is 'defended' or 'undefended' was required. It was not within the scope of the project to individually identify areas where an 'undefended' or 'defended' approach would be more appropriate and the aim was to make minimal changes to the model setup because the model had been approved for use by the Environment Agency based on its existing setup parameters.
- When coastal defences reach the end of their residual life estimate and eventually fail, it is unlikely that the full length of the asset would fail in one go. Instead, it is likely that assets would fail in certain hotspot locations initially and then the remainder of the defence would gradually fail over time. There is therefore considerable uncertainty in the residual life estimates and for a strategic level study a pragmatic approach to incorporating asset failure into the economics is required.
- To avoid potentially over estimating flood damages / benefits in some locations, a conservative approach was adopted whereby all defences on the island were assumed to remain in place until year 20 (2041). From this point forward, the Annual Average Damages in the economic calculations were interpolated between the 'Defended' 2041 scenario and the 'Undefended' 2071 scenario. Therefore from 2041 onwards, the risk of defences failure starts to be incorporated into the economic damages in a linear manner (0% failure risk in 2041 interpolated up to 100% failure risk by 2071).
- A less conservative approach whereby the 2041 modelling simulations were based on an 'Undefended' scenario was initially considered but not adopted. This approach would have assumed all coastal defences on the island had completely failed by 2041 and in the economic calculations by interpolating between a 2021 'Defended' scenario and a 2041 'Undefended' scenario would have, on average, assumed that the defences would have failed by year 10 in the assessment. This had the potential to significantly overestimate the economic damages for the island as many defences are likely to last longer than this.
- It is noted that the baseline Do Nothing erosion zones developed for the island are based on less conservative assumptions, with erosion starting immediately in the year after the estimated residual life of the defences is exceeded. This is appropriate given that the erosion zone calculations incorporated local level detail on defence residual life and an island wide approach was not required (as it was in the modelling).

Wave overtopping uncertainties

There are some uncertainties associated with the wave overtopping inputs to the East Solent Modelling. These are described below.

Firstly, the beach management activities and existing beach profile on the south side of the island is designed to a 0.5% AEP (1:200) year standard of protection for unimodal waves. However, as outlined in the HR Wallingford Shingle-B Beach modelling report (2021), in the last 10 years several storms events have occurred along the beach defence which triggered flooding events and damages at the rear-side, which were characterised by swell components. HR Wallingford have subsequently undertaken a bimodal wave study and a localised overtopping assessment which suggests that if bimodal waves are considered, the wave overtopping rates in the East Solent Model could be an order of magnitude too small for some return periods and locations. Increased wave overtopping inputs in the East Solent Model could increase the flooding extent and depth of the simulation results on the south side of the island.

This was discussed by the AECOM and Coastal Partners project team and it was agreed that due to the strategic nature of the project, no updates to the wave overtopping boundaries in the model were required. Changes to the overtopping boundaries would have caused extensive delays and required significant additional budget which was not available. Furthermore, for the purpose of the optioneering and economic assessment, the existing Environment Agency approved model setup is sufficient for this project. It should however be recognised that the model extents and depths on the south side of the island are likely conservative and the actual risk may be greater. In subsequent work, such as scheme appraisal or design, it is recommended that the risk of wave overtopping from bimodal waves is studied in more detail and incorporated into any scheme level design. This may involve undertaking additional wave overtopping calculations and modelling to inform the design process.

A further uncertainty associated with wave overtopping relates to the values used in the new modelling simulations undertaken by AECOM in 2019 and 2021. In the original East Solent Modelling build, wave overtopping inputs were only generated for a small number of return period events (full selection of return periods for 2015, then 0.5% and 0.1% return periods for 2031, 2065 and 2115). It was beyond the scope of the Strategy to undertake new wave overtopping calculations for return periods required in the economic assessment and optioneering and therefore the original overtopping values included in the East Solent Model have been used on an equivalency basis in the model simulations. The extreme water level for each overtopping dataset has been used as a proxy for matching appropriate overtopping values to an AECOM simulation. There are clear uncertainties with this approach but for a strategic level project, and for the purposes of informing optioneering in the Strategy it is considered acceptable. Further work should be undertaken at the scheme development stage to reduce uncertainty in the wave overtopping values incorporated into the model (including consideration of bimodal waves).

Appendix B Partnership Funding Scores

Table B 1: Partnership Funding Scores for the FCERM Leading Options

ODU	Strategic Option (for 100 year appraisal period)	Benefit Cost Ratio	Indicative Raw Partnership Funding Score	Approximate contributions required to achieve score of 100% and maintenance	Estimated amount of GiA available over option lifespan
1	**Sustain 1.33% AEP with managed realignment -** Setback embankment on the east and west side, with habitat creation. Increasing length and height over time to keep pace with sea level rise	2.1	22%	£1,482,740	£429,260
2	**Do Nothing –** No Active Intervention. Baseline scenario	N/A	N/A	N/A	N/A
3	**Sustain 0.5% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	1.2	57%	£972,159	£1,314,841
4	**Do Nothing –** No Active Intervention. Baseline scenario	N/A	N/A	N/A	N/A
5	**Improve from 2071 (Maintain then Improve) 0.5% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	2.3	40%	£1,510,462	£1,016,539
6	**Improve from 2071 (Maintain then Improve) 0.5% Frontline –** Maximise the life of existing defences, then implement frontline floodwall	1.9	22%	£769,627	£216,374
7	**Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	2.5	18%	£3,279,926	£721,074
8	**Sustain 0.5% AEP** – Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	4.5	61%	£21,630,147	£33,209,854

ODU	Strategic Option (for 100 year appraisal period)	Benefit Cost Ratio	Indicative Raw Partnership Funding Score	Approximate contributions required to achieve score of 100% and maintenance	Estimated amount of GiA available over option lifespan
9	**Sustain 0.5% AEP Replace Inn on the Beach -** Setback floodwall, increasing length and height over time to keep pace with sea level rise. Replacement of Inn on the Beach with a rock groyne. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	1.0	19%	£8,342,134	£1,981,866
10	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	5.5	33%	£855,860	£424,140
11	**Improve 0.5% AEP –** Floodwall around west side only. Full length and height from present day	2.5	18%	£1,074,874	£229,126
12	**Do Nothing –** No Active Intervention. Baseline scenario	N/A	N/A	N/A	N/A
13	**Sustain from 2041 (Maintain then Sustain) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	9.3	65%	£120,040	£221,960
14	**Do Nothing –** No Active Intervention. Baseline scenario	N/A	N/A	N/A	N/A
15	**Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	1.6	11%	£5,608,195	£661,805
16	**Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	1.7	10%	£369,020	£40,980

Table B 2: Partnership Funding Scores for the Overall Leading Options

ODU	Strategic Option	Benefit Cost Ratio	Indicative Raw Partnership Funding Score	Approximate contributions required to achieve score of 100% and maintenance	Estimated amount of GiA available over option lifespan
1	**Sustain 0.5% AEP with managed realignment hybrid -** Frontline floodwall on the west and setback embankment on the east and frontline embankment in front of historic landfill, with habitat creation. Increasing length and height over time to keep pace with sea level rise	0.8	N/A	N/A	N/A
2	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	0.0	N/A	N/A	N/A
3	**Sustain 0.5% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	2.0	18%	£563,193	£124,807
4	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	0.8	N/A	N/A	N/A
5	**Sustain 1.33% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	1.8	34%	£1,977,054	£1,005,947
6	**Improve from 2071 (Maintain then Improve) 0.5% Frontline –** Maximise the life of existing defences, then implement frontline floodwall	1.9	22%	£769,627	£216,374
7	**Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	2.5	18%	£3,279,926	£721,074
8	**Sustain 0.5%** - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	3.2	43%	£43,673,969	£33,169,031

