REPORT

Sidmouth Beach Management Scheme Economic Appraisal

Client: East Devon District Council

Reference: PC1679-RHD-ZZ-XX-RP-Z-0014

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Date: 5 October 2023

Royal HaskoningDHV

Enhancing Society Together

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Revision	Date	Description	Prepared	Checked	Approved
P01	09/12/2022	For Information	SE	EH	LS
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C01	05/10/2023	For Information	SE	IB	IB

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1 Introduction

This report is the Economic Appraisal appendix to the Outline Business Case (OBC) for the Sidmouth Beach Management Scheme. Sidmouth has a long history of coastal flooding and erosion which has resulted in a number of defence schemes over the years. The recommended scheme in the OBC will improve the protection to properties and infrastructure at risk of coastal flooding and erosion over the next 100-year appraisal period.

The economic assessment has been carried out over a **100-year appraisal period** and has a base date of **31st July 2020**. Further to the assessment being undertaken in 2020 the damage values have been uplifted to the Outline Business Case (OBC) date of 2022 using the *GDP deflator indices (HM Treasury, 2022)* following the advice in *Managing financial pressure on the FCRM programme: Guidance note for Risk Management Authorities on the effect of increasing inflation and financial pressures on scheme viability (Environment Agency, 2022b)*.

2 Summary

Whole life benefits of £196.17 million

Total costs for approval of £19,07 million

Whole life costs of £20.05 million

Project benefit to cost ratio: 9.8 to 1

113 households at risk will be better protected against flood risk

59 households at risk will be better protected against coastal erosion

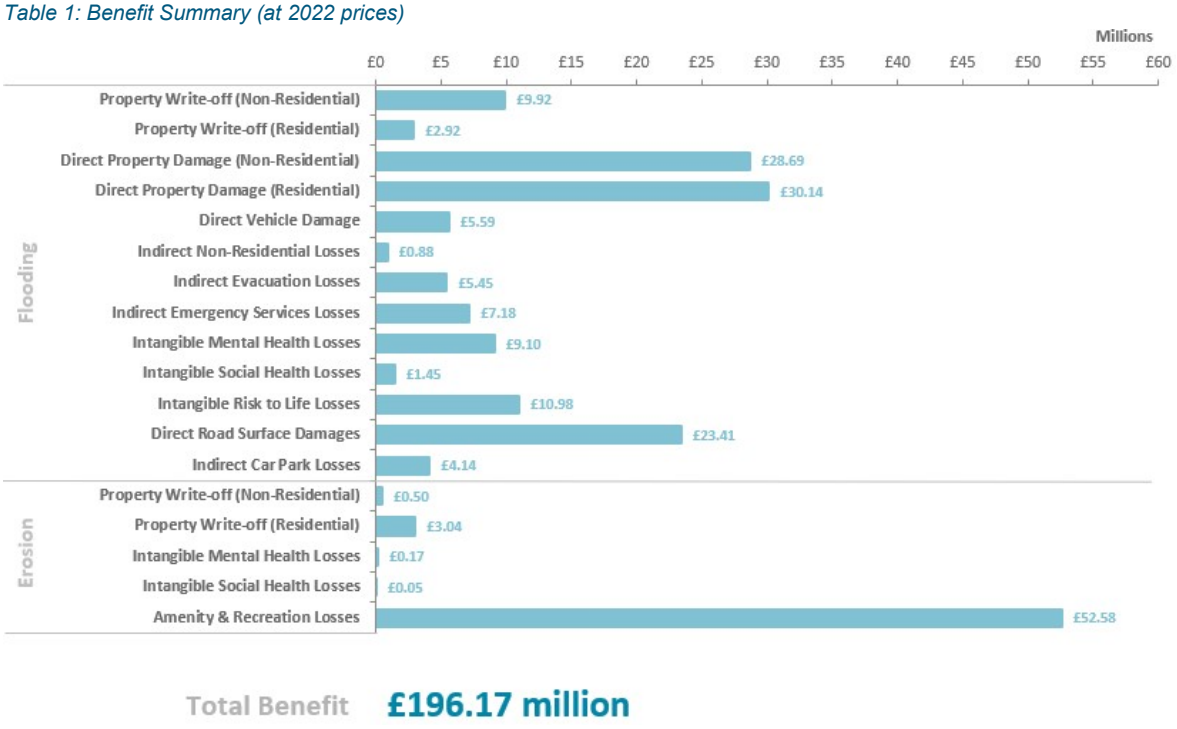
Potential maximum FCERM GiA: £17.09 million

Minimum contribution required: £3.50 million

FCERM GiA towards up-front costs: £15.57 million

Raw PF Score: 85%
Adjusted PF Score: 104%

Table 1: Benefit Summary (at 2022 prices)



Total Benefit £196.17 million

Table 2: Present Value Damage Summary (at 2022 prices)

		Do Nothing PVd	Do Something PVd	Do Something PVb
Flooding	Property Write-off (Non-Residential)	£9,917,369	£0	£9,917,369
	Property Write-off (Residential)	£2,921,977	£0	£2,921,977
	Direct Property Damage (Non-Residential)	£29,294,566	£602,969	£28,691,597
	Direct Property Damage (Residential)	£30,426,384	£288,209	£30,138,174
	Direct Vehicle Damage	£5,608,815	£22,253	£5,586,562
	Indirect Non-Residential Losses	£900,761	£18,089	£882,672
	Indirect Evacuation Losses	£5,508,771	£56,529	£5,452,242
	Indirect Emergency Services Losses	£7,313,493	£137,279	£7,176,214
	Intangible Mental Health Losses	£9,289,202	£193,937	£9,095,265
	Intangible Social Health Losses	£1,631,405	£183,440	£1,447,965
	Intangible Risk to Life Losses	£11,175,052	£192,213	£10,982,840
	Direct Road Surface Damages	£23,645,905	£238,115	£23,407,790
	Indirect Car Park Losses	£4,136,766	£0	£4,136,766
	Flooding sub-total	**£141,770,466**	**£1,933,033**	**£139,837,433**
Erosion	Property Write-off (Non-Residential)	£498,770	£0	£498,770
	Property Write-off (Residential)	£3,040,248	£0	£3,040,248
	Intangible Mental Health Losses	£169,254	£0	£169,254
	Intangible Social Health Losses	£47,419	£0	£47,419
	Amenity & Recreation Losses	£35,454,110	-£17,124,140	£52,578,250
	Erosion sub-total	£39,209,801	-£17,124,140	£56,333,941
		£180,980,267	**-£15,191,107**	**£196,171,374**

3 Coastal Flood Risk

The calculation of damages due to flooding was undertaken using the Royal HaskoningDHV (RHDHV) Flood Risk and Economic Damages (FRED) Tool, in accordance with the *Flood and coastal erosion risk management appraisal guidance (FCERM-AG) (Environment Agency, 2010)* using approaches set out by the *Multi-Coloured Manual (MCM) 2013 (Penning-Rowsell et al., 2013)* and *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)*.

