ARUP

Bristol City Council

Bristol Avon Flood Strategy

GHG assessment technical note

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1. Introduction

Bristol City Council is working with the Environment Agency and key stakeholders to create a vital long-term strategy to protect the city from increased flood events, supported by Arup. The Strategy includes the provision of flood defence infrastructure to manage the flood risk from the River Avon to the centre of Bristol with placemaking to seek opportunities for inclusive growth, quality of life, environmental improvement and resilience. The current stage of Strategy delivery is preparation of the Outline Business Case (OBC).

The Bristol Avon Flood Strategy sets out a strategic long-term plan for managing flood risk from the River Avon to Bristol and its neighbouring communities. Following public consultation on the SOC a supporting Strategic Environmental Assessment (SEA) was completed in Autumn 2020.

During SOC, a top down carbon assessment was also conducted that used, in lieu of specific design information, assumptions and benchmarks to approximate carbon. The SOC carbon assessment also concluded that:

- the construction of raised defences in the 2020s and raising them further in the 2060s has a considerably lower embodied carbon impact than constructing raised defences combined with a 'narrow' tidal barrier,
- the study was limited by the available tools and information, as it used a limited number of built-in benchmark values, and;
- the operational stage (which includes maintenance and repair) accounted for the largest proportion of carbon consumption for the raised defences option.

The design has now progressed significantly, and using this new design and updated guidance, a bottom up carbon assessment has been conducted at OBC.

This Carbon Optimisation Report outlines the changes in design since SOC and reports on a bottom up carbon assessment of the current design.

This assessment focusses on the embodied carbon of the preferred option. As part of the economic assessment (Economics technical report, appendix E of the OBC), the Environment Agency's Carbon Impacts Tool was used to calculate the carbon avoided due to the Strategy. Flood protection options avoid carbon impacts for example, from the emergency response and significant repair and recovery prompted by flood events. It is estimated that over the 100-year design life the scheme would avoid 1,372,000t tCO_{2e} of these impacts.

2. Policy background

In 2020 BCC published the Bristol One City Climate Strategy[1] setting out a strategy for a carbon neutral, climate resilient Bristol by 2030. The Bristol Avon Flood Strategy is one of the pilot projects for the draft Bristol City Council Sustainability Framework. This framework sets out a series of sustainability objectives and metrics, from carbon to biodiversity, for the capital portfolio as a whole. Therefore, this carbon assessment supports the BAFS with the delivery against the carbon related objectives to 'support achieving a carbon neutral Bristol' and 'ensure that all Bristol City Council assets can be net zero carbon in operation.'

[1] Bristol City Council, "One City Climate Strategy" [online]. Available: https://www.bristolonecity.com/wp-content/uploads/2020/02/one-city-climate-strategy.pdf

The Environment Agency have committed[2] to becoming a net zero organisation by 2030. The construction of FCRM capital projects forms a major source of carbon emissions and early consideration of carbon is required to identify solutions that efficiently minimise whole life carbon impacts. As part of the net zero commitment, the Environment Agency aims to reduce the annual carbon emissions from construction by 45%[3], including by reducing the need for construction and achieving wider benefits like green spaces for communities and better wildlife habitat. Emissions will be limited from materials, processes and suppliers.

3. Assessment boundary

The Environment Agency's (EA) 'ERIC' Carbon Planning tool used for this assessment enables whole-life carbon modelling across all lifecycle stages of constructed assets. The ERIC Internal Carbon Calculator (see Appendix A) provides a bottom up whole-life carbon assessment, designed to be used at SOC stage. The purpose of which is to guide a project to deliver carbon management processes and requirements and to capture evidence to support the carbon management verification process.

4. Basis of design

During SOC two different designs were assessed for carbon emissions; the lowest carbon option was taken forward to OBC. The OBC design built on the leading SOC option of raised defences and generally looked to add detail to the SOC design. Specific interventions were discussed during carbon workshops, outlining low carbon principles and how these could reduce carbon further through design.