ODU	Strategic Option	Benefit Cost Ratio	Indicative Raw Partnership Funding Score	Approximate contributions required to achieve score of 100% and maintenance	Estimated amount of GiA available over option lifespan
9	**Sustain 0.5% AEP Maintain Inn on the Beach** – Setback floodwall, increasing length and height over time to keep pace with sea level rise. Capital refurbishment of the defences in front of Inn on the Beach. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	1.0	19%	£8,229,134	£1,981,866
10	**Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	5.5	33%	£855,860	£424,140
11	**Sustain 1.33% AEP –** Floodwall around the west side, followed by a floodwall around the east side in 2041. Increasing length and height over time to keep pace with sea level rise	2.5	18%	£1,067,256	£235,744
12	**Do Nothing –** No Active Intervention. Baseline scenario	N/A	N/A	N/A	N/A
13	**Sustain from 2041 (Maintain then Sustain) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	9.3	65%	£120,040	£221,960
14	**Do Nothing –** No Active Intervention. Baseline scenario	N/A	N/A	N/A	N/A
15	**Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	1.6	11%	£5,608,195	£661,805
16	**Sustain 0.5% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	1.6	9%	£403,420	£41,580

Table B 3: Partnership Funding Scores for the Aspirational Options

ODU	Strategic Option	Benefit Cost Ratio	Indicative Raw Partnership Funding Score	Approximate contributions required to achieve score of 100% and maintenance	Estimated amount of GiA available over option lifespan
2	**Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	0.1	N/A	N/A	N/A
10	**Improve 1.33% AEP –** North side defence, with raising of Ferry Road. Full length and height from present day	0.5	N/A	N/A	N/A
12	**Managed realignment –** Setback earth embankment with habitat creation	0.1	N/A	N/A	N/A
14	**Sustain 1.33% AEP with managed realignment and relocation of the Billy Trail –** Setback earth embankment around assets only, with habitat creation. Increasing length and height over time to keep pace with sea level rise	0.1	N/A	N/A	N/A

Appendix C Benefit Cost Ratios

ODU 1 (Hayling Bridge to Northney Farm)

Table C 1 shows that the majority of strategic options in ODU 1 have an ABCR < 1 and are therefore not economically viable. Options 12, 13, 14, 15, 16, 17 and 18 have ABCR's >1, with option 12; Sustain 1.33% AEP with managed realignment having the greatest ABCR of 2.68. Based on this analysis, option 12 is selected as the provisional leading FCERM option.

Table C 1: ODU 1 (Hayling Bridge to Northney Farm) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	321	1,077	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	1,077	3,022	883	0.82
4. **Sustain 1.33% AEP –** Frontline floodwall on the west side, and a setback embankment on the east side. Increasing length and height over time to keep pace with sea level rise	5,192	12,544	4,334	0.83
5. **Sustain 0.5% AEP –** Frontline floodwall on the west side, and a setback embankment on the east side. Increasing length and height over time to keep pace with sea level rise	5,739	13,440	4,895	0.85
6. **Improve 1.33% AEP –** Frontline floodwall on the west side, and a setback embankment on the east side. Full length and height from present day	7,180	12,521	4,423	0.62
7. **Improve 0.5% AEP –** Frontline floodwall on the west side, and a setback embankment on the east side. Full length and height from present day	7,520	13,050	4,895	0.65
8. **Improve 1.33% AEP with Road Raising -** Raising of Northney Road, and a setback embankment on the east side. Full length and height from present day	16,415	18,905	4,423	0.27
9. **Improve 0.5% AEP with Road Raising -** Raising of Northney Road, and a setback embankment on the east side. Full length and height from present day	16,675	19,276	4,895	0.29
10. **Improve 1.33% AEP with Road Raising and Coastal Remediation -** Raising of Northney Road, a setback embankment on the east side and historic landfill remediation. Full length and height from present day	19,350	21,840	4,423	0.23

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
11. **Improve 0.5% AEP with Road Raising and Coastal Remediation -** Raising of Northney Road, a setback embankment on the east side and historic landfill remediation. Full length and height from present day	19,610	22,211	4,895	0.25
12. **Sustain 1.33% AEP with managed realignment –** Setback embankment on the east and west side, with habitat creation. Increasing length and height over time to keep pace with sea level rise	1,912	4,821	5,116	2.68
13. **Sustain 0.5% AEP with managed realignment -** Setback embankment on the east and west side, with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,341	5,501	5,403	2.31
14. **Sustain 1.33% AEP with managed realignment hybrid -** Frontline floodwall on the west and setback embankment on the east and frontline embankment in front of historic landfill, with habitat creation. Increasing length and height over time to keep pace with sea level rise	5,217	10,407	6,188	1.19
15. **Sustain 0.5% AEP with managed realignment hybrid -** Frontline floodwall on the west and setback embankment on the east and frontline embankment in front of historic landfill, with habitat creation. Increasing length and height over time to keep pace with sea level rise	5,353	10,613	6,749	1.26
16. **Improve 1.33% AEP with managed realignment -** Setback embankment on the east and west side, with habitat creation. Full length and height from present day	3,393	5,288	5,220	1.54
17. **Improve 0.5% AEP with managed realignment -** Setback embankment on the east and west side, with habitat creation. Full length and height from present day	3,678	5,732	5,403	1.47
18. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	1,807	4,689	2,400	1.33

Table C 2 shows a comparison of the provisional leading FCERM option and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1. The Do Minimum and Do Nothing options are also included in this table for comparison purposes. As can be seen, the IBCR between option 12 and option 16 is 0.07, which is significantly below unity and demonstrates that there is no economic case to select option 16 as the new leading FCERM option. As a result, option 12 remains the provisional leading FCERM option.

Table C 2: ODU 1 (Hayling Bridge to Northney Farm) - Strategic Options for a 1.33% AEP, with an ABCR >1

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
12. Sustain 1.33% AEP with managed realignment - Setback embankment on the east and west side, with habitat creation. Increasing length and height over time to keep pace with sea level rise	1,912	4,821	5,116	2.68	NA
16. Improve 1.33% AEP with managed realignment - Setback embankment on the east and west side, with habitat creation. Full length and height from present day	3,393	5,288	5,220	1.54	0.07
18. Resilience – PFR for properties at risk of flooding from a 5% AEP flood event.	1,807	3,933	2,400	1.33	1.78
14. Sustain 1.33% AEP with managed realignment hybrid - Frontline floodwall on the west and setback embankment on the east and frontline embankment in front of historic landfill, with habitat creation. Increasing length and height over time to keep pace with sea level rise	5,217	10,407	6,188	1.19	1.11
2. Do Minimum – Patch and repair on existing assets	321	1,077	0	NA	NA
1. Do Nothing – No Active Intervention. Baseline scenario	0	0	0	NA	NA

Table C 3 shows a comparison between the provisional leading FCERM option and the equivalent option (option 13) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 13), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 0.67, and therefore option 12 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 3: ODU 1 (Hayling Bridge to Northney Farm) - Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
12. Sustain with Managed realignment 1.33% - Setback embankment on the east and west side, with habitat creation. Increasing length and height over time to keep pace with sea level rise	1,912	4,821	5,516	2.68	NA
13. Sustain with Managed realignment 0.5% - Setback embankment on the east and west side, with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,341	5,501	5,403	2.31	0.67

ODU 2 (Northney Marina)

Table C 4 shows that all of the strategic options in ODU 2 have an ABCR < 1 and are therefore not economically viable. Based on this analysis, option 1 is selected as the provisional leading FCERM option.

