Carbon Assessment Technical Note

Project name	Project number	Client	Date
Christchurch Bay and Harbour	60656006	BCP	26 April 2024

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1. Introduction

AECOM is developing an FCERM Strategy for Christchurch Bay and Harbour on behalf of Bournemouth, Christchurch and Poole Council (BCP) and New Forest District Council (NFDC).

The Strategy has identified a series of Leading Strategic Options for managing the coastal flood and erosion risks over the next century. A strategic level carbon assessment has been undertaken to estimate the carbon impact of the proposed defences that are recommended as part of the Leading Options. This technical note summarises the methodology and results of this assessment.

The assessment of carbon is a high-level, strategic assessment to estimate the carbon impacts of all the Leading Options throughout the lifetime of the project and will support the final Strategy submission.

The scope of this note includes:

- The carbon assessment methodology;
- Results of the carbon assessment; and
- Assumptions and considerations made throughout the assessment.

2. Methodology

2.1 Whole Life Carbon Emissions

The Environment Agency's Whole Life Construction Carbon Planning and Budgeting Tools have been supplied to AECOM by the Environment Agency and used to help estimate the whole life carbon emissions of the Leading Options. The Carbon Planning Tool (also known as ERIC) has three main components. These are: the Carbon Modelling Tool (CMT), the Carbon Calculator (CC) and the Carbon Budget Tool (CBT).

The CMT has been used as part of this project to help develop a top-down whole life carbon emission estimate for each of the Leading Options. The tool provides an estimate of the whole life carbon emissions (tonnes CO2e) of flood and coastal defences over their lifespan (including construction, operation, maintenance, demolition). Details of the tools include:

- This tool is designed to be used during the project appraisal phase of projects, in the absence of detailed design information (for example, exact material quantities), to produce a quick and simple carbon estimation. The tool uses previous Environment Agency data of individually constructed assets, produced by the CC (another component of the Carbon Planning Tool). The outputs of the tool include the whole life carbon emissions at each lifecycle stage of a defence (construction, operation, maintenance, and demolition) and a total value across the full lifecycle.
- The CMT tool provides rates for different defence types. The unit of measurement for the geometry of the defences varies in the CMT. Depending on the defence type, the rates of carbon emissions can be provided for a defence geometry in m^2, m^3 or tonnes. For example, the geometry of a sheet pile wall is measured in m^2 in the tool whereas the geometry of rock armour is measures in tonnes in the tool.
- A rate for most of the defence types used in the Leading Options for the Strategy could be found in the CMT. However, some defence types in the Leading Options, such as Sand Dune Enhancement for example, did not have a rate in the CMT and therefore where possible an equivalent rate from a related defence type was adopted in the assessment. Some defences in the Strategy options did not have an appropriate equivalent in the CMT tool and therefore a carbon emission has not been estimated.

Rather than inputting the Leading Options details into the CMT directly to estimate the total carbon emissions of an option, the CMT tool was used to create a lookup table of carbon emissions for different defence types of different geometry (see Table 2-1). In producing the lookup table, specific considerations have been made for each asset type and are summarised in Table 2-1.

The values in the lookup table were then linked to the Leading Option defence geometry values from the option costing spreadsheet to create a whole life carbon emissions value for each Leading Option. Repeat interventions are included in the Strategy costing at the end of a typical defence design life. This ensured that the carbon emissions for future interventions within the Leading options are included in the whole life emissions value (i.e. the whole life carbon emissions are not just for the initial intervention but also repeat interventions in the future).

The whole life carbon emissions avoided that have been estimated using this approach are suitably high level for a strategic study such as this, and there will be variations as more detailed studies and designs are undertaken at scheme development stage following the Strategy.

Table 2-1: Carbon rates per m length of defence within the Strategy.