4.1 Low carbon principles

The following principles were discussed during the Carbon Workshops, and where possible applied to the design:

- Incorporate an 'adaptive' strategy, meaning defences constructed in phase 1 (the 2020s) will be raised in phase 2 (2060s). This means the possibility of building overly large defences (and hence greater emissions) in phase 1 is avoided. By delaying construction of some defences to their full height, it also increases the possibility of lower-carbon alternatives (in both materials and construction methodology) being available through technological advance. Foundations have been designed to allow for future raising, and hence defences can be raised rather than rebuilt.
- Reduce defence lengths and relative heights though interrogation of the hydraulic model and topographic data.
- Use defences for 'practical betterment' rather than detriment mitigation reducing the need for impractically large defences to serve small numbers of properties.
- Incorporate existing structures, reducing total material required.
- Reduce the area that would need to be raised, reducing the need for additional Type 1 and asphalt.
- Increase the habitat retention by moving small areas of walls back from the river.
- Make the scheme as passive as possible, reducing the risk of failure, operational maintenance and electricity use.

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[2] Environment Agency, "Environment Agency sets net zero emissions aim" [online]. Available: https://www.gov.uk/government/news/environment-agency-sets-net-zero-emissions-aim

[3] Environment Agency, "Reaching Net Zero by 2030" [online]. Available: https://assets.publishing.service.gov.uk/media/60ae699be90e071b5d705d20/EA-net-zero-2030.pdf

- Consider other Bristol projects in pre-construction. For example, this could include incorporating the Bristol heat network construction programme into the scheme's construction, reducing temporary works, movement of construction compounds and plant.
- A report considering natural flood management measures (NFM) suggested that these could sequester around 86.05 TCO_{2e} per year. These have not been included in the estimate below as they are not in the costed preferred option.

At this stage of the design, standard values for carbon intensity have been considered in order to give a conservative but realistic value for the carbon impact of the design. Further low carbon principles including the use of low carbon concrete and steel, and enhanced on-site materials management, will be considered during detailed design, and are included in the recommendations in section 6.

4.2 Design Assumptions

Even though the design has progressed significantly since SOC, the proposed scheme is still a concept design, and therefore a further detailed design remains. This detailed design stage will still hold opportunities to reduce carbon further. As such, the current carbon assessment still relies on assumptions to fill specific design knowledge gaps. The assumptions used for the project are listed in Table 1.

Table 1 Project assumptions

Category	Assumptions
Design – Structural	• Wall defence structures are assumed to be 0.45m thick with 0.75m gates. • Embankments are assumed to have a crest width of 3m with a slope of 1:3. • Roads are assumed to be 6m wide. • Gravity flood wall foundation dimensions have been calculated on the assumption that the ratio of base width to average phase 1 defence height is 1:1, with a footing height of 0.4m. • Piled and sheet piled foundation dimensions have been assumed to be the same as specified in the current section drawings, with the necessary depth, diameter and number of piles estimated from a geotechnical desk study. • Floodwalls are assumed to be clad with brick on both sides, with the cladded area on each side to be the average phase 1 defence height x alignment length. Bricks assumed to be 102.5mm in depth. • All floodwalls and embankments are assumed to be non-tidal. • Assume cladding is present on both sides of structures and covers the length and height of the structure.
Design - Materials	• Unless otherwise stated, the carbon intensity of materials is taken from the Inventory of Carbon and Energy (ICE) database. • In-situ reinforced concrete is assumed to be sourced locally (transport return distance of 50km). • Steel is assumed to be sourced nationally (transport return distance of 300km).

	• Assume all soil/clay materials are transported to site from external sources. • Assume cladding material is brick transported to site from external sources. • All assets assumed to be new builds.
Construction	• 500 litres of diesel is assumed to be used per week of construction for plant, with an assumed project length of 8 years. • Materials won from site or reused from older infrastructure are assumed to result in zero transport emissions. • All construction materials are assumed to be transported by HGV.
Operation	• Maintenance, repair and use activity assumptions are listed in Appendix A1. • The return distance to manned assets for maintenance purposes is assumed to be 50km.