Table C 4: ODU 2 (Northney Marina) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	303	1,133	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	394	1,229	64	0.16
4. **Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	942	2,225	108	0.11
5. **Sustain 0.5% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	994	2,305	115	0.12
6. **Improve 1.33% AEP –** Frontline floodwall. Full length and height from present day	1,914	2,983	108	0.06
7. **Improve 0.5% AEP –** Frontline floodwall. Full length and height from present day	2,042	3,182	115	0.06
8. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	318	1,050	67	0.21

ODU 3 (Northney Farm to Chichester Road)

Table C 5 shows that the majority of strategic options in ODU 3 have an ABCR < 1 and are therefore not economically viable. Options 14, 15, 16 and 17 have ABCR's >1, with options 14 and 15; Sustain with managed realignment having the greatest ABCRs of 2.68. Based on this analysis, option 14 is selected as the provisional leading FCERM option.

Table C 5: ODU 3 (Northney Farm to Chichester Road) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	338	1,133	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	7,040	9,117	331	0.05
4. **Sustain 1.33% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	13,901	23,018	2,637	0.19
5. **Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	14,886	24,517	2,991	0.20
6. **Improve 1.33% AEP –** Frontline rock revetment. Full length and height from present day	20,473	31,902	2,670	0.13
7. **Improve 0.5% AEP –** Frontline rock revetment. Full length and height from present day	20,473	31,902	2,991	0.15
8. **Improve from 2071 (Maintain then Improve) 1.33% Frontline –** Maximise the life of existing defences, then implement frontline rock revetment	4,413	24,479	1,332	0.30
9. **Improve from 2071 (Maintain then Improve) 0.5% Frontline –** Maximise the life of existing defences, then implement frontline rock revetment	4,223	24,289	1,502	0.36
10. **Improve from 2071 (Maintain then Improve) 1.33% Setback –** Maximise the life of existing defences, then implement setback earth embankment	7,883	13,233	1,332	0.17
11. **Improve from 2071 (Maintain then Improve) 0.5% Setback –** Maximise the life of existing defences, then implement setback earth embankment	7,935	13,625	1,502	0.19
12. **Improve from 2071 (Maintain then Improve) 1.33% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	7,865	13,222	5,135	0.65

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
13. **Improve from 2071 (Maintain then Improve) 0.5% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	7,850	13,207	5,299	0.67
14. **Sustain 1.33% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,252	7,358	6,032	2.68
15. **Sustain 0.5% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,287	7,535	6,140	2.68
16. **Improve 1.33% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	5,246	8,174	6,065	1.16
17. **Improve 0.5% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	5,597	8,721	6,183	1.10
18. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	509	1,618	335	0.66

Table C 6 shows a comparison of the provisional leading FCERM option and the other strategic option that delivers a 1.33% SoP and that has a ABCR >1 (option 16). The Do Minimum and Do Nothing options are also included in this table for comparison purposes. As can be seen, the IBCR between option 14 and option 16 is 0.01, which is significantly below unity and demonstrates that there is no economic case to select option 16 as the new leading FCERM option. As a result, option 14 remains the provisional leading FCERM option.

Table C 6: ODU 3 (Northney Farm to Chichester Road) - Strategic Options for a 1.33% AEP, with an ABCR >1

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
14. Sustain 1.33% AEP with managed realignment – Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,252	7,358	6,032	2.68	NA
16. Improve 1.33% with managed realignment – Maximise the life of existing defences, then implement setback earth embankment with habitat creation	5246	8174	6,065	1.16	0.01
2. Do Minimum – Patch and repair on existing assets	338	1,133	0	NA	NA
1. Do Nothing – No Active Intervention. Baseline scenario	0	0	0	NA	NA

Table C 7 shows a comparison between the provisional leading FCERM option and the equivalent option (option 15) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 15), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 3.01, and therefore option 15 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 7: ODU 3 (Northney Farm to Chichester Road) - Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
14. Sustain 1.33% AEP with managed realignment – Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,252	7,358	6,032	2.68	NA
15. Sustain 0.5% AEP with managed realignment – Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	2,287	7,535	6,140	2.68	3.01

ODU 4 (Chichester Road to Mill Rythe Junior School)

Table C 8 shows that all of the strategic options in ODU 4 have an ABCR < 1 and are therefore not economically viable. Based on this analysis, option 1 is selected as the provisional leading FCERM option.

Table C 8: ODU 4 (Chichester Road to Mill Rythe Junior School) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	904	3,032	41	0.05
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	3,204	8,408	757	0.24
4. **Sustain 1.33% AEP –** Floodwall around assets only. Increasing length and height over time to keep pace with sea level rise	7,752	19,223	4,517	0.58
5. **Sustain 0.5% AEP –** Floodwall around assets only. Increasing length and height over time to keep pace with sea level rise	8,292	20,382	4,753	0.57
6. **Improve 1.33% AEP –** Floodwall around assets only. Full length and height from present day	13,703	21,352	3,691	0.27
7. **Improve 0.5% AEP –** Floodwall around assets only. Full length and height from present day	14,557	22,684	3,891	0.27
8. **Improve 1.33% AEP –** Frontline floodwall. Full length and height from present day	25,900	40,359	5,453	0.21
9. **Improve 0.5% AEP –** Frontline floodwall. Full length and height from present day	26,934	41,971	5,710	0.21
10. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event. This also includes Patch repair on existing assets. H&S compliance.	1,181	3,857	937	0.79

ODU 5 (Mill Rythe Junior School to Salterns Lane)

Table C 9 shows that there are several strategic options for ODU 5 with an ABCR > 1 (Options 3-5, 8-18). Option 16 - Improve from 2071 (Maintain then Improve) 1.33% with managed realignment - has an ABCR of 2.09, and is selected as the provisional leading FCERM option. Although there are some options with a higher ABCR, these are 0.5% SoP. Table C 10 focusses on options with a 1.33% SoP, with Table C 11 comparing these to options with a 0.5% SoP to determine if there is an economic case for a higher SoP.

Table C 9: ODU 5 (Mill Rythe Junior School to Salterns Lane) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	778	2,610	13	0.02
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	1,309	3,851	2,566	1.96
4. **Sustain 1.33% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	3,994	11,304	6,214	1.56
5. **Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	4,769	12,481	7,373	1.55
6. **Improve 1.33% AEP –** Frontline rock revetment. Full length and height from present day	11,010	17,157	6,219	0.56
7. **Improve 0.5% AEP –** Frontline rock revetment. Full length and height from present day	12,314	19,188	7,373	0.60
8. **Improve from 2071 (Maintain then Improve) 1.33% Frontline –** Maximise the life of existing defences, then implement frontline rock revetment	3,044	14,558	4,358	1.43
9. **Improve from 2071 (Maintain then Improve) 0.5% Frontline –** Maximise the life of existing defences, then implement frontline rock revetment	3,238	15,983	6,768	2.09
10. **Improve from 2071 (Maintain then Improve) 1.33% Setback –** Maximise the life of existing defences, then implement setback earth embankment	2,564	9,716	4,358	1.70
11. **Improve from 2071 (Maintain then Improve) 0.5% Setback –** Maximise the life of existing defences, then implement setback earth embankment	2,506	9,631	6,768	2.70
12. **Sustain 1.33% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	4,671	9,113	7,116	1.52

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
13. **Sustain 0.5% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	5,506	11,398	7,724	1.40
14. **Improve 1.33% with managed realignment –** Setback earth embankment with habitat creation. Full length and height from present day	6,038	9,409	7,120	1.18
15. **Improve 0.5% with managed realignment –** Setback earth embankment with habitat creation. Full length and height from present day	6,038	9,409	7,724	1.28
16. **Improve from 2071 (Maintain then Improve) 1.33% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	2,527	9,417	5,274	2.09
17. **Improve from 2071 (Maintain then Improve) 0.5% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	2,527	9,417	7,683	3.04
18. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	1,196	3,960	1,447	1.21

Table C 10 shows a comparison of the provisional leading FCERM option (option 16) and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1. The Do Minimum and Do Nothing options are also included in this table for comparison purposes. There is justification for option 16 remaining as the provisional leading option, as the next option is maintain which would result in a lower SoP with less benefits delivered. If the IBCR for each of the alternative options was calculated against the provisional leading option, they would all be <1.