Flood depths were determined at all properties in the flood risk area for a range of flood events, based on the flood levels determined by the modelling and the threshold levels of the individual properties. Flood damages were then calculated for each property based on the flood depths for each modelled flood event using the flooding depth damage data included in the *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)*. These single event flood damages were used to calculate the equivalent annual average damage (AAD) for each property. Flood damage estimates were derived for the following categories:

- Direct Property Damages
- Direct Vehicle Damages
- Indirect Non-Residential Losses
- Indirect Evacuation Losses
- Indirect Emergency Services Losses
- Intangible Social Health Losses
- Intangible Mental Health Losses
- Intangible Risk to Life Losses
- Property Write-off

3.1 Modelled Scenarios

The Do Nothing scenario is the baseline for this appraisal and represents a cessation of all operational and maintenance activities leading to degradation and in time failure of the existing defences.

The single Do Something model scenario used for the economic damage assessment is applicable to all of the options identified within the Appraisal Summary Table. The differences between the options within the economic appraisal is within the cost estimates relating to the differing works required for each option.

The coastal frontage of Sidmouth is orientated in a northeast to southwest direction. Waves approach the coastline from the southeast, south and southwest as presented in Figure 1. The predominant wave regime along the coastline is south westerly waves, however south easterly storm conditions do occur throughout the year as presented below. As a result of this analysis, rather than undertaking modelling for a single storm event, two sets of model runs were created (one for south westerly and southerly storms and one for south easterly storms). This was deemed a valid approach since the storm events are independent of each other and the frequency suggested that in any one year both events would occur.

Damage calculations were undertaken for both sets of model outputs and combined at the annual average damage stage. Property write-off and capping ensured that the resultant damage values were not overestimated.

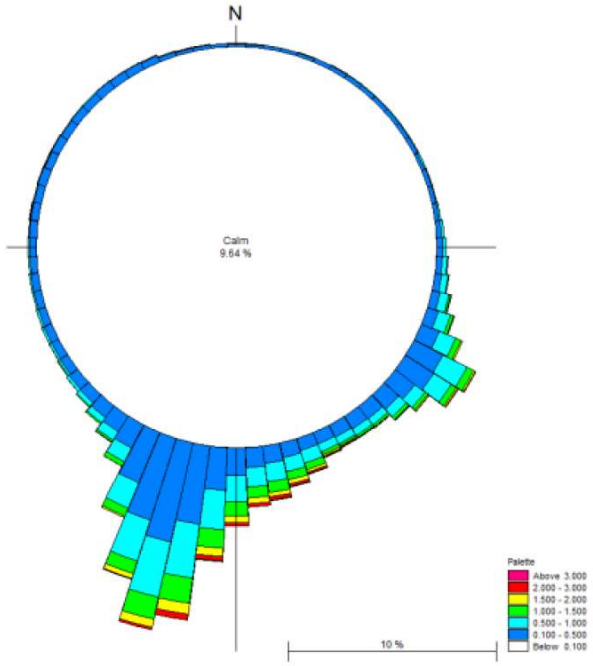


Figure 1: Met Office WaveWatch III Hindcast wave record

Table 3: Modelled coastal flood events

Scenario	Epoch	Event	Return Periods
Do Nothing	**Present Day 2017**	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000
	Climate Change 2027	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000
	Climate Change 2037	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000
	Climate Change 2067	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000
	Climate Change 2117	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000
Do Something	**Present Day 2017**	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000
	Climate Change 2037	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000
	Climate Change 2067	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000
	Climate Change 2117	South Easterly storm event	1, 10, 20, 50, 75, 100, 200, 1000
		South Westerly storm event	1, 10, 20, 50, 75, 100, 200, 1000

3.2 Properties at Risk of Flooding Summary

Properties at risk of flooding are reported by risk bands as used in the Partnership Funding Calculator (Environment Agency, 2022b). Table 3 shows the definition of these risk bands based on flood event probabilities.

Table 4: Flood risk bands

Flood risk band	Probability band	
Very significant	>=5%	more frequent than a 1 in 20 event
Significant	<5% to >2%	more frequent than a 1 in 50 event, but less frequent than a 1 in 20 event
Intermediate	2% to >1%	more frequent than a 1 in 100 event, but less frequent or equal to a 1 in 50 event
Moderate	1% to >0.5%	more frequent than a 1 in 200 event, but less frequent or equal to a 1 in 100 event
Low	<=0.5%	less frequent or equal to a 1 In 200 event

No property counts are available for the significant risk band. This is due to the way the significant risk band has been defined, with the events at both the upper and lower limits being excluded and there being no modelled flood events between 5% AEP (1 in 20) and 2% AEP (1 in 50).

The following tables present the number of properties at risk of flooding above threshold for the modelled flood events. These property counts represent the worst case derived from comparing the model results for the south easterly and south westerly storm events for each epoch.

3.2.1 Do Nothing

Table 5: Residential properties at risk of flooding summary for the Do Nothing scenario

Flood risk band	Present Day 2017	Climate Change 2027	Climate Change 2037	Climate Change 2067	Climate Change 2117
Very significant	52	64	119	136	215
Significant	0	0	0	0	0
Intermediate	70	58	7	29	58
Moderate	1	1	0	17	37
Low	438	438	435	379	251
Total 'At Risk'	561	561	561	561	561

Table 6: Non-residential properties at risk of flooding summary for the Do Nothing scenario

Flood risk band	Present Day 2017	Climate Change 2027	Climate Change 2037	Climate Change 2067	Climate Change 2117
Very significant	36	43	73	87	155
Significant	0	0	0	0	0
Intermediate	38	31	5	21	27
Moderate	2	2	0	15	4
Low	170	170	168	123	60
Total 'At Risk'	246	246	246	246	246

3.2.2 Do Something

Table 7: Residential properties at risk of flooding summary for the Do Something scenario

Flood risk band	Present Day 2017	Climate Change 2037	Climate Change 2067	Climate Change 2117
Very significant	0	0	0	0
Significant	0	0	0	0
Intermediate	0	0	23	61
Moderate	0	0	4	38
Low	561	561	534	462
Total 'At Risk'	561	561	561	561

Table 8: Non-residential properties at risk of flooding summary for the Do Something scenario

Flood risk band	Present Day 2017	Climate Change 2037	Climate Change 2067	Climate Change 2117
Very significant	0	0	0	0
Significant	0	0	0	0
Intermediate	0	0	12	37
Moderate	0	1	4	15
Low	246	245	230	194
Total 'At Risk'	246	246	246	246

4 Erosion Risk

The calculation of damages due to erosion was undertaken in accordance with the *Flood and coastal erosion risk management appraisal guidance (FCERM-AG) (Environment Agency, 2010)* using approaches set out by the *Multi-Coloured Manual (MCM) 2013 (Penning-Rowsell et al., 2013)* and *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)*.