Defence Type in Strategy Leading Options	CMT Asset Classification Used	Geometry	Whole Life Carbon per m length of defence (tonnes CO2e)	Considerations
Sheet Pile Wall	Tidal Wall - Retaining - Sheetpiled	1m high sheet pile (above ground)	3.61	Assumed that 75% of the sheet pile area is below ground. For example every 1 metre pile wall height has 3 metres height below ground.
		2m high sheet pile (above ground)	7.23	
		3m high sheet pile (above ground)	10.84	
		4m high sheet pile (above ground)	14.45	
Sheet Pile Wall with Parapet	Tidal Wall - Retaining – Sheetpiled & Non-tidal Wall - Retaining - Concrete	0.5m high parapet	12.12	For this asset, the carbon cost of a 3 metres high sheet pile wall and the carbon cost of varying height of parapet was used.
		1m high parapet	12.50	
		1.5m high parapet	13.39	
		2m high parapet	14.24	
		2.5m high parapet	15.09	
Floodwall	Non-tidal Wall - Retaining - Concrete	0.5m high floodwall	1.28	The non-tidal wall asset was used for the floodwall as these structures in the Leading Options are generally intended to be setback from the frontline.
		1m high floodwall	1.70	
		1.5m high floodwall	2.55	
		2m high floodwall	3.40	
		2.5m high floodwall	4.25	
Crest Raise	Wall Raising	0.5m high crest raising	0.39	For this asset the wall raising carbon rate in the CMT was considered most appropriate.
		1m high crest raising	0.77	
		1.5m high crest raising	1.16	
		2m high crest raising	1.55	
		2.5m high crest raising	1.93	

Defence Type in Strategy Leading Options	CMT Asset Classification Used	Geometry	Whole Life Carbon per m length of defence (tonnes CO2e)	Considerations
Seawall	Sea Wall - Retaining - Concrete	0.5m high seawall	3.65	CMT tool geometry measurement for seawall is in m^3. To establish the volume of the structure it has conservatively been assumed that the average thickness of a seawall will be approximately 50% of its height.
		1m high seawall	7.31	
		1.5m seawall	10.96	
		2m high seawall	14.61	
		2.5m high seawall	18.27	
Rock Groynes	Revetment Works - Rock Armour	2m high rock groyne	45.58	There is not a specific CMT asset class for rock groynes so therefore the rock armour asset class was used. CMT tool geometry for rock armour is in tonnes and therefore the m^3 of rock assumed in the Strategy costing was converted to tonnes assuming 1.9tonnes/m^3.
Rock Revetment	Revetment Works - Rock Armour	2m high rock revetment	33.21	CMT tool geometry for rock armour is in tonnes and therefore the m^3 of rock assumed in the Strategy costing was converted to tonnes assuming 1.9tonnes/m^3.
		3m high rock revetment	45.16	
		4m high rock revetment	57.12	
Cliff Slope Drainage	Drainage -Land/Field	Per m length of shoreline	3.45	The assumption for this asset is highly uncertain as the closest CMT asset (Drainage – Land/Field) as it is intended for land drainage rather than cliffs and is measured in metres cubed which is not directly applicable to a cliff face.
Sand Dune Enhancements	Soft Landscaping - Shrubs/Trees	Per m length of sand dune	0.003	The CMT lacks an asset type for sand dune enhancements, so the soft landscaping has been used as a substitute. It has been assumed that for per metre length of sand dune, 5 metres squared of landscaping is expected.
Beach Nourishment	Beach Recharge	Per m^3 of material	0.12	The beach recharge asset type has been used for beach nourishment, using the estimated volumes of beach nourishment required for each ODU that were assumed in the costing.
Beach Recycling	Beach Recharge	Per m^3 of material	0.12	For this asset, the beach recharge value has been used as there is no separate value for beach recycling in the CMT.
Embankment	Embankment - New	0.5m high embankment	0.45	