Table C 10: ODU 5 (Mill Rythe Junior School to Salterns Lane) - Strategic Options for a 1.33% AEP, with an ABCR >1

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
16. **Improve from 2071 (Maintain then Improve) 1.33% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	2,527	9,417	5,274	2.09	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	1,309	3,851	2,566	1.96	NA
10. **Improve from 2071 (Maintain then Improve) 1.33% Setback –** Maximise the life of existing defences, then implement setback earth embankment	2,564	9,716	4,358	1.70	1.43
4. **Sustain 1.33% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	3,994	11,304	6,214	1.56	1.30
11. **Sustain 1.33% AEP with managed realignment –** Setback earth embankment with habitat creation. Increasing length and height over time to keep pace with sea level rise	4,671	9,113	7,116	1.52	1.33
9. **Improve from 2071 (Maintain then Improve) 1.33% Frontline –** Maximise the life of existing defences, then implement frontline rock revetment	3,044	14,558	4,358	1.43	NA
17. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	1,196	3,960	1,447	1.21	NA

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
14. **Improve 1.33% with managed realignment –** Setback earth embankment with habitat creation. Full length and height from present day	6,038	9,409	7,120	1.18	1.17
2. **Do Minimum –** Patch and repair on existing assets	778	2,610	13	0.02	NA
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA	NA

Table C 11 shows a comparison between the provisional leading FCERM option and the equivalent option (option 17) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 17), the IBCR between the two options needs to exceed three. However in this case, option 17 provides more benefits for the same cost and therefore is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 11: ODU 5 (Mill Rythe Junior School to Salterns Lane) - Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
16. **Improve from 2071 (Maintain then Improve) 1.33% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	2,527	9,417	5,274	2.09	NA
17. **Improve from 2071 (Maintain then Improve) 0.5% with managed realignment –** Maximise the life of existing defences, then implement setback earth embankment with habitat creation	2,527	9,417	7,683	3.04	0.00

ODU 6 (Salterns Lane to Wilsons Boat Yard)

Table C 12 shows that the majority of strategic options in ODU 6 have an ABCR < 1 and are therefore not economically viable. Options 3, 8, 9 and 12 have ABCR's >1, with option 8 – Improve from 2071 (Maintain then Improve) 1.33% Frontline - having the greatest ABCR of those options providing a 1.33% AEP (2.24). Based on this analysis, option 8 is selected as the provisional leading FCERM option.

Table C 12: ODU 6 (Salterns Lane to Wilsons Boat Yard) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	118	395	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	830	2,061	829	1.00
4. **Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	2,807	5,028	1,979	0.71
5. **Sustain 0.5% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	2,941	5,230	2,493	0.85
6. **Improve 1.33% AEP –** Frontline floodwall. Full length and height from present day	3,837	5,978	1,997	0.52
7. **Improve 0.5% AEP –** Frontline floodwall. Full length and height from present day	3,973	6,192	2,493	0.63
8. **Improve from 2071 (Maintain then Improve) 1.33% Frontline –** Maximise the life of existing defences, then implement frontline floodwall	977	5,026	2,194	2.24
9. **Improve from 2071 (Maintain then Improve) 0.5% Frontline –** Maximise the life of existing defences, then implement frontline floodwall	986	5,166	2,299	2.33
10. **Advance the Line 0.5% –** Creek barrier	12,281	19,349	2,493	0.20
11. **Advance the Line (from 2071) 0.5% –** Maximise the life of existing defences, then implement a creek barrier	2,539	14,624	2,299	0.91
12. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	1,039	2,676	1,620	1.56

Table C 13 shows a comparison of the provisional leading FCERM option and the other strategic options that have a ABCR >1. The Do Minimum and Do Nothing options are also included in this table for comparison purposes. As can be seen, the IBCR between option 12 and option 8 is NA as the option benefits decrease between these options. The choice of the provisional leading economic option therefore remains unchanged.

Table C 13: ODU 6 (Salterns Lane to Wilsons Boat Yard) - Strategic Options for a 1.33% AEP, with an ABCR >1

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
8. Improve from 2071 (Maintain then Improve) 1.33% Frontline – Maximise the life of existing defences, then implement frontline floodwall	977	5,026	2,194	2.24	NA
12. Resilience – PFR for properties at risk of flooding from a 5% AEP flood event.	1,039	2,676	1,620	1.56	NA
3. Maintain – Capital refurbishment and patch and repair on existing assets	830	2,061	829	1.00	NA
2. Do Minimum – Patch and repair on existing assets	118	395	0	NA	NA
1. Do Nothing – No Active Intervention. Baseline scenario	0	0	0	NA	NA

Table C 14 shows a comparison between the provisional leading FCERM option and the equivalent option (option 9) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 9), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 12.90, and therefore option 9 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 14: ODU 6 (Salterns Lane to Wilsons Boat Yard) - Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
8. **Improve from 2071 (Maintain then Improve) 1.33% Frontline –** Maximise the life of existing defences, then implement frontline floodwall	977	5,026	2,194	2.24	NA
9. **Improve from 2071 (Maintain then Improve) 0.5% Frontline –** Maximise the life of existing defences, then implement frontline floodwall	986	5,166	2,299	2.33	12.90

ODU 7 (Wilsons Boat Yard to Fishery Creek)

Table C 15 shows that there are several strategic options for ODU 7 with an ABCR > 1 (Options 3-11). Option 3 - Maintain - has the greatest ABCR of 5.66. Based on this analysis, option 3 is selected as the provisional leading FCERM option.

Table C 15: ODU 7 (Wilsons Boat Yard to Fishery Creek) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	391	1,313	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	913	2,532	5,169	5.66
4. **Sustain 1.33% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	3,607	8,141	11,224	3.11
5. **Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	4,001	8,739	12,878	3.22
6. **Improve 1.33% AEP –** Frontline rock revetment. Full length and height from present day	9,024	14,062	11,508	1.28
7. **Improve 0.5% AEP –** Frontline rock revetment. Full length and height from present day	9,945	15,497	12,878	1.29
8. **Sustain 1.33% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	3,666	8,367	11,224	3.06
9. **Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	3,914	8,744	12,878	3.29
10. **Improve 1.33% AEP –** Setback earth embankment. Full length and height from present day	5,728	9,332	11,508	2.01
11. **Improve 0.5% AEP –** Setback earth embankment. Full length and height from present day	6,113	9,932	12,878	2.11
12. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	3,939	6,208	2,987	0.76

Table C 16 shows a comparison of the provisional leading FCERM option (option 3) and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1. The Do Minimum and Do Nothing options are also included in this table for comparison purposes. There is justification for option 4 to become the provisional leading option, as it has an IBCR >1.