4.3 Limitations

The ERIC Tool does have constraints in that there are not adequate benchmarks for more specific construction activities. Therefore, this iteration of the carbon assessment is missing key items such as temporary works, utility diversions and all carbon related to Property Flood Resilience measures (PFR). Given these known unknowns within the assessment it has been agreed that a 50% contingency is applied to the capital carbon value. This value is similar to the optimism bias applied to the scheme costs, and as with optimism bias it is expected that this value would reduce as the design of the scheme is progressed and greater certainty derived.

This assessment also does not consider the economic assessment of the scheme, which includes the carbon impacts of the scheme in terms of flood damages avoided and the embodied carbon saved through these protections. These can be found in BAFS OBC Economic Appendix. This means the positive carbon outcomes from flood protection within this report are underestimated.

5. Findings

The total emissions produced by the scheme is estimated to be 41,895 tCO2e, 72.7% of which will be emitted during construction, 25.6% during operation, 1.77% for demolition and -4.4% for residual.

The findings from the ERIC Internal Carbon Calculator are presented in Table 2.

Table 2 SOC tCO_2e findings

Emissions stage	Footprint, tCO_2e
A1 (Materials)	27,826
A2 (Material Transport)	286
A4 (Transport of Personnel)	1,084
A4 (Transport of Plant)	1.68
A5 (Site establishment)	488
A5 (Plant use – Diesel)	705

A5 (Waste)	23
Total Construction	30,409
Total Construction with 50% contingency	**45,613**
B1 (Use)	1.8
B2 (Maintenance)	5,833
B3 (Repair)	19.5
B4 (Replacement)	3,946
B5 (Refurbishment)	948
Total Operation	**10,748**
C1-C2 (Demolition)	743
D (Residual)	-1,839
Whole Life Carbon (Total)	**55,600**

5.1 Construction

The largest proportion, 91.5%, of emissions comes from the materials used, specifically 58.7% of them are from steel and 14.8% is from concrete, the second and third highest are transporting personnel/plant to site and the use of diesel plant and generators contributing 3.6% and 2.3% respectively. The smallest proportion of construction emissions is related to material waste (0.08%).

5.2 Operation

The largest proportion of emissions comes from the maintenance of the scheme (54.2%), which is to be expected given the geographically large size requiring numerous inspection visits and maintenance tasks. The second largest is replacement of materials (37.6%) which is also expected given the scheme is made up of floodwalls and flood gates. It is expected that operational visits will be managed generally by local teams, and with maintenance organised by task and / or location to reduce travel and other associated emissions.

5.3 Comparison with other flood schemes

The EA use the capital intensity metric to compare different flood schemes. This is a measure of tonnes of carbon divided by the cost of the scheme. This allows for the size of the scheme to be taken into consideration when deciding whether a scheme should be taken forward. Table 3 shows the carbon intensity of the BAFS at SOC and OBC stages, showing the change with additional design information. It also shows the comparison of BAFS OBC with other recent flood defence schemes and the current EA carbon intensity baseline and the 2023 target. Due to the varied reporting of project costs and carbon emissions estimates, as well as differences in the nature of schemes, direct comparisons are difficult. Table 3 shows a number of similar examples to demonstrate confidence in the estimate for BAFS calculated in this report.

Table 3 Carbon intensity of similar schemes, and the EA baseline and target

Project	Capital intensity (tCO2e/£10k)
BAFS SOC	~10
BAFS OBC	1.88*
Greyfriars OBC	1.43
Beales Corner FBC	1.93

Leeds FAS Phase 2[4] [5]	2.72
EA 2021 baseline	4.32
EA 2031 target	1.38

*50% Contingency added to construction

Greyfriars is a scheme proposing the implementation of a combination of flood walls, flood gates, embankments, and Property Flood Resilience measures, with an approximate cost of construction of £6.5m.

Leeds FAS comprises linear defence alignments adjacent to the River Aire varying in height from 1.2 to 2.5m, the removal of 2 bridges that obstruct high flows, a flood storage area located upstream of the city limits and an extensive programme of tree planting in the upper catchment.