Defence Type in Strategy Leading Options	CMT Asset Classification Used	Geometry	Whole Life Carbon per m length of defence (tonnes CO2e)	Considerations
		1m high embankment	0.92	For this defence, the embankment (new) asset was used. The CMT geometric units for this asset type are in m^3 and the volume of embankment for different heights was obtained from the Leading Option costing estimates.
		1.5m embankment	1.56	
		2m high embankment	2.37	
		2.5m high embankment	3.34	
Armoured Embankment	Embankment – New & Erosion Protection	0.5m high embankment	0.59	For this defence, the embankment (new) and erosion protection assets were used. The CMT geometric units for the embankment asset type are in m^3 and the volume of embankment for different heights was obtained from the Leading Option costing estimates. The CMT geometric units for erosion protection are in m^2 and the area for different defence heights was obtained from the Leading Option costing estimates.
		1m high embankment	1.20	
		1.5m embankment	1.98	
		2m high embankment	2.93	
		2.5m high embankment	4.04	
Slope Armouring	Erosion Protection	1m high slope armouring	0.28	The CMT geometric units for erosion protection are in m^2 and the area for different defence heights was obtained from the Leading Option costing estimates.

Note that the following defence types in the Strategy Leading Options did not have a CMT Asset type or an appropriate substitute and therefore carbon impacts have not been estimated:

- Property level resilience

2.2 Whole Life Carbon Emissions Avoided

The Environment Agency's Carbon Impacts tool[1] (2022 version) has been used to estimate the projected carbon emissions avoided (tCO2e) by the Leading Options as a result of reduced flooding and erosion risk. The tool uses 4 sets of data to help estimate the emissions avoided[2]. These are the carbon emissions avoided of:

- Refurbishing a residential home after it has flooded;
- Replacing a car and disposal of the damaged car after it has flooding;
- Living in and travelling to temporary accommodation; and
- Demolishing a home before it is eroded.

The tool has different levels of calculation, depending on the data available and stage of assessment. Given that this assessment is being used to support a Strategic study, the least detailed / highest level calculation has been used (Flood Level 1 and Erosion Level 1 calculations).

To estimate the carbon emissions avoided through a reduction in flood risk with the Flood Level 1 calculation, the tool requires the user to input the option present value benefits (in £) over the appraisal period. This value was obtained from the economic appraisal of the Leading Options and then input into the tool.

To estimate the carbon emissions avoided through a reduction in erosion risk with the Erosion Level 1 calculation, the tool requires the user to input the number of residential properties at risk in the medium term (0-20 years) and long term (20-100 years), in addition to the area of non-residential property at risk in the medium and long term. These properties at risk are assumed to benefit from the scheme / Leading option. The values were obtained from the economic appraisal of the Leading options and then input into the tool. The total area of non-residential property at risk/benefiting was approximated using the average footprint area of non-residential properties at risk in the Strategy area, multiplied by the number of non-residential properties at risk.

2.3 Estimated Monetary Value (£) of Whole Life Carbon Emissions / Emissions Avoided

The GOV.UK policy paper on the valuation of greenhouse gas emissions: for policy appraisal and evaluation[3] has been used to estimate the equivalent value in monetary terms (£) of the estimated carbon emissions and carbon emissions avoided (tonnes CO2e) for the Leading Options.

The paper sets out the revised approach to valuing the greenhouse gas emissions in policy appraisal. The paper provides annual representations of an estimated monetary value that society places on one tonne of carbon dioxide equivalent (£/tCO2e). Annex 1 of the paper presents the carbon values for a given year.

There is an uncertainty range in the carbon values derived in the paper, this can be driven by differing modelling approaches or by underlying scenario assumptions of socioeconomic factors. There are three sensitivity ranges: Low Series, Central Series, High Series. The central series was used for this assessment.

To estimate the monetary values (£) for each Leading Option, the estimated carbon emissions and emissions avoided (tCO2e) of each option were multiplied by the 2024 Central Series carbon value of 256 (£/tCO2e). This process produced a monetary carbon value (£) for the estimated carbon emissions and emissions avoided for each Leading Option. See Table 3-1 for the estimated values (rounded to the nearest hundred £).

No discounting has been applied to future monetary value of carbon emissions / emissions avoided in the estimates.