Table C 16: ODU 7 (Wilsons Boat Yard to Fishery Creek) - Strategic Options for a 1.33% AEP, with an ABCR >1

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	913	2,532	2,122	5.66	NA
4. **Sustain 1.33% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	3,607	8,141	11,224	3.11	2.25
8. **Sustain 1.33% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	3,666	8,367	11,224	3.06	NA
10. **Improve 1.33% AEP –** Setback earth embankment. Full length and height from present day	5,728	9,332	11,508	2.01	0.14
6. **Improve 1.33% AEP –** Frontline rock revetment. Full length and height from present day	9,024	14,062	11,508	1.28	NA
2. **Do Minimum –** Patch and repair on existing assets	118	395	0	0.01	NA
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA	NA

Table C 17 shows a comparison between the provisional leading FCERM option and the equivalent option (option 5) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 5), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 4.02, and therefore option 5 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 17: ODU 7 (Wilsons Boat Yard to Fishery Creek) - Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
4. **Sustain 1.33% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	3,607	8,141	11,224	3.11	NA
5. **Sustain 0.5% AEP –** Frontline rock revetment. Increasing length and height over time to keep pace with sea level rise	4,001	8,739	12,878	3.22	4.20

ODU 8 (Eastoke)

Table C 18 shows that all of the options for ODU 8 which involve the construction of new defences have an ABCR > 1 (Options 4-27). As such, there is an economic justification to move beyond 'Do Nothing', 'Do Minimum', 'Maintain' and 'Resilience'. The remaining options have been organised by the different defence measures in Table C 19 to Table C 21show a comparison of the provisional leading FCERM option for concrete revetments (option 14) and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1.

Table C 18: ODU 8 (Eastoke) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	20,135	73,198	5,450	0.27
3. **Maintain –** Capital refurbishment and patch and repair on existing assets. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	23,156	80,259	199,665	8.62
4. **Sustain 1.33%** - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	53,981	13,0573	243,208	4.51
5. **Sustain 0.5%** - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	54,840	132,001	250,085	4.56
6. **Sustain 1.33%** - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	74,597	163,066	243,208	3.26

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
7. **Sustain 0.5%** - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	76,843	167,042	250,085	3.25
8. **Sustain 1.33%** - Combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	79,546	169,369	243,208	3.06
9. **Sustain 0.5%** - Combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	50,040	172,245	250,085	5.00
10. **Improve 1.33%** - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	60,313	134,135	243,466	4.04
11. **Improve 0.5%** - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	61,410	135,845	250,085	4.07
12. **Improve 1.33%** - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	94,527	187,450	243,466	2.58

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
13. Improve 0.5% - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	98,659	193,888	250,085	2.53
14. Improve 1.33% - Combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	97,280	191,739	243,466	2.50
15. Improve 0.5% - Combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	99,582	195,327	250,085	2.51
16. Sustain from 2041 (Maintain then Sustain) 1.33% - Maximise the life of existing defences, then implement a combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	50,380	132,764	213,460	4.24
17. Sustain from 2041 (Maintain then Sustain) 0.5% - Maximise the life of existing defences, then implement a combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	50,857	134,141	215,911	4.25
18. Sustain from 2041 (Maintain then Sustain) 1.33% - Maximise the life of existing defences, then implement a combination of rock revetment floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	62,986	168,160	213,460	3.39

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
19. Sustain from 2041 (Maintain then Sustain) 0.5% - Maximise the life of existing defences, then implement a combination of rock revetment floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	64,218	171,926	215,911	3.36
20. Sustain from 2041 (Maintain then Sustain) 1.33% - Maximise the life of existing defences, then implement a combination of concrete revetment floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	65,158	173,224	213,460	3.28
21. Sustain from 2041 (Maintain then Sustain) 0.5% - Maximise the life of existing defences, then implement a combination of concrete revetment floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	66,170	175,909	215,911	3.26
22. Improve from 2041 (Maintain then Improve) 1.33% - Maximise the life of existing defences, then implement a combination of crest raising, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	52,963	136,908	213,590	4.03
23. Improve from 2041 (Maintain then Improve) 0.5% - Maximise the life of existing defences, then implement a combination of crest raising, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	53,516	138,443	215,911	4.03

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
24. **Improve from 2041 (Maintain then Improve) 1.33%** - Maximise the life of existing defences, then implement a combination of rock revetment, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	70,191	184,755	213,590	3.04
25. **Improve from 2041 (Maintain then Improve) 0.5%** - Maximise the life of existing defences, then implement a combination of rock revetment, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	72,271	190,533	215,911	2.99
26. **Improve from 2041 (Maintain then Improve) 1.33%** - Maximise the life of existing defences, then implement a combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	71,577	188,604	213,590	2.98
27. **Improve from 2041 (Maintain then Improve) 0.5%** - Maximise the life of existing defences, then implement a combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	72,736	191,824	215,911	2.97
28. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	26,047	86,313	33,019	1.27

Table C 19 shows a comparison of the provisional leading FCERM option for crest raising (option 4) and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1. The IBCR of option 16 is NA, as the benefits and costs are both reduced in comparison to the provisional leading option. As a result, option 4 remains the provisional leading FCERM option.

Table C 19: ODU 8 (Eastoke) – Strategic Options for a 1.33% AEP, with an ABCR >1 – Crest raising, floodwalls and setback floodwalls

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
4. Sustain 1.33% - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	53,981	130,573	243,208	4.51	NA
16. Sustain from 2041 (Maintain then Sustain) 1.33% - Maximise the life of existing defences, then implement a combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	50,380	132,764	213,460	4.24	NA
10. Improve 1.33% - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	60,313	134,135	243,466	4.04	3.02
22. Improve from 2041 (Maintain then Improve) 1.33% - Maximise the life of existing defences, then implement a combination of crest raising, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	52,963	136,908	213,590	4.03	NA

Table C 20 shows a comparison of the provisional leading FCERM option for rock revetments (option 18) and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1. As can be seen, the IBCR between option 18 and option 6 is 2.56, which is significantly above unity and demonstrates that there is an economic case to select option 6 as the new leading FCERM option.

Table C 20: ODU 8 (Eastoke) – Strategic Options for a 1.33% AEP, with an ABCR >1 – Rock revetment, floodwalls and setback floodwalls

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
18. Sustain from 2041 (Maintain then Sustain) 1.33% - Maximise the life of existing defences, then implement a combination of rock revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	62,986	168160	213,460	3.39	NA
6. Sustain 1.33% - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	74,597	163066	243,208	3.26	2.56
24. Improve from 2041 (Maintain then Improve) 1.33% - Maximise the life of existing defences, then implement a combination of rock revetment, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	70,191	184755	213,590	3.04	NA
12. Improve 1.33% - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	94,527	187,450	243,466	2.58	1.23

Table C 21 shows a comparison of the provisional leading FCERM option for concrete revetments (option 20) and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1. As can be seen, the IBCR between option 20 and option 8 is 2.07, which is significantly above unity and demonstrates that there is an economic case to select option 8 as the new leading FCERM option.

Table C 21: ODU 8 (Eastoke) – Strategic Options for a 1.33% AEP, with an ABCR >1 – Concrete revetment, floodwalls and setback floodwalls

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
20. Sustain from 2041 (Maintain then Sustain) 1.33% - Maximise the life of existing defences, then implement a combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	65,158	173,224	213,460	3.28	NA
8. Sustain 1.33% - Combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	79,546	169,369	243,208	3.06	2.07
26. Improve from 2041 (Maintain then Improve) 1.33% - Maximise the life of existing defences, then implement a combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Full length and height from 2041. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	71,577	188,604	213,590	2.98	NA
14. Improve 1.33% - Combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Full length and height from present day. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	97,280	191,739	243,466	2.50	1.16

Table C 22 compares the provisional leading FCERM option for each defence measure – options 4, 6 and 8. As they all have equal benefits, the IBCR cannot be calculated. Option 4 remains the provisional leading FCERM option as it is the lowest cost solution, with the highest ABCR.