By using these comparisons, it shows that even though the carbon associated with constructing the Strategy at this time is high, it is within the current capital intensity targets and comparable to other schemes. This indicates that the amount of carbon generated is due to the large nature of the scheme, and shows that the low carbon principles adopted have reduced its carbon intensity to an acceptable level, noting that additional reductions will be explored within FBC.

As outlined in section 1, the amount of carbon emissions avoided by construction in the scheme, due to the reduced need to repair and rebuild communities after flooding, is 1,372,000t tCO_{2e} , meaning that overall the scheme makes net savings of carbon.

6. Recommendations

To minimise embodied carbon the following recommendations are based on the GHG assessment and aim to have the biggest impact. As such these recommendations are as follows:

- Steel and concrete make up the majority of the GHG from this scheme. At the next stage, explore where recycled steel and low carbon concrete can be substituted within the design.
- Explore site wide electric hook ups, including the use of electric and other non-diesel plant, to reduce the use of diesel generators during construction.
- Explore opportunities for reuse and recycling of waste materials.
- Work within the design to reduce the maintenance regime of specific design elements and reduce the need for a large replacement of materials over operation.
- Incorporate the existing structures into the design to reduce demolitions to as close to zero as possible.
- Further structural and geotechnical investigations to determine the extent to which existing structures can be used or refurbished rather than replaced.
- Work with contractors at an early stage to minimise transport distances for materials in construction, and reduction in temporary works.
- Consider the use of precast elements.

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[4] Defra, "2 September 2021: Leeds Flood Alleviation Scheme Phase 2 accounting officer assessment" [online}. Available: https://www.gov.uk/government/publications/defra-accounting-officer-assessments/leeds-flood-alleviation-scheme-phase-2-accounting-officer-assessment#regularity

[5] Leeds Climate Commission, "Flood alleviation – carbon savings and low carbon innovation" [online]. Available: https://www.leedsclimate.org.uk/leeds-flood-alleviation-scheme-phase-2

- Develop proposals for interventions that sequester carbon including habitat creation and natural flood management to work alongside the proposed defences. An NFM opportunities report suggested 86 tCO_{2e}/yr could be sequestered, and it is expected that more developed landscaping and habitat creation proposals could significantly add to this.

Appendix A

ERIC Internal Carbon Calculator

Summary

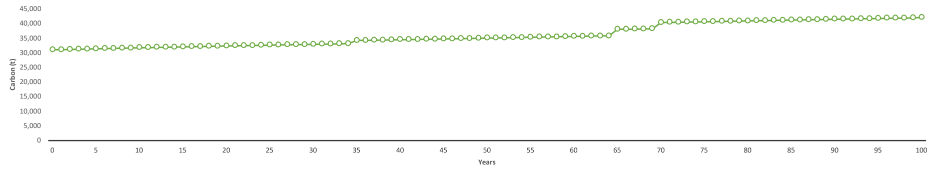
SOP	Project manager	Produced by
NA	**Robin Campbell**	**Seth Shaw**

Project name	Date produced	Reviewed by
Bristol Avon Flood S	**29/11/2023**	**Cameron Toms**

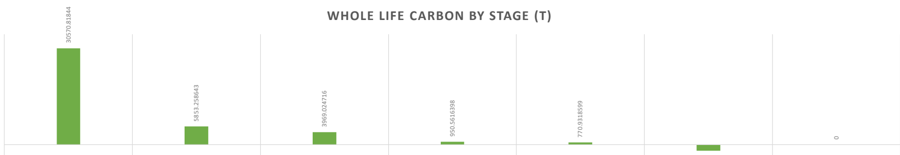
Results

Total Whole Life Carbon	Residual Carbon	Carbon Sequestration	Net Whole Life Carbon
42114.60	**-1848.51**	**0.00**	**40266.09**

WHOLE LIFE CARBON (TCO2E) - CUMULATIVE OVER TIME

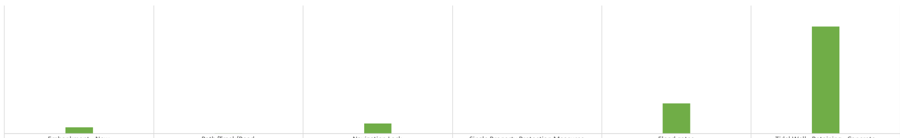


WHOLE LIFE CARBON BY STAGE (T)