[1] Environment Agency Carbon Impacts Tool (2022). Available at: https://www.gov.uk/government/publications/fcerm-carbon-impacts-tool
[2] Valuing the Carbon Net Impacts of FCERM projects (2022). Available at: https://www.gov.uk/government/publications/valuing-the-carbon-net-impacts-of-fcerm-projects
[3] Valuation of greenhouse gas emissions: for policy appraisal and evaluation. (2021). Available at: Valuation of greenhouse gas emissions: for policy appraisal and evaluation - GOV.UK (www.gov.uk)

3. Results

The results of the whole life carbon emission and whole life carbon emission avoided estimates are presented in Table 3-1 and Table 3-2 for the Strategy Leading Options.

In total, delivery of the Strategy Leading Options is estimated to lead to approximately 814,000 tonnes of CO2e emissions over the next 100 years. Through the reduction of flooding and erosion risk, delivery of the Leading Options is estimated to reduce emissions by approximately 36,000 tonnes of CO2e over the next 100 years. These estimates are based on the emission values for the Local Aspirational Option (where identified) or the National Economic Option (if a Local Aspirational Option hasn't been identified). The estimates only include values from the Option Development Units (ODUs) in which it has been possible to make an estimate.

There will be opportunities to significantly reduce carbon emissions of the Leading Options through appropriate design at the scheme stage, such as through the use of low carbon concrete, reuse of materials or using local sources of rock / beach nourishment material.

Table 3-1: Leading Options summary and carbon assessment results

ODU			National Economic Leading Option	Local Aspirational Leading Option	Backup Option/s
1 – Hengistbury Head East	**Option**		Do Minimum	Managed Realignment	-
	Details		Small scale repairs to existing defences (i.e. patch-repairs)	Maintain toe defences and undertake beach recycling from epoch 1. Erosion of cliff would be controlled but not stopped entirely	-
	Whole life carbon emissions	tonnes CO2e	Not estimated – only small scale patch repairs required	66,150	-
		£		£16,934,400	
	Whole life carbon emissions avoided	tonnes CO2e	Not estimated – flood & erosion risk benefits on national basis are 0	Not estimated – flood & erosion risk benefits on national basis are 0	-
		£			-
2 – Mudeford Sandbank	**Option**		Do Minimum	Maintain with Adaptation	-
	Details		Small scale repairs to existing defences (i.e. patch-repairs)	Sustain the FCERM service of the Sandbank by holding its form over time and aiming to keep it broadly in its current position. Achieved through beach nourishment and defence maintenance. Property level protection to permanent properties on the Sandbank.	-
	Whole life carbon emissions	tonnes CO2e	Not estimated – only small scale patch repairs required	105,341	**-**
		£		£26,967,300	**-**
	Whole life carbon emissions avoided	tonnes CO2e	Not estimated – flood & erosion risk benefits on national basis are 0	30	**-**
		£		£7,700	**-**
3 – Christchurch Harbour South	**Option**		Adaptation / Resilience A	Adaptation / Resilience C	-
	Details		Property level protection to properties at risk	As per Adaptation / Resilience A, but with localised erosion defences to the access road to Hengistbury Head and around Wick historic landfill site	-
	Whole life carbon emissions	tonnes CO2e	Not estimated – only property level resilience / protection measures included	1,932	-
		£		£494,600	
	Whole life carbon emissions avoided	tonnes CO2e	222	293	-
		£	£56,800	£75,000	-