Table C 22: ODU 8 (Eastoke) – Comparison of Leading FCERM options for each defence measure

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
4. **Sustain 1.33%** - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	53,981	130,573	243,208	4.51	NA
6. **Sustain 1.33%** - Combination of rock revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	74,597	163,066	243,208	3.26	NA
8. **Sustain 1.33%** - Combination of concrete revetment, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	79,546	169,369	243,208	3.06	NA

Table C 23 shows a comparison between the provisional leading FCERM option and the equivalent option (option 5) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 17), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 8.01, and therefore option 5 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 23: ODU 8 (Eastoke) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
4. **Sustain 1.33%** - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	53,981	130,573	243,208	4.51	NA
5. **Sustain 0.5%** - Combination of crest raising, floodwalls and setback floodwalls across the frontage. Increasing length and height over time to keep pace with sea level rise. Includes beach management (replacement of all groynes with new rock groynes, beach nourishment and beach recycling)	54,840	132,001	250,085	4.56	8.01

ODU 9 (Eastoke Corner to Inn on the Beach)

Table C 24 shows that the majority of strategic options in ODU 9 have an ABCR < 1 and are therefore not economically viable. Options 5 and 7 have ABCR's >1, with option 7; Sustain 0.5% AEP replace Inn on the Beach having the greatest ABCR of 1.03. Based on this analysis, option 7 is selected as the provisional leading FCERM option.

Table C 24: ODU 9 (Eastoke Corner to Inn on the Beach) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	6,393	21,205	2,344	0.37
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	7,625	24,086	4,531	0.59
4. **Sustain 1.33% AEP Maintain Inn on the Beach** - Setback floodwall, increasing length and height over time to keep pace with sea level rise. Capital refurbishment of the defences in front of Inn on the Beach. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	9,541	28,795	8,469	0.89
5. **Sustain 0.5% AEP Maintain Inn on the Beach** - Setback floodwall, increasing length and height over time to keep pace with sea level rise. Capital refurbishment of the defences in front of Inn on the Beach. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	10,324	30,635	10,543	1.02
6. **Sustain 1.33% AEP Replace Inn on the Beach -** Setback floodwall, increasing length and height over time to keep pace with sea level rise. Replacement of Inn on the Beach with a rock groyne. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	9,448	28,503	8,469	0.90
7. **Sustain 0.5% AEP Replace Inn on the Beach -** Setback floodwall, increasing length and height over time to keep pace with sea level rise. Replacement of Inn on the Beach with a rock groyne. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	10,211	30,313	10,543	1.03

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
8. **Improve 1.33% AEP Remove Inn on the Beach** – Setback floodwall, full length and height from present day. Beach management including replacement of the timber groynes with rock groynes (extending the size of the groyne field to the full frontage), beach nourishment and beach recycling	13,820	32,085	8,702	0.63
9. **Improve 0.5% AEP Remove Inn on the Beach** - Setback floodwall, full length and height from present day. Beach management including replacement of the timber groynes with rock groynes (extending the size of the groyne field to the full frontage), beach nourishment and beach recycling	14,328	32,876	10,543	0.74
10. **Sustain from 2041 (Maintain then Sustain) 1.33% AEP -** Maximise the life of existing defences, then implement a rock revetment. Increasing length and height over time to keep pace with sea level rise	10,327	27,898	5,571	0.54
11. **Sustain from 2041 (Maintain then Sustain) 0.5% AEP** - Maximise the life of existing defences, then implement a rock revetment. Increasing length and height over time to keep pace with sea level rise	10,876	29,565	6,001	0.55
12. **Improve from 2041 (Maintain then Improve) 1.33% AEP** - Maximise the life of existing defences, then implement a rock revetment. Full length and height from present day	15,978	39,348	5,586	0.35
13. **Improve from 2041 (Maintain then Improve) 0.5% AEP** - Maximise the life of existing defences, then implement a rock revetment. Full length and height from present day	16,778	41,570	6,001	0.36
14. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	6,582	21,795	4,548	0.69

Table C 25 shows a comparison between the provisional leading FCERM option and option 5, which also has an ABCR >1. None of the options with a 1.33% SoP have an ABCR >1, therefore only the 0.5% SoP options have been considered. As can be seen, the IBCR to the option 7 is NA, and therefore option 5 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 25: ODU 9 (Eastoke Corner to Inn on the Beach) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
5. **Sustain 0.5% AEP Replace Inn on the Beach -** Setback floodwall, increasing length and height over time to keep pace with sea level rise. Replacement of Inn on the Beach with a rock groyne. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	10,211	30,313	10,543	1.03	NA
7. **Sustain 0.5% AEP Maintain Inn on the Beach** – Setback floodwall, increasing length and height over time to keep pace with sea level rise. Capital refurbishment of the defences in front of Inn on the Beach. Beach management including replacement of the timber groynes with rock groynes (same size of groyne field), beach nourishment and beach recycling	10,324	30,635	10,543	1.02	NA

ODU 10 (Inn on the Beach to North Shore Road)

Table C 26 shows that the majority of strategic options in ODU 10 have an ABCR < 1 and are therefore not economically viable. Options 3 and 10 have ABCR's >1, option 10; resilience has the greatest ABCR of 2.84. Based on this analysis, option 10 is selected as the provisional leading FCERM option.

Table C 26: ODU 10 (Inn on the Beach to North Shore Road) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	966	3,239	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	1,407	4,271	3,326	2.36
4. **Sustain 1.33% AEP –** North side defence, with raising of Ferry Road. Increasing length and height over time to keep pace with sea level rise	27,441	54,483	9,472	0.35
5. **Sustain 0.5% AEP –** North side defence, with raising of Ferry Road. Increasing length and height over time to keep pace with sea level rise	28,013	55,187	9,969	0.36
6. **Improve 1.33% AEP –** Defences on the north and south side. North side defence, with raising of Ferry Road. Full length and height from present day	18,055	28,135	9,472	0.52
7. **Improve 0.5% AEP –** Defences on the north and south side. North side defence, with raising of Ferry Road. Full length and height from present day	14,729	22,952	9,969	0.68
8. **Improve 1.33% AEP –** North side defence, with raising of Ferry Road. Full length and height from present day	51,951	56,635	9,546	0.18
9. **Improve 0.5% AEP –** North side defence, with raising of Ferry Road. Full length and height from present day	52,677	57,653	9,969	0.19
10. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	1,280	4,104	3,634	2.84

Table C 27 shows a comparison of the provisional leading FCERM option and the other strategic option that has a ABCR >1 (option 3). The IBCR of option 3 is NA, as the benefits are reduced and the costs increased in comparison to the provisional leading option. As a result, option 10 remains the leading FCERM option.