Damage estimates were derived for the following categories:

- Property Write-off
- Intangible Social Health Losses
- Intangible Mental Health Losses

4.1 Properties at Risk of Erosion Summary

With the Do Nothing scenario 107 properties are at risk of being lost to erosion during the 100 year appraisal period. Of these 107 properties, 33 would be written-off due to the frequency of coastal flooding prior to being lost to erosion. The distribution of the remaining properties that would be lost to erosion with the Do Nothing scenario are shown in Table 9.

Table 9: Properties that would be lost to erosion with the Do Nothing scenario

Year lost to erosion	Non-Residential	Residential	Total
2037	0	6	6
2042	0	2	2
2047	0	2	2
2095	15	45	60
2117	0	4	4
	15	59	74

5 Damage Calculation Methodology

5.1 Event Damages / Losses

5.1.1 Direct Property Damages

Flood event damages to properties for the individual return periods were calculated using the saltwater long duration depth damage datasets from the *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)*.

Properties at risk of erosion are written-off at their market value at the predicted year of loss. For East Beach Cliff this is based on erosion lines which have been derived. The properties along the Esplanade are at risk at the point of failure of the seawall, due to their proximity to the seawall and the immediate loss of access (and associated services within the road).

5.1.2 Direct Vehicle Damages

Direct vehicle damages are applied to residential properties only using the 'full-scale appraisal' method from the *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)*. This assumes the average value of a car for appraisal purposes is £3,100 and 2011 UK Census data (ONS, 2013) is used to ascertain the average number of vehicles per household. These values are attributed to each property using ESRI ArcGIS.

The *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)* advises that it should be assumed that 25% of the residential properties in the benefit area will not have a vehicle present if a flood warning is issued. To allow for this, for scenarios where flood warnings are issued (this excludes Do Nothing) the number of vehicles at each property that lies within a flood warning area is reduced by 25%.

Following the guidance in the *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)* damages to vehicles only occur if the water depth above ground level (not above property threshold level) at the property location is greater than 0.35m.

5.1.3 Indirect Non-residential Losses

The *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)* provides a method for estimating the indirect losses to non-residential properties. These losses are likely to be incurred by most flooded non-residential properties and are additional losses for seeking to respond to the threat of disruption, or to actual disruption, due to flooding. They exclude post-flood clean-up costs but include the cost of additional work and other costs associated with efforts to minimise or avoid disruption. These losses are estimated by applying the 3% uplift factor from the guidance to the non-residential direct property damages for each event.

5.1.4 Indirect Evacuation Losses

Indirect evacuation losses are applied to all flooded residential properties using the 'initial appraisal' methods from the *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)* based on the property type and water depth above threshold. Additional evacuation costs are applied using the evacuation datasets (Table 4.20, Table 4.22, and Table 4.25) from the *Multi-Coloured Manual 2013 (Penning-Rowsell et al., 2013)* for any non-flooded upper floor residential properties where there is flooding at ground floor level, due to loss of access and disruption to services provision. It is assumed that properties would be evacuated for up to one week, giving a value of £494.24/household based on the data extracted from the *Multi-Coloured Manual 2013 (Penning-Rowsell et al., 2013):*

Table 10: Additional evacuation and temporary accommodation costs (at 2013 prices)

Item	Cost per household
Mid-range temporary accommodation costs	**£46.00**
Mid-range potential extra food costs per household evacuated to hotels/B&Bs for up to 1 week	**£337.00**
Mid-range extra travel costs per household evacuated	**£83.97**
Mid-range extra time costs per household evacuated	**£27.27**

5.1.5 Indirect Emergency Services Losses

The *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)* advises that an allowance should be made for losses incurred by various organisations in tackling flood incidents and in the recovery process. The *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)* suggests this varies between 5.6% and 10.7% of the total property damages. The value should be lower in urban areas to reflect the economies of scale in emergency services. The value used for each property by the RHDHV FRED Tool is based on the *Rural-Urban Classification dataset (Defra, 2016).*

Table 11: Emergency services uplift factor

Rural-Urban Classification		Description	Emergency Services Uplift Factor
Urban	A1	Major Conurbation	**5.6%**
	B1	Minor Conurbation	**5.6%**
	C1	Urban City and Town	**5.6%**
	C2	City and Town in a Sparse Setting	**5.6%**
	D1	Town and Fringe	**10.7%**
	D2	Town and Fringe in a Sparse Setting	**10.7%**
Rural	E1	Village	**10.7%**
	E2	Village in a Sparse Setting	**10.7%**
	F1	Hamlets and Isolated Dwellings	**10.7%**
	F2	Hamlets and Isolated Dwellings in a Sparse Setting	**10.7%**

These values are attributed to each property using ESRI ArcGIS.

5.1.6 Intangible Mental Health Losses

Intangible mental health losses due to flooding are applied to all flooded residential properties using the methodology outlined in *Advice for Flood and Coastal Erosion Risk Management: Mental Health Costs of Flooding and Erosion (Environment Agency, 2020)* based on the property type and water depth above threshold.

Table 12: Mental health impacts of flooding, per adult, per flood event (at 2020 prices)

Flood depth band above internal floor level	Mental health losses per adult per flood event
>0cm - <30cm	**£1,878**
30 - 100cm	**£3,028**
>100cm	**£4,136**

These values are multiplied by the number of adults exposed to flooding. The FRED Tool uses the national averages of number of adults per residential property by property type for England from the guidance.