ODU			National Economic Leading Option	Local Aspirational Leading Option	Backup Option/s
4 - Wick	**Option**		Sustain C	Sustain B	-
	Details		Raise and lengthen existing setback embankment defence from epoch 1, and then progressively over time to keep pace with sea level rise	As per Sustain C, however, repeat maintenance / refurbishments would also be undertaken on the frontline quay wall to prevent erosion of historic landfill	-
	Whole life carbon emissions	tonnes CO2e	1,166	11,268	-
		£	£298,500	£2,884,600	-
	Whole life carbon emissions avoided	tonnes CO2e	1,294	1,208	-
		£	£331,300	£309,200	-
5 – Willow Drive and the Quomps	**Option**		Improve D-F (alignment to be decided)	Improve A-C (alignment to be decided)	Adaptation / Resilience
	Details		Raise height of defences to improve SoP from epoch 2. Maintain / replace frontline defence adjacent to historic landfill site at the Quomps	As per Improve D-F, except defence height would be raised in epoch 1 rather than epoch 2	Maintain frontline defences and undertake property level protection to properties at risk of flooding
	Whole life carbon emissions	tonnes CO2e	25,875 – 30,160	25,853 – 29,967	26,715
		£	£6,624,000 - £7,721,000	£6,618,400 - £7,671,600	£6,839,000
	Whole life carbon emissions avoided	tonnes CO2e	11,691 – 12,388	11,436 - 12,131	5,488
		£	£2,992,900 - £3,171,300	£2,927,600 - £3,105,500	£1,404,900
6 – River Avon West Bank	**Option**		Adaptation / Resilience	-	-
	Details		Maintain frontline defences and undertake property level protection to properties at risk of flooding	-	-
	Whole life carbon emissions	tonnes CO2e	8,155	-	-
		£	£2,087,700	-	-
	Whole life carbon emissions avoided	tonnes CO2e	955	-	-
		£	£244,500	-	-
7 – Rossiters Quay	**Option**		Improve A	-	Adaptation / Resilience
	Details		Raise existing / construct new flood defences in epoch 2	-	Maintain / refurbish existing defences and undertake property level protection to properties at risk of flooding

ODU			National Economic Leading Option	Local Aspirational Leading Option	Backup Option/s
	Whole life carbon emissions	tonnes CO2e	8,120	-	9,065
		£	£2,078,700	-	£2,320,600
	Whole life carbon emissions avoided	tonnes CO2e	1,770	-	1,080
		£	£453,100	-	£276,500
8 -River Avon East Bank			Options appraised separately by Environment Agency		
9 - Stanpit	**Option**		Sustain A	-	Adaptation / Resilience
	Details		Raise existing / construct new flood defences from epoch 2 and then raise over time to keep pace with sea level rise. Defences would defend Stanpit historic landfill site	-	Maintain / refurbish existing defences and undertake property level protection to properties at risk of flooding
	Whole life carbon emissions	tonnes CO2e	9,713	-	8,489
		£	£2,486,500	-	£2,173,200
	Whole life carbon emissions avoided	tonnes CO2e	12,555	-	4,169
		£	£3,214,000	-	£1,067,300
10 - Mudeford	**Option**		Improve A	-	Adaptation / Resilience
	Details		Property level protection to properties at risk in epochs 1 and 2. Construct new flood defences in epoch 3 to increase the SoP against flooding	-	Maintain / refurbish existing quay walls and undertake property level protection to properties at risk of flooding
	Whole life carbon emissions	tonnes CO2e	46,603	-	25,133
		£	£11,930,400	-	£6,434,000
	Whole life carbon emissions avoided	tonnes CO2e	3,694	-	922
		£	£945,700	-	£236,000
11 – Mudeford Quay	**Option**		Do Minimum	Adaptation / Resilience	-
	Details		Small scale repairs to existing defences (i.e. patch-repairs)	Property level protection to properties at risk. Maintain existing quay walls.	-