Table C 27: ODU 10 (Inn on the Beach to North Shore Road) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
10. Resilience – PFR for properties at risk of flooding from a 5% AEP flood event	1,280	4,104	3,634	2.84	NA
3. Maintain – Capital refurbishment and patch and repair on existing assets	1,407	4,271	3,326	2.36	NA
2. Do Minimum – Patch and repair on existing assets	966	3,239	0	NA	NA
1. Do Nothing – No Active Intervention. Baseline scenario	0	0	0	NA	NA

ODU 11 (North Shore Road)

Table C 28 shows that the majority of strategic options in ODU 16 have an ABCR < 1 and are therefore not economically viable. Options 3-7, 10, 11 and 14 have ABCR's >1. Option 6 – Improve 1.33% AEP - has an ABCR of 2.40, and is selected as the provisional leading FCERM option. Although there are some options with a higher ABCR, these are 0.5% SoP. Table C 29 focusses on options with a 1.33% SoP, with Table C 30 comparing these to options with a 0.5% SoP to determine if there is an economic case for a higher SoP.

Table C 28: ODU 11 (North Shore Road) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	155	521	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	1,104	2,739	2,194	1.99
4. **Sustain 1.33% AEP –** Floodwall around the west side, followed by a floodwall around the east side in 2041. Increasing length and height over time to keep pace with sea level rise	2,508	7,496	2,942	1.17
5. **Sustain 0.5% AEP –** Floodwall around the west side, followed by a floodwall around the east side in 2041. Increasing length and height over time to keep pace with sea level rise	3,020	8,807	3,278	1.09
6. **Improve 1.33% AEP –** Floodwall around west side only. Full length and height from present day	1,225	2,200	2,943	2.40
7. **Improve 0.5% AEP –** Floodwall around west side only. Full length and height from present day	1,303	2,322	3,278	2.52
8. **Improve 1.33% AEP –** Frontline floodwall. Full length and height from present day	6,867	10,701	2,943	0.43
9. **Improve 0.5% AEP –** Frontline floodwall. Full length and height from present day	7,299	11,374	3,278	0.45
10. **Sustain (2041) 1.33% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	2,994	9,029	3,126	1.04
11. **Sustain (2041) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	3,085	9,277	3,219	1.04
12. **Improve (2041) 1.33% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Full length and height from present day	3,544	9,717	3,157	0.89

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
13. **Improve (2041) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Full length and height from present day	3,762	10,321	3,247	0.86
14. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	1,166	2,350	2,339	2.01

Table C 29 shows a comparison of the provisional leading FCERM option (option 6) and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1. The Do Minimum and Do Nothing options are also included in this table for comparison purposes. There is justification for option 6 remaining as the provisional leading option, as the next option is resilience which would result in a lower SoP with less benefits delivered. If the IBCR for each of the alternative options was calculated against the provisional leading option, they would all be <1.

Table C 29: ODU 11 (North Shore Road) – Strategic Options for a 1.33% AEP, with an ABCR >1

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
6. **Improve 1.33% AEP –** Floodwall around west side only. Full length and height from present day	1,225	2,200	2,943	2.40	NA
14. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	1,166	2,350	2,339	2.01	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	1,104	2,739	2,194	1.99	2.36
4. **Sustain 1.33% AEP –** Floodwall around the west side, followed by a floodwall around the east side in 2041. Increasing length and height over time to keep pace with sea level rise	2,508	7,496	2,942	1.17	0.53
10. **Sustain (2041) 1.33% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	2,994	9,029	3,126	1.04	0.38
2. **Do Minimum –** Patch and repair on existing assets	155	521	0	NA	NA
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA	NA

Table C 30 shows a comparison between the provisional leading FCERM option and the equivalent option (option 7) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 7), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 4.29, and therefore option 5 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 30: ODU 11 (North Shore Road) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
6. **Improve 1.33% AEP –** Floodwall around west side only. Full length and height from present day	1,225	2,200	2,943	2.40	NA
7. **Improve 0.5% AEP –** Floodwall around west side only. Full length and height from present day	1,303	2,322	3,278	2.52	4.29

ODU 12 (North Shore Road to Newtown)

Table C 31 shows that all of the strategic options in ODU 12 have an ABCR < 1 and are therefore not economically viable. Based on this analysis, option 1 is selected as the provisional leading FCERM option.

Table C 31: ODU 12 (North Shore Road to Newtown) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Erosion Protection –** Concrete revetment	2,339	3,645	61	0.03
3. **Erosion Protection –** Gabions	421	655	61	0.15
4. **Erosion Protection –** Rock revetment	284	443	61	0.22
5. **Managed realignment –** Setback earth embankment with habitat creation	601	836	558	0.93

ODU 13 (Newtown)

Table C 32 shows that there are several strategic options for ODU 13 with an ABCR > 1 (Options 3-12). Option 4 – Sustain from 2041 (Maintain then Sustain) 1.33% - has an ABCR of 10.09, and is selected as the provisional leading FCERM option. Based on this analysis, option 4 is selected as the provisional leading FCERM option.

Table C 32: ODU 13 (Newtown) - All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	53	176	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	88	258	578	6.60
4. **Sustain from 2041 (Maintain then Sustain) 1.33% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	311	955	3,136	10.09
5. **Sustain from 2041 (Maintain then Sustain) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	342	1,045	3,298	9.65
6. **Improve from 2041 (Maintain then Improve) 1.33% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Full length and height from present day	450	1,209	3,134	6.96
7. **Improve from 2041 (Maintain then Improve) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Full length and height from present day	492	1,285	3,298	6.70
8. **Sustain from 2041 (Maintain then Sustain) 1.33% AEP with managed realignment –** Maximise the life of existing defences, then implement a setback earth embankment. Maintain frontline defences, operating a regulated tidal exchange. Increasing length and height over time to keep pace with sea level rise	469	1,459	3,138	6.70
9. **Sustain from 2041 (Maintain then Sustain) 0.5% AEP with managed realignment –** Maximise the life of existing defences, then implement a setback earth embankment. Maintain frontline defences, operating a regulated tidal exchange. Increasing length and height over time to keep pace with sea level rise	491	1,515	3,298	6.72

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
10. **Improve from 2041 (Maintain then Improve) 1.33% AEP with managed realignment –** Maximise the life of existing defences, then implement a setback earth embankment. Maintain frontline defences, operating a regulated tidal exchange. Full length and height from present day	593	1,630	3,138	5.29
11. **Improve from 2041 (Maintain then Improve) 0.5% AEP with managed realignment –** Maximise the life of existing defences, then implement a setback earth embankment. Maintain frontline defences, operating a regulated tidal exchange. Full length and height from present day	629	1,728	3,298	5.24
12. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	218	870	1,033	4.73

Table C 33 shows a comparison of the provisional leading FCERM option and the other strategic options that deliver a 1.33% SoP and that has a ABCR >1. The Do Minimum and Do Nothing options are also included in this table for comparison purposes. The IBCR of option 6 is NA, as the benefits are reduced the costs increased in comparison to the provisional leading option. As a result, option 4 remains the leading FCERM option.

Table C 33: ODU 13 (Newtown) - Strategic Options for a 1.33% AEP, with an ABCR >1

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
4. **Sustain from 2041 (Maintain then Sustain) 1.33% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	311	955	3,136	10.09	NA
6. **Improve from 2041 (Maintain then Improve) 1.33% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Full length and height from present day	450	1,209	3,134	6.96	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	88	258	578	6.60	NA
12. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event	218	870	1,033	4.73	3.48

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
8. **Sustain from 2041 (Maintain then Sustain) 1.33% AEP with managed realignment –** Maximise the life of existing defences, then implement a setback earth embankment. Maintain frontline defences, operating a regulated tidal exchange. Increasing length and height over time to keep pace with sea level rise	469	1,459	3,138	6.70	8.41
10. **Improve from 2041 (Maintain then Improve) 1.33% AEP with managed realignment –** Maximise the life of existing defences, then implement a setback earth embankment. Maintain frontline defences, operating a regulated tidal exchange. Full length and height from present day	593	1,630	3,138	5.29	NA
2. **Do Minimum –** Patch and repair on existing assets	53	176	0	0.00	NA
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0.00	NA

Table C 34 shows a comparison between the provisional leading FCERM option and the equivalent option (option 5) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 5), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 5.19, and therefore option 5 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 34: ODU 13 (Newtown) - Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
4. **Sustain from 2041 (Maintain then Sustain) 1.33% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	311	955	3,136	10.09	NA
5. **Sustain from 2041 (Maintain then Sustain) 0.5% AEP –** Maximise the life of existing defences, then implement a frontline floodwall. Increasing length and height over time to keep pace with sea level rise	342	1,045	3,298	9.65	5.19

ODU 14 (Newtown to Stoke)

Table C 35 shows that all of the strategic options in ODU 14 have an ABCR < 1 and are therefore not economically viable. Based on this analysis, option 1 is selected as the provisional leading FCERM option.