Table 13: National average number of adults per property in England

Property type	Number of adults per property
Average (all categories)	**1.85**
Detached	**2.01**
Semi-detached	**2.00**
Terraced	**1.95**
Bungalow	**1.99**
Flat	**1.45**

5.1.7 Intangible Social Health Losses

The calculation of damages due to the impacts of flooding on human health are calculated using the approach outlined by the *Appraisal of Human Related Intangible Impacts of Flooding – R&D Technical Report FD2005/TR (Defra, 2004)*. The equation given on page 83 of the report and shown below enables the calculation of the annual damages due to impacts on health per residential household.

$$\textbf{Damages}\ (£/year/household) = £225 \times \{1.026 - (1/(1 + 37.5\, e^{-0.06/AEP})\}$$

This equation is used to calculate the losses due to flooding for each property and this is treated in the same way as an annual average damage. These 'social health AADs' are converted into present value damages using the same approach used for the other damage categories.

This FRED Tool uses the revised value of £247 per year per household value from the *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)* instead of the £225 per year value in the original *Defra guidance (Defra, 2004)*.

5.1.8 Intangible Risk to Life Losses

The method in *"Assessing and Valuing the Risk to Life from Flooding for Use in Appraisal of Risk Management Measures" (Defra, 2008)* is used in the FRED Tool. This methodology is commonly applied at

a zone or regional level; however, the FRED Tool applies it at a property level to retain consistency with other assessment category approaches.

5.1.8.1 Hazard Rating

The hazard rating is provided as an output from the modelling or can be calculated by the FRED Tool using the following equation from the guidance:

$$HR = d * (v + 0.5) + DF$$

Where:
HR = hazard rating
d = depth of flooding (m)
v = velocity of floodwaters (m/s)
DF = debris factor

The depth of flooding value used for this calculation is the depth above ground level immediately outside the building, not the depth above threshold.

5.1.8.2 Area Vulnerability

The Area Vulnerability is calculated using the following equation:

Area Vulnerability = Speed of Onset + Nature of Area + Flood Warning

5.1.8.3 Speed of Onset

The guidance on selecting an appropriate Speed of Onset score is shown below.

Table 14: Guidance on Speed of Onset

	Low Risk Area Score = 1e	**Medium Risk Area** Score = 2	**High Risk Area** Score = 3
Speed of onset	Onset of flooding is very gradual (many hours)	Onset of flooding is gradual (an hour or so)	Rapid Flooding

5.1.8.4 Nature of Area

The guidance on selecting a Nature of Area score is shown below.

Table 15: Guidance on Nature of Area

	Low Risk Area Score = 1e	**Medium Risk Area** Score = 2	**High Risk Area** Score = 3
Nature of area	Multi-storey apartments	Typical residential area (2-storey homes); commercial and industrial properties	Bungalows, mobile homes, busy roads, parks, single storey schools, campsites, etc.

5.1.8.5 Flood Warning Score

The guidance gives an indicative score for England of 2.15.

5.1.8.6 People Vulnerability (Y)

The People Vulnerability is the sum of the percentage of residents that are aged over 75 and the percentage suffering from long term illness. *2011 UK Census data (ONS, 2013)* is used to calculate the people vulnerability scores used in this assessment. These values have been attributed to each property using ESRI ArcGIS.

5.1.8.7 Percentage Exposed to the Flood (X)

The Hazard Rating is multiplied by the Area Vulnerability to represent the percentage of people exposed to the risk. This is not a true percentage but provides a practical empirical approach to assessment.

5.1.8.8 People Exposed to the Flood (NZE)

To determine the number of people exposed to a flood, the percentage exposed to the Flood (X) is multiplied by the average residential occupancy. *2011 UK Census data (ONS, 2013)* data gives an average household size of 2.4 people for England, which is used by the FRED Tool.

5.1.8.9 Number of Injuries

The number of injuries associated with the flood event is calculated by multiplying the number of people exposed to the flood (NZE) by twice the calculated people vulnerability (Y):

Number of injuries = 2 * Y * NZE

5.1.8.10 Fatality Rate

The fatality rate is assumed to be proportional to the Hazard Rating and is calculated by multiplying the Hazard Rating (HR) by two and taking this number empirically as a percentage.

Fatality Rate (%) = 2 * HR

5.1.8.11 Number of Fatalities

The number of fatalities is calculated by multiplying the number of injuries by the fatality rate.

5.1.8.12 Value of Injury and Loss of Life

The value for fatalities used by the FRED Tool are the *Department for Transport (DfT) TAG Data Book average values of prevention per fatal casualty in the context of road accidents (Department for Transport, 2021). This value is considered to be the best estimates available for assessment.*

Table 16: Average value of prevention per fatality (at 2010 prices and 2020 values)

Casualty type	Total
Fatal	**£1,630,826**

5.1.9 Road Surface Damages

There is a clear history of damage to road surfaces as a consequence of flooding. These damage required closure of roads and significant repairs.

Figure 2: Example of historic damage to promenade road area.

Damages to road surfaces have been calculated by applying the 'Surface damage urban road' cost based on length of road (m), not area (m2). The rate used was£188,061/km from the Weather Extremes: Assessment of Impacts on Transport Systems and Hazards for European Regions document as outlined in Table 17 to the total length of road flooded. This was calculated within ESRI ArcMAP 10 by extracting the lengths of the road network that fall within each flood extent.

The method and values were combined with the information in Section 6d (Losses Due to the flooding of Roads) in the Multi-Coloured Handbook 2015.

Table 17: European average road damage costs (Weather Extremes: Assessment of Impacts on Transport Systems and Hazards for European Regions, Claus Doll, Niklas Sieber, 2011)

Damage	Cost £/km
Surface damage motorway	470,152
Surface damage trunk Road	352,614
Surface damage urban road	188,061
Substantial damage motorways	470,723
Substantial damage trunk road	353,042
Substantial damage urban road	188,289

Total loss motorway	6,800,411
Total loss trunk road	3,212,704
Total loss urban road	2,326,132

This provides a conservative estimate when compared with the Multi-Coloured Handbook 2015 which gives unit reconstruction costs for resurfacing a local road range between approximately £15/m² for a quiet road to up to approximately £50m² for a busier road (which require a thicker surface layer and road works may need to occur at night or off-peak and thus incurring overtime costs).

A sensitivity check to see how this fitted with the MCM £15-50 /m^2 range gave £25.76 /m^2. This assessment used an average road width of 7.3m which is common for single carriage roads in urban areas. In reality, this is likely to be higher as the promenade road is wider. A wider road would reduce this £25.76/m^2 even further. Given that this is less than a third along the range from £15 to £50, and the roads being damaged are by no means quiet roads, it is felt this is a conservative approach in the context of the area.