ODU			National Economic Leading Option	Local Aspirational Leading Option	Backup Option/s
	Whole life carbon emissions	tonnes CO2e	Not estimated – only small scale patch repairs required	26,303	-
		£		£6,733,600	-
	Whole life carbon emissions avoided	tonnes CO2e	Not estimated – flood risk benefits on national basis are 0	226	-
		£		£482,000	-
12 Avon Beach and Friars Cliff	**Option**		Improve A	Improve C	'Scaled back' Improve A
	Details		Maintain / refurbish existing defences from epoch 1. Undertake beach nourishment from epoch 2 as well as new rock groynes and raising Avon Beach seawall. Localised property level protection in epoch 3 to manage flood risk.	As per Improve A but undertake broader public realm enhancements (such as promenade raising)	Reduce beach nourishment volume / scale of defence improvements to reduce cost and improve affordability
	Whole life carbon emissions	tonnes CO2e	78,872	83,372	-
		£	£20,191,200	£21,343,200	-
	Whole life carbon emissions avoided	tonnes CO2e	443	443	-
		£	£113,400	£113,400	-
13 - Highcliffe	**Option**		Improve C	Improve A	'Scaled back' Improve C
	Details		In epoch 1 construct rock armour defence at east end of unit to reduce outflanking risk. In epoch 1 and 2 maintain existing defences and undertake beach recycling. From epoch 3 undertake beach nourishment, construct new rock groynes and refurbish defences	As per Improve C, except the beach nourishment in epoch 3 would be brought forward to be undertaken from epoch 2. New rock groynes from epoch 3	Reduce beach nourishment volume / scale of defence improvements to reduce cost and improve affordability
	Whole life carbon emissions	tonnes CO2e	92,034	97,635	-
		£	£23,560,700	£24,994,600	-
	Whole life carbon emissions avoided	tonnes CO2e	456	456	-
		£	£116,700	£116,700	
14 – Naish Cliff and Barton on Sea	ODU 14 presented in Table 3-2 due to multiple Backup options requiring different table format				

ODU			National Economic Leading Option	Local Aspirational Leading Option	Backup Option/s
15 – Barton on Sea to Hordle Cliff	**Option**		Do Nothing	-	-
	Details		No defence maintenance or beach management undertaken. Undertake health and safety activities following cliff erosion events to make safe public spaces.	-	-
	Whole life carbon emissions	tonnes CO2e	Not estimated – no interventions as part of this option	-	-
		£		-	-
	Whole life carbon emissions avoided	tonnes CO2e		-	-
		£		-	-
16 – Cliff Road	**Option**		Managed Realignment C	Managed Realignment A or B	Maintain
	Details		From second half of epoch 2 undertake beach nourishment and construct local strong point to control rate of cliff erosion. Cliff top recession would still occur but intent would be to prevent it reaching Cliff Road.	As per Managed Realignment C, except beach nourishment and strong point would be constructed much sooner, in either epoch 1 (Managed Realignment A) or start of epoch 2 (Managed Realignment B)	Maintain existing defences and undertake beach recycling to control beach levels. In the long term this is likely to lead to more erosion than the Managed Realignment options.
	Whole life carbon emissions	tonnes CO2e	58,935	41,424 - 52,143	15,258
		£	£15,087,400	£10,604,500 - 13,348,600	£3,906,000
	Whole life carbon emissions avoided	tonnes CO2e	573	573	Not estimated due to greater uncertainty in long term erosion / shoreline position with this option
		£	£146,700	£146,700	
17 – Rook Cliff	**Option**		Improve C	Improve A or B	Maintain
	Details		Refurbish existing cliff toe defences in epoch 1. From second half of epoch 2 upgrade defences at cliff toe.	As per Improve C, except toe defence improvements would be constructed much sooner, in either epoch 1 (Managed Realignment A) or start of epoch 2 (Managed Realignment B)	Maintain existing defences at the toe of the cliff. Long term sustainability of this approach is uncertain given lowering beach levels in this location and this option is therefore likely to lead to more erosion than the Improve options.
	Whole life carbon emissions	tonnes CO2e	116,392	93,202	62,619
		£	£29,796,400	£23,859,700	£16,030,500
	Whole life carbon emissions avoided	tonnes CO2e	686	686	Not estimated due to greater uncertainty in long term erosion / shoreline position with this option
		£	£175,600	£175,600	

ODU		National Economic Leading Option	Local Aspirational Leading Option	Backup Option/s
18 – Milford on Sea	ODU 18 presented in Table 3-2 due to multiple Backup options requiring different table format			