Table C 35: ODU 14 (Newtown to Stoke) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	371	1,243	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	725	1,835	0	NA
4. **Erosion Protection –** Frontline rock revetment	1,245	1,940	0	NA
5. **Sustain (2041) 1.33% AEP -** Maximise the life of existing defences and implement a frontline rock revetment from present day, then implement setback earth embankment. Increasing length and height over time to keep pace with sea level rise	1,389	2,515	125	0.09
6. **Sustain (2041) 0.5% AEP -** Maximise the life of existing defences and implement a frontline rock revetment from present day, then implement setback earth embankment. Increasing length and height over time to keep pace with sea level rise	1,788	3,161	136	0.08
7. **Improve (2041) 1.33% AEP -** Maximise the life of existing defences and implement a frontline rock revetment from present day, then implement setback earth embankment. Full length and height from present day	1,484	2,604	125	0.08
8. **Improve (2041) 1.33% AEP -** Maximise the life of existing defences and implement a frontline rock revetment from present day, then implement setback earth embankment. Full length and height from present day	1,888	3,264	136	0.07
9. **Sustain 1.33% AEP with managed realignment and relocation of the Billy Trail –** Setback earth embankment around assets only, with habitat creation. Increasing length and height over time to keep pace with sea level rise	3,682	4,148	429	0.12

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
10. **Sustain 0.5% AEP with managed realignment and relocation of the Billy Trail –** Setback earth embankment around assets only, with habitat creation. Increasing length and height over time to keep pace with sea level rise	3,782	4,251	440	0.12
11. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	11	35	0	NA

ODU 15 (Stoke to Langstone Bridge Carpark)

Table C 36 shows that there are several strategic options for ODU 15 with an ABCR > 1 (Options 3-5, 7-11). Option 3 - Maintain - has the greatest ABCRs of 2.67. Based on this analysis, option 3 is selected as the provisional leading FCERM option.

Table C 36: ODU 15 (Stoke to Langstone Bridge Carpark) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	391	1,312	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	1,303	3,443	3,481	2.67
4. **Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	7,630	13,959	10,312	1.35
5. **Sustain 0.5% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	8,017	14,315	11,600	1.45
6. **Improve 1.33% AEP –** Frontline floodwall. Full length and height from present day	10,793	16,819	10,372	0.96
7. **Improve 0.5% AEP –** Frontline floodwall. Full length and height from present day	11,243	17,519	11,600	1.03
8. **Sustain 1.33% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	6,025	9,291	10,312	1.71
9. **Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	6,270	9,722	11,600	1.85
10. **Improve 1.33% AEP –** Setback earth embankment. Full length and height from present day	7,717	10,073	10,372	1.34
11. **Improve 0.5% AEP –** Setback earth embankment. Full length and height from present day	8,087	10,650	11,600	1.43
12. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	846	2,907	2,777	0.96

Table C 37 shows a comparison of the provisional leading FCERM option (option 3) and the other strategic options that deliver a 1.33% SoP and that have an ABCR >1. The Do Minimum and Do Nothing options are also included in this table for comparison purposes. There is justification for option 8 to become the provisional leading option, as it has an IBCR >1.

Table C 37: ODU 15 (Stoke to Langstone Bridge Carpark) - Strategic Options for a 1.33% AEP, with an ABCR >1

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	1,303	3,443	3,481	2.67	NA
8. **Sustain 1.33% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	6,025	9,291	10,312	1.71	1.44
4. **Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	7,630	13,959	10,312	1.35	NA
10. **Improve 1.33% AEP –** Setback earth embankment. Full length and height from present day	7,717	10,073	10,372	1.34	0.70
2. **Do Minimum –** Patch and repair on existing assets	391	1,312	0	0.00	NA
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0	NA

Table C 38 shows a comparison between the provisional leading FCERM option and the equivalent option (option 9) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 9), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 5.26, and therefore option 9 is the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 38: ODU 15 (Stoke to Langstone Bridge Carpark) - Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
8. **Sustain 1.33% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	6,025	9,291	10,312	1.71	NA
9. **Sustain 0.5% AEP –** Setback earth embankment. Increasing length and height over time to keep pace with sea level rise	6,270	9,722	11,600	1.85	5.26

ODU 16 (Langstone Bridge Carpark to Langstone Bridge)

Table C 39 shows that the majority of strategic options in ODU 16 have an ABCR < 1 and are therefore not economically viable. Options 4 and 5 have ABCR's >1, with option 4 - Sustain 1.33% AEP - having the greatest ABCR of 2.68. Based on this analysis, option 4 is selected as the provisional leading FCERM option.

Table C 39: ODU 16 (Langstone Bridge Carpark to Langstone Bridge) – All Strategic Options

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	NA
2. **Do Minimum –** Patch and repair on existing assets	102	344	0	NA
3. **Maintain –** Capital refurbishment and patch and repair on existing assets	141	434	0	NA
4. **Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	410	836	683	1.66
5. **Sustain 0.5% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	445	868	702	1.58
6. **Improve 1.33% AEP –** Frontline floodwall. Full length and height from present day	687	1,070	683	0.99
7. **Improve 0.5% AEP –** Frontline floodwall. Full length and height from present day	727	1,133	702	0.97
8. **Resilience –** PFR for properties at risk of flooding from a 5% AEP flood event.	104	354	50	0.47

Table C 40 shows a comparison of the provisional leading FCERM option, Do Minimum and Do Nothing for comparison purposes. As the only option with an ABCR >1, option 4 remains the provisional leading FCERM option.

Table C 40: ODU 16 (Langstone Bridge Carpark to Langstone Bridge) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
4. **Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	410	836	683	1.66	NA
2. **Do Minimum –** Patch and repair on existing assets	102	344	0	0.00	NA
1. **Do Nothing –** No Active Intervention. Baseline scenario	0	0	0	0.00	NA

Table C 41 shows a comparison between the provisional leading FCERM option and the equivalent option (option 5) with a higher SoP (0.5% SoP). According to FCERM-AG, in order to select the option with the higher SoP (option 5), the IBCR between the two options needs to exceed three. As can be seen, the IBCR is 0.55 and therefore option 4 remains the preferred choice and is confirmed as the leading FCERM option for this unit.

Table C 41: ODU 16 (Langstone Bridge Carpark to Langstone Bridge) – Leading FCERM option

Strategic Option	Whole Life PV Cost (£k)	Whole Life Cash Cost (£k)	Whole Life PV Benefits (£k)	ABCR	IBCR
4. **Sustain 1.33% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	410	836	683	1.66	NA
5. **Sustain 0.5% AEP –** Frontline floodwall. Increasing length and height over time to keep pace with sea level rise	445	868	702	1.58	0.55

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