The damages have been applied up to year 75 when the seawall would fail under the Do Nothing and the road would become unsafe to use and be closed. Values have been adjusted to the assessment base date using the *Gross Domestic Product (GDP) Deflator (HM Treasury, 2022)*.

5.1.10 Vehicle Losses in Car Parks

There are four public car parks at risk of flooding in Sidmouth which place vehicles at risk of flooding and therefore being damaged and written off. The following method has been used to estimate the vehicle damages in the car parks, with the results shown in Table 18 and Table 19:

1. Identify number of parking spaces from EDDC parking website
2. Estimate average daily income using EDDC revenue data (assumes charges apply 7 days a week)
3. Estimate number of cars using car parks daily, assuming average stay of 2 hours with hourly rate of £1/hour (maximum stay is 3 hours)
4. Calculate daily capacity of car parks assuming average stay of 2 hours, and charging period is 10 hours (8am to 6pm)
5. Calculate average occupancy rate (using steps 3 and 4)
6. Calculate average number of vehicles present at any one time (using steps 1 and 5), assuming constant rate of use and no variability in demand for parking throughout the day
7. Calculate vehicle damage per flood, using damage rate from MCM of £3,100 per vehicle
8. Check which return periods the car parks are inundated
9. Calculate AADs for different climate change epochs, assuming same damage value for all return periods where flooding occurs
10. Calculate PVd

Table 18: Car park vehicle damage per flood calculation

Car Park	No. Spaces	Ave. Daily Income	Ave. No. Cars per Day	Daily Capacity	Ave. Occupancy Rate	Ave. Vehicles Present	Damage per Flood Event
Mill Street	34	£66.73	33	170	20%	7	£20,687
Roxburgh	73	£252.36	126	365	35%	25	£78,232
Ham East	70	£155.16	78	350	22%	16	£48,100
Ham West	183	£279.38	140	915	15%	28	£86,607

Total	**472**	**£988.09**	**494**	**2,360**	**21%**	**99**	**£306,309**

Table 19: Car park vehicle damage AAD and PVd

Car Park	2017 AAD	2037 AAD	2067 AAD	2117 AAD	PVd
Mill Street	£0	£0	£0	£0	£0
Roxburgh	£0	£0	£587	£1,304	£3,157
Ham East	£48,100	£48,100	£48,100	£48,100	£1,433,977
Ham West	£86,607	£86,607	£86,607	£86,607	£2,581,963
Total	£134,706	£134,706	£135,293	£136,010	£4,019,098

Values have been adjusted to the assessment base date using the *Gross Domestic Product (GDP) Deflator (HM Treasury, 2022)*.

5.1.11 Recreation and Tourism Losses

The approved Sidmouth and East Beach Management Plan provided an update of the amenity benefits providing a conservative estimate of the amenity benefits that could be realised along the Sidmouth frontage. The assessment within the BMP was based upon a previous assessment in 1992 and has been inflated to present day prices and extended from a 50 year to a 100 year appraisal period.

The results of applying these two updates are presented in Table 20. The table shows that the potential Present Value losses from visitors to the Sidmouth seafront under a 'Do Nothing' scenario is likely to be in the order of over £31,431,000 over 100 years allowing for the application of discount factors. If defences are maintained and improved there is a potential PV gain over 100 years of about £15,181,000 on top of avoiding the loss of £31,431,000 (i.e. the total benefit is £46,621,000 over 100 years).

Table 20: Amenity benefits (BMP, 2017)

Visitor Type	No. of visitors per 150 days summer season	Loss per 150 day summer season (£k)	Total PV loss over 100 years (£) (A)	Gain per 150 day summer season (£)	Total PV gain over 100 years (£k) (B)	Total PV benefit over 100 years (£k) (A + B)
Day	100,837	468.40	13,988	129.67	3,872	17,860
Staying	50,500	549.25	16,402	355.76	10,624	27,026
Local	11,250	34.85	1,041	22.93	685	1,726
Totals	162,587	1,053	31,431	508.36	15,181	46,612

Values have been adjusted to the assessment base date using the *Gross Domestic Product (GDP) Deflator (HM Treasury, 2022)*.

5.2 Present Value Damages

To determine the present value damages (PVd) the varying rates of annual average damage (AAD) are applied across the relevant years of the appraisal period according to the climate change epoch. The annual average damage values used in the PVd calculation are combined AAD values created by summating the corresponding AAD values from the south west event and south east event.

Below is an example application of climate change for coastal flooding.

Table 21: Example application of climate change AAD across the appraisal period

AAD	Appraisal Period Years	Actual Years
Present Day AAD to Climate Change 2020s AAD	0 - 7 (linear interpolation)	2020 – 2027 (linear interpolation)
Climate Change 2020s AAD to Climate Change 2050s AAD	7 – 17 (linear interpolation)	2027 - 2037
Climate Change 2050s AAD to Climate Change 2080s AAD	17 – 47 (linear interpolation)	2037 - 2067
Climate Change 2080s AAD to Climate Change 2100s AAD	47 – 97 (linear interpolation)	2067 - 2117
Climate Change 2100s AAD	97 – 99	2117 - 2119