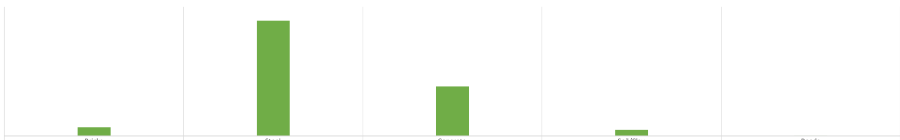
	Capital Carbon - (A1-A5)	Operational Carbon - (B1-B3)	Replacement Carbon - (B4)	Refurbishment Carbon - (B5)	Demolition Carbon - (C1-C2)	Residual Carbon - (D)	Carbon Sequestration (woodland and peatland)
Total	30570.81844	5853.258643	3969.024716	950.5616398	770.9318599	-1848.506708	0

WHOLE LIFE CARBON BY ASSET(T)



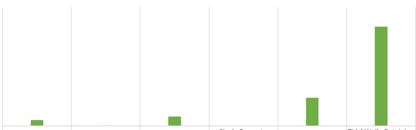
	Embankment - New	Path/Track/Road	Navigation Lock	Single Property Protection Measures	Flood gates	Tidal Wall - Retaining - Concrete
Total	1755.701159	39.66959992	2743.813548	0	8293.441333	29281.96966

NEW BUILD MATERIALS - (A1) CARBON (T)



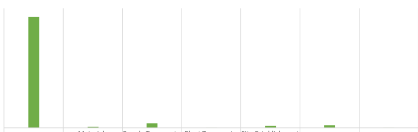
	Bricks	Steel	Concrete	Soil/Clay	Roads
Total	1332.079422	17864.8034	7673.560986	933.2952672	22.632

NEW BUILD CARBON (A1-A5) BY ASSET(T)



	Embankment - New	Path/Track/Road	Navigation Lock	Single Property Protection Measures	Flood gates	Tidal Wall - Retaining - Concrete
Total	1755.701159	39.66959992	2743.813548	0	8293.441333	29281.96966

NEW BUILD CARBON BY TYPE (T)

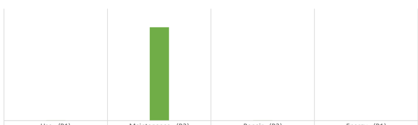


	Materials - (A1)	Materials Transport - (A2)	People Transport - (A4)	Plant Transport - (A4)	Site Establishment - (A5)	Plant Use - (A5)	Waste - (A5)
Total	27826.37	286.17	1193.80	1.67	537.75	701.72	23.33

WHOLE LIFE OPERATIONAL (B1-B2) CARBON BY ASSET(T)

	Embankment - New	Path/Track/Road	Navigation Lock	Single Property Protection Measures	Flood gates	Tidal Wall - Retaining - Concrete
Total	685.3691901	0	0	0	2476.225069	2691.664383

WHOLE LIFE OPERATIONAL CARBON BY TYPE (T)



	Use - (B1)	Maintenance - (B2)	Repair - (B3)	Energy - (B1)
Total	0.359797092	5833.439289	19.45955599	0

Environment Agency

Carbon Planning Tool

+ - Project details

Date produced	Version	Produced by	Reviewed by	SOP	Project name	EA project manager	National Project Number	Project Type
29/11/2023	1	Seth Shaw	Cameron Toms	NA	Bristol Avon Flood Strategy	Robin Campbell	NA	FCRM

Total project cost	Total construction cost	Total salaries cost	Total consultant cost	Construction start date	Construction finish date	Project Stage	Project Location	EA Area
£239,000,066	£239,000,066	£0	£0	01/04/2029	31/12/2036	OBC	South West	Wessex