Table 3-2: ODU 14 and 18 Leading Options summary and carbon assessment results

ODU			National Economic Leading Option	Backup Options		
14 – Naish Cliff and Barton on Sea	**Option**		Managed realignment A	Managed Realignment B	Managed Realignment D	Maintain
	Details		Improved toe defences and cliff stabilisation / drainage in the area between Marine Drive West and the eastern end of Barton on Sea during epoch 1. This would help to slow rates of cliff top recession but not stop it entirely.	Improved toe defences and cliff stabilisation / drainage in the area between Marine Drive West and the eastern end of Barton on Sea from epoch 2. Beach nourishment at Naish cliff from epoch 2. This would help to slow rates of cliff top recession but not stop it entirely.	In epoch 2 upgrade existing toe defences and cliff drainage to cover central and eastern parts of the Barton on Sea frontage. Marine Drive West would remain undefended. Beach nourishment would be included at Naish Cliff.	Maintain existing defences and functioning drainage but no new defences constructed. Would help to slow rates of erosion in defended areas but not as effectively as the Managed Realignment options.
	Whole life carbon emissions	tonnes CO2e	124,265	150,065	120,556	123,336
		£	£31,811,800	£38,416,600	£30,862,300	£31,574,000
	Whole life carbon emissions avoided	tonnes CO2e	841	Not estimated due to greater uncertainty in long term erosion / shoreline position with this option	Not estimated due to greater uncertainty in long term erosion / shoreline position with this option	Not estimated due to greater uncertainty in long term erosion / shoreline position with this option
		£	£215,300			
18 – Milford on Sea	Option		Improve A	Improve B	Maintain	-
	Details		Upgrade seawall, construct new groynes/beach control structures and undertake major beach nourishment from epoch 1. Construct setback tidal flood defences at eastern end of Milford on Sea to reduce risk of flooding from Sturt Pond direction in epoch 2.	As per Improve A, except upgrade coastal defences and beach nourishment in epoch 2. Refurbish existing defences in epoch 1 to extend service life until upgrade.	Maintain existing defences and undertake beach recycling. Long term effectiveness uncertain.	-
	Whole life carbon emissions	tonnes CO2e	50,132	62,271	45,050	-
		£	£12,833,800	£15,941,400	£11,532,800	-
	Whole life carbon emissions avoided	tonnes CO2e	345	345	Not estimated due to greater uncertainty in long term erosion / shoreline position with this option	-
		£	£88,300	£88,300		-

4. Assumptions and Considerations

To estimate the emissions and emissions avoided by the Strategy Leading Options several assumptions and considerations have been made:

- The emission estimates are a high level estimate appropriate for a strategic level of assessment. As more detail is developed during scheme level appraisal the carbon estimates will be subject to change and should be updated accordingly.
- The emission estimates have been estimated making use of the Environment Agency's CMT tool and the limitations and uncertainties associated with this tool also apply to this assessment.
- The emission estimations also make use of the Strategy costing assumptions, which include assumptions on defence type, alignment and geometry. When schemes are delivered following the Strategy it is likely that the defence alignment and geometry will change, and there may also be variations in the defence type used. As a result, the carbon estimations will need to be updated.
- Using the CMT tool it was not possible to estimate the carbon emissions for property level resilience / protection measures and therefore no carbon emissions have been included for this measure in the Leading Options for which it is recommended.
- The estimates of emissions avoided have been estimated using the Environment Agency's Carbon Impact Tool and the limitations and uncertainties associated with this tool also apply to this assessment.
- The carbon price used to estimate monetary values is the 2024 value (£256 /tCO2e) and has not been changed over the lifetime of the Leading option (i.e. assumed to remain constant). The GOV.UK policy paper on the valuation of greenhouse gas emissions: for policy appraisal and evaluation indicates a likely increase in carbon price in the future and therefore more detailed assessments at scheme level should consider this uplift over time.