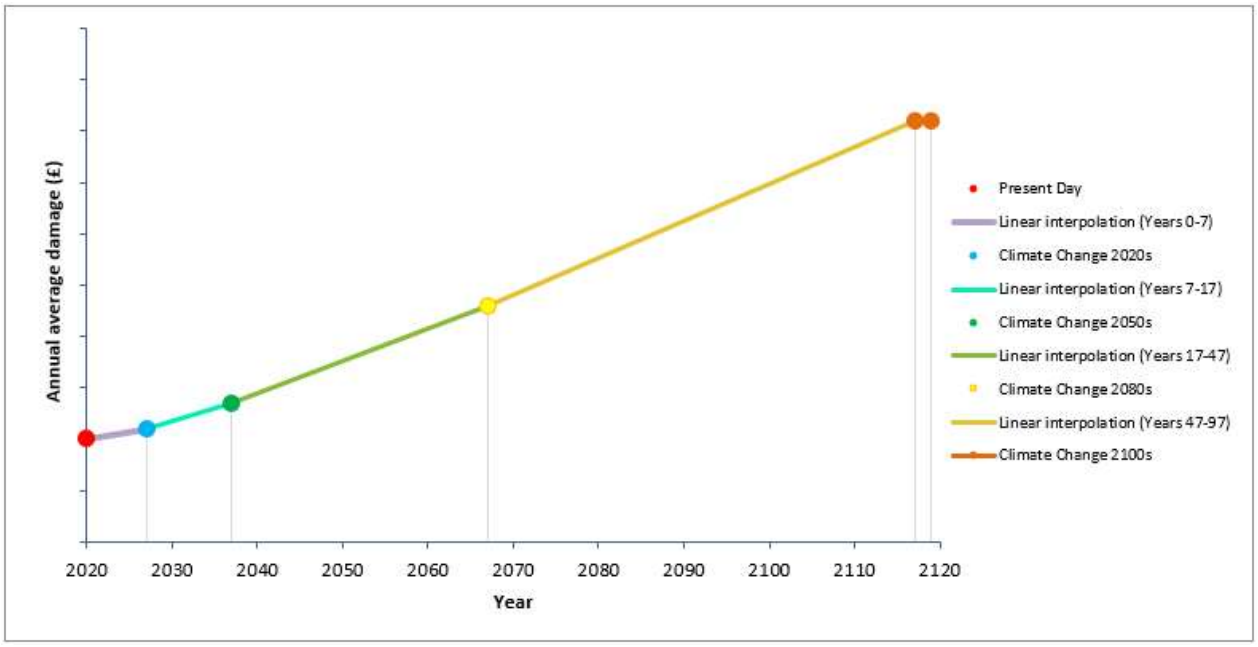


Figure 3: Example application of climate change AAD across the appraisal period

This series of yearly values is then discounted by multiplying the AAD by the relevant discount rate as specified in the *HM Treasury 'Green Book' (HM Treasury, 2018) and Discount Rate Guidance (Environment Agency, 2020b)*.

With the latest guidance a new lower discount rate applicable for 'risk to health and life' was introduced and is applied to the following damage categories by the FRED Tool in accordance with this guidance.

- Indirect Emergency Services Losses
- Intangible Social Health Losses
- Intangible Mental Health Losses
- Intangible Risk to Life Losses

The standard discount rate has been applied to the remaining damage categories.

- Direct Property Damages
- Direct Vehicle Damages
- Indirect Non-Residential Losses
- Indirect Evacuation Losses
- Road Surface Damages
- Car Park Losses
- Recreation and Tourism Losses

Table 22: Discount rates

	Appraisal Years 0-30	Appraisal Years 31-75	Appraisal Years 75-99
Standard discount rate	3.5%	3.0%	2.5%
Health discount rate	1.5%	1.296%	1.071%

5.3 Property Write-off

Following the advice in the *Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG) (Environment Agency, 2010)*, properties are written-off if they are flooded above threshold on average more than once every three years. The reasoning behind this is that at this frequency of flooding there would be insufficient time between floods to repair and return the properties to full use before they were flooded again. Linear interpolation between modelled return periods is used to determine whether a property is likely to be flooded above threshold for a 1 in 3 event. For any properties where this occurred the appraisal year at the point this happened was recorded. As there are two separate storm events included for each year within this assessment, for each property any write-off years identified were compared and the earliest occurring write-off year was applied to the property.

Properties at risk of erosion are written-off at their market value at the predicted year of loss. Where properties are at risk of both flooding and erosion, no further flood damages are accrued after the property is written-off due to coastal erosion. If a property is written-off due to frequency of flooding or it reaches its capping point prior to becoming at risk of coastal erosion, no erosion damages are incurred as it is expected that the property will have been abandoned already due to the severity of flooding.

Write-off values are taken as the risk-free market value of a property, discounted at the rate for the year in which the property is written-off. Damages across all categories are removed from the point in time where properties are written-off as it is assumed the property is abandoned.

5.4 Capping of Property Damages

The capping of property damages has been undertaken, as required, in accordance with the Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG) (Environment Agency, 2021) and Discount Rate Guidance (Environment Agency, 2020b). For each property, the yearly discounted property damage was applied to each year within the appraisal period until the present value damages equalled the risk-free market value. For any properties where the total property damage exceeded the property valuation, the appraisal year at the point this happens was recorded and any further damages/losses (from all damage streams) were removed from this point onwards within the appraisal period.

6 Data Preparation

6.1 Property Data

The National Receptor Dataset 2014 (NRD) was obtained from East Devon District Council, and this forms the basis of the assessment of damages to property. This dataset provides the necessary information on location, property type and floor area of each property in most cases.

6.1.1 Property Type (MCM Code/House Type)

The property type within NRD has been used to classify the properties. For the residential properties, the house type was used to update the MCM Code which allowed a more accurate property market value and damage rate to be used.

6.1.2 Floor Area

A proportion of the non-residential properties did not have a defined floor area in NRD. Floor area is required to determine a market value and flood damage of such properties. Any non-residential properties that did not have a floor area and identified as being upper floor properties had a default value of 50m² entered. This allowed the property to be processed so that at least conservative damages could be estimated in the event of it being flooded above threshold. The remaining, ground floor, properties were investigated individually and, depending on the actual property type and what could be seen using OS MasterMap Topography dataset, aerial photos, and Google Street View, were either removed from the assessment or a floor area was calculated using ESRI ArcGIS.

6.1.3 Property Threshold

The ground level at each property was obtained through extracting the elevation of the filtered LiDAR topography. The NRD property point was used for extracting the ground level information using ESRI ArcGIS.

Thresholds of properties (i.e., height water would have to rise up the side of a building before it could get inside) vary between properties. As no threshold survey data was available residential properties have been given a threshold level of 100mm above ground level and non-residential properties have been given a threshold level of 0mm above ground level.

6.1.4 Property Market Value

Property market values have been obtained from a range of sources dependent upon the property type and the amount of information available. Market values were inflated to the assessment date using the *Consumer Price Index (CPI) (Office for National Statistics, 2020)*.

6.1.4.1 Residential Market Value

The *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)* indicates that the market value for residential properties should be obtained from the Land Registry website, based upon the average for each property type for the Local Authority area involved.

The average residential market values were obtained from the *UK House Price Index (H.M. Land Registry, 2020)* for the East Devon local authority area and are given in Table 23. These were applied to residential properties based upon their MCM Code, for cases where the type of residential property was not defined the average value was used.