+ - Assets

Please ensure no more than 35 assets are entered

Asset ID	Asset class	Asset description	Asset measure	Asset unit	Asset value
EmbaEA15	Embankment - New	Embankments	18969	m3	£ 4,568,133.09
TidaEA63	Tidal Wall - Retaining - Concrete	Floodwalls	18685	m3	£ 211,097,062.57
FlooEA70	Flood gates	Floodgates	231	m2	£ 12,570,532.13
NaviEA34	Navigation Lock	Entrance Lock	223	m3	£ 8,395,658.75
PathEA41	Path/Track/Road	Road Raising	690	m2	£ 1,197,573.27
SingEA75	Single Property Protection Measures	PFR	60	nr.	£ 1,171,105.98
					£239,000,065.78

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+ - Sub-Assets

Please ensure no more than 50 sub assets are entered

Asset ID	Asset description	Asset class	Sub-Asset ref.	Sub-Asset description	Sub-Asset category	Standard life	First intervention	Expected new build/Replacement life	Refurbishment type	Expected refurbished Life
EmbaEA15	Embankments	Embankment - New	EmbaEA1553	New Embankments	Embankment - Fluvial	130	Refurbishment	40	Major Refurbishment	130
TidaEA63	Floodwalls	Tidal Wall - Retaining - Concrete	TidaEA6354	RC Floodwall	Wall - Fluvial	130	Refurbishment	40	Major Refurbishment	130
TidaEA63	Floodwalls	Tidal Wall - Retaining - Concrete	TidaEA6355	Sheet Piled Floodwall	Wall - Fluvial	130	Refurbishment	40	Major Refurbishment	130
TidaEA63	Floodwalls	Tidal Wall - Retaining - Concrete	TidaEA6356	RC Foundations	Wall - Fluvial	130	New Build	101	Not Possible	
TidaEA63	Floodwalls	Tidal Wall - Retaining - Concrete	TidaEA6357	Steel Foundations	Wall - Fluvial	130	New Build	101	Not Possible	
TidaEA63	Floodwalls	Tidal Wall - Retaining - Concrete	TidaEA6358	Cladding	Wall - Fluvial	130	Refurbishment	40	Major Refurbishment	65
NaviEA34	Entrance Lock	Navigation Lock	NaviEA3459	Entrance Lock	Navigation Lock	60	Refurbishment	40	Major Refurbishment	130
PathEA41	Road Raising	Path/Track/Road	PathEA4160	Road Raising	Paths/tracks/roads	60	Refurbishment	40	Major Refurbishment	130
SingEA75	PFR	Single Property Protection Measures	SingEA7561	PFR	Single Property Protection Measures	60	New Build	20	Not Possible	
FlooEA70	Floodgates	Flood gates	FlooEA7062	New Floodgates	Flood gates	35	New Build	35	Major Refurbishment	35

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Total project net whole life carbon 40,272.19

+ - Capital carbon 30,576.92

Materials - (A1) 27,826.37

Materials - (A1) / Waste - (A5) / Transport of materials - (A2)

Sub-Asset ref.	Sub-Asset description	Material	Material type	Material description	Measure units	Quantity	CO2e (t)	Embodied emissions factor (tCO^2e/t or tCO2e/m^3) - overwrite	Waste %	Reused / Recycle / Removed	Distance to waste disposal	Temporary Works - project reuse frequency	Mode of transport	Supplier distance to site	Supplier distance to site (km) - overwrite	Distance (km)	Other modes of transport used	Other distance (km)
EmbaEA1553	New Embankments	Soil/Clay	Imported (includes transport to site)	General (Rammed Soil) (includes some compaction)	m3	18969.4	933.295		5%	Reused	Local		HGV	Local		50		
TidaEA6354	RC Floodwall	Concrete	Reinforced In-situ Concrete (General)	32/40 MPa	m3	6864.0	3545.865		5%	Removed	Local		HGV	Local		50		
TidaEA6355	Sheet Piled Floodwall	Concrete	Reinforced In-situ Concrete (General)	32/40 MPa	m3	1177.8	608.451		5%	Removed	Local		HGV	Local		50		
TidaEA6356	RC Foundations	