Table 23: Estimated residential property market values (at 2020 prices)

MCM Code	Property Type	Market Value
1	Unclassified	£299,059
11	Detached	£443,479
12	Semi-Detached	£294,360
13	Terraced	£239,065
15	Flat	£177,623

6.1.4.2 Non-Residential Market Value

The market values for non-residential properties have been estimated using the South West region business floor space mean rateable values in Table 5.4 of the *Multi-Coloured Handbook 2020 (Penning-Rowsell et al., 2020)*. These mean rateable values have been multiplied by the gross rent multipliers for the relevant property types to calculate the market value rate per square metre.

The market value rates for the different non-residential property types within the study area are summarised below in Table 24.

Table 24: Estimated non-residential property market values (at 2020 prices)

MCM Code	Property Type	Main Category	Mean Rateable Value	Gross Rent Multiplier	Market Value Rate (£/m²)
2	Retail	Retail	£155.41	18	£2,797
3	Offices	Office	£112.61	21	£2,365
4	Distribution/Logistics	Industrial	£41.67	25	£1,042
6	Public Buildings	Office	£112.61	21	£2,365
8	Industry	Industrial	£41.67	25	£1,042
51	Leisure	Other	£65.32	15	£980
523	Sports and Leisure Centres	Other	£65.32	15	£980

For each non-residential property the market value rate was multiplied by the floor area to estimate the market value of the property.

For several properties the type of property deemed the business floor space mean rateable values to be not applicable. For these properties the rateable value was obtained from the Valuation Office Agency (VOA) and multiplied by the gross rent multiplier. The market values for these properties are summarised in Table 25.

Table 25: Estimated non-residential property market values (VOA)

Address	Rateable Value	Gross Rent Multiplier	Market Value
The Filling Station, Cross Lane, Sidmouth, EX10 8AE	£11,000	18	£198,000
Carinas Niteclub, Fore Street, Sidmouth, EX10 8AG	£13,700	18	£246,600
Black Horse Hotel, Fore Street, Sidmouth, EX10 8AQ	£15,850	18	£285,300
Dukes, Market Place, Sidmouth, EX10 8AR	£136,700	18	£2,460,600
Hotel Elizabeth, The Esplanade, Sidmouth, EX10 8AT	£81,000	15	£1,215,000
The Kingswood and Devoran Hotel, The Esplanade, Sidmouth, EX10 8AX	£117,000	15	£1,755,000
Hotel Riviera, The Esplanade, Sidmouth, EX10 8AY	£63,800	15	£957,000
Royal York & Faulkner Hotel, The Esplanade, Sidmouth, EX10 8AZ	£167,000	15	£2,505,000
The Marine, The Esplanade, Sidmouth, EX10 8BB	£31,800	18	£572,000
Sidmouth Lifeboat, The Lifeboat Station, The Esplanade, Sidmouth, EX10 8BE	£2,050	21	£43,050
Caxton House, East Street, Sidmouth, EX10 8BL	£2,350	21	£49,350
Swan Inn, York Street, Sidmouth, EX10 8BY	£27,700	18	£498,600
Mill Street Dentist, Mill Street, Sidmouth, EX10 8DF	£12,500	21	£262,500
The Holmedale Surgery, 1 Woodberry House, Holmdale, Sidmouth, EX10 8DH	£2,800	21	£58,800
Merrifield Dental Practice, Mill Street, Sidmouth, EX10 8DW	£7,900	21	£165,900
Anchor Inn, Old Fore Street, Sidmouth, EX10 8LP	£77,000	18	£1,386,000
The Bedford Hotel, The Esplanade, Sidmouth, EX10 8NR	£93,500	15	£1,402,500

These valuations were inflated to the assessment date using the Consumer Price Index (ONS, 2020).

6.1.5 Deprivation Categories

Where Grant in Aid (GiA) funding is sought the partnership funding arrangements use deprivation categories as a way of distributing FCERM GiA. This assessment has been carried out in line with the requirements of the latest Partnership Funding Guidance (Environment Agency, 2022a).

These values from the English Indices of Deprivation (ONS, 2019) have been attributed to each property using ESRI ArcGIS.

6.2 Water Depths

The flood water depths for each property have been obtained from the results of the flood propagation modelling by extracting the water depths from the model results at the NRD property point using ESRI ArcGIS.

7 References

Defra (2004), Appraisal of Human Related Intangible Impacts of Flooding - R&D Technical Report FD2005/TR

Defra (2006), R&D Outputs: Flood Risks to People Phase 2, The Risks to People Methodology, Report FD2321/TR1, March 2006
https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/flood-risks-to-people-phase-2-managing-risks-and-dangers

Defra (2008), Assessing and Valuing the Risk to Life from Flooding for Use in Appraisal of Risk Management Measures, May 2008
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/181441/risktopeople.pdf

Defra (2016), Rural-Urban Classification
https://www.gov.uk/government/collections/rural-urban-classification

Department for Transport (2021), TAG Data Book, November 2021
https://www.gov.uk/government/publications/tag-data-book

Environment Agency (2021), Flood and coastal erosion risk management appraisal guidance (FCERM-AG), September 2021, Environment Agency, Bristol
https://www.gov.uk/guidance/fcerm-appraisal-guidance

Environment Agency (2020a), Advice for flood and coastal erosion risk management authorities: Mental health costs of flooding and erosion, April 2020, Environment Agency, Bristol
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/879942/Mental_Health_Guidance.pdf

Environment Agency (2020b), Advice for flood and coastal erosion risk management authorities: Discount rates, price indices and capping, April 2020, Environment Agency, Bristol
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/879934/Discount_Rate_Guidance.pdf

Environment Agency (2020c), Flood and coastal risk projects, scheme and strategies: climate change allowances, July 2020, Environment Agency, Bristol
https://www.gov.uk/guidance/flood-and-coastal-risk-projects-schemes-and-strategies-climate-change-allowances

Environment Agency (2022a), Partnership Funding Calculator, April 2022
https://www.gov.uk/government/publications/partnership-funding-calculator-2020-for-fcerm-grant-in-aid-gia

Environment Agency (2022b), Managing financial pressure on the FCRM programme: Guidance note for Risk Management Authorities on the effect of increasing inflation and financial pressures on scheme viability, May 2022

FHRC (2020), MCM-Online
https://www.mcm-online.co.uk/

HM Land Registry (2020), UK House Price Index, May 2020
https://landregistry.data.gov.uk/app/ukhpi

HM Treasury (2018), The 'Green Book': central government guidance on appraisal and evaluation, London, H.M. Treasury
https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

HM Treasury (2022), GDP deflators at market prices, and money GDP, June 2022
https://www.gov.uk/government/collections/gdp-deflators-at-market-prices-and-money-gdp

Office for National Statistics (2013), 2011 UK Census Data
https://www.ons.gov.uk/census/2011census

Office for National Statistics (2019), English Indices of Deprivation 2019
https://www.gov.uk/guidance/english-indices-of-deprivation-2019-mapping-resources

Office for National Statistics (2020), Consumer Price Index, July 2020
https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/consumerpriceinflation/previousReleases

Penning-Rowsell, E., Priest, S., Parker, D., Morris, J., Tunstall, S., Viavattene, C., Chatterton, J., Owen, D. (2013), Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal, London and New York, Routledge

Penning-Rowsell, E., Priest, S., Parker, D., Morris, J., Tunstall, S., Viavattene, C., Chatterton, J., Owen, D. (2020), Flood and Coastal Erosion Risk Management: Handbook for Economic Appraisal 2020, London and New York, Routledge
https://www.mcm-online.co.uk/

Valuation Office Agency (2020), Business Rates Valuation
https://www.gov.uk/find-business-rates

Acronyms

Acronym	Acronym description
AAD	Annual Average Damage
AEP	Annual Exceedance Probability
AST	Appraisal Summary Table
CPI	Consumer Price Index
DfT	Department for Transport
ESRI	Environmental Systems Research Institute
FCERM	Flood and Coastal Erosion Risk Management
FCERM-AG	Flood and Coastal Erosion Risk Management Appraisal Guidance
FHRC	Flood Hazard Research Centre
FRED	Flood Risk Economic Damages
GDP	Gross Domestic Product
GiA	Grant in Aid
LiDAR	Light Detection and Ranging
MCH	Multi-Coloured Handbook
MCM	Multi-Coloured Manual
NRD	National Receptor Dataset
OBC	Outline Business Case
PVd	Present Value Damage
VOA	Valuation Office Agency

Glossary

Glossary Term	Glossary Text
Annual average damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage. The annual average damage is the average damage in pounds (£) per year that would occur in a designated area from flooding over a year long period of time. In many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, in a few years, there will be major flood damage (caused by large, rare floods). Annual average damage is calculated by estimating the probability of different damage values being experienced (in practice by determining the area under the damage-probability curve).
Annual exceedance probability (AEP)	The chance of a flood of a given size (or larger) occurring in any one year. It can be expressed as a percentage (such as 1%) or a chance of occurrence (for example, 1 in 100).
Appraisal	The process of defining the problem, setting objectives, examining options and weighing up costs, impacts (positive and negative), risks and uncertainties in order to make a decision.
Asset	Any property or object of value.
Baseline	The set of current and future risk projections used as a benchmark for the analyses of the impact of different flood risk management options.
Benefits	The positive quantifiable and unquantifiable changes that a project is expected to produce. It includes damages avoided.
Benefit-cost ratio	The total present value benefits divided by the total present value costs.
Climate change	A change in the state of the climate that persists for an extended period, typically decades or longer. Climate change may be due to natural processes or (directly or indirectly) to human activities that alter the composition of the atmosphere.
Cost	The costs of a project including any capital and recurrent expenditure, administrative costs, monitoring and enforcement costs, and research and development costs. Cost savings (such as materials sales) should be treated as negative costs not as benefits. Similarly contributions should be treated as deductions from the costs.

Cost-benefit analysis	Comparison of present value benefits and costs as part of an economic appraisal.
Damages	The value of negative social, economic and environmental impacts caused by flooding or erosion.
Damages avoided	Any damages that would not occur under an option when compared with the baseline (see benefits).
Discount rate	An interest rate used to convert future streams of costs and benefits to their present value. It can be thought of as a social "interest rate". The discount rate is established by HM Treasure for Government funded projects.
Discounting	A method used to convert future costs or benefits to present values using an appropriate discount rate.
Do minimum option	An option where an operating authority takes the minimum amount of action necessary to maintain an asset.
Do nothing option	An option used in appraisal to act as a baseline against which all other options are tested. It assumes that no action whatsoever is taken. In the case of existing works, it assumes for the purposes of appraisal that operating authorities cease all maintenance, repairs and other activities immediately. In the case of new works, it assumes that there is no intervention, and natural and other external processes are allowed to take their course.
Do something option	Any option other than do nothing.
Economic appraisal	An appraisal technique based on attaching monetary values to the costs and benefits of actions.
Flood risk	A combination of the probability and consequences of flooding.
Incremental benefit-cost ratio	The ratio of the additional benefit to the additional cost, when two options are compared.
Indirect loss	Losses caused by disruption of physical and economic linkages of the economy and the extra costs of emergency and other actions taken to prevent damages and loss beyond the immediate direct physical impact area.

Intangibles	The costs, benefits and risks which are difficult to quantify but which are nevertheless relevant for the decision-making process. The term is usually applied to non-monetary impacts.
Market value	The price at which an asset would change hands if it was sold on the open market.
Net present value (NPV)	The discounted benefits minus the discounted costs.
Operating authority	A body with statutory powers to undertake flood and coastal erosion risk management activities. This is usually the Environment Agency, local authority or internal drainage board.
Present value (PV)	The value of a stream of benefits or costs when discounted back to the present time at a prescribed discount rate.
Probability	A statistical measure of the likely frequency or occurrence of flooding or erosion.
Return period	The average interval in years between events of similar or greater magnitude (for example, a flow with a return period of 1 in 100 years will be equalled or exceeded on average once in every 100 years). However, this does not imply regular occurrence, more correctly the 100-year flood should be expressed as the event that has a 1% probability of being met or exceeded in any one year.
Robust	A decision is robust if the choice between the options is unaffected by a wide range of possible future scenarios.
Scenario	A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios are neither predictions nor forecasts.
Scheme	The implementation of a risk management measure on the ground. It is normally the case that a scheme is identified as a consequence of a broad based investigation and has quite specific objectives.
Tangibles	Those costs and benefits, which can be related to specific items of loss or expenditure, that can be quantified in monetary terms and for which there are accepted methods of valuation.

Treasury Green Book	A publication of HM Treasury providing guidance to other public sector bodies on how proposals should be appraised, before significant funds are committed – and how past and present activities should be evaluated encouraging a thorough, long-term and analytically robust approach to appraisal and evaluation. It is relevant to all appraisals and evaluations.
Valuation	A method of applying a monetary value to positive and negative impacts.

Extracted from FCEREM-AG (Environment Agency, 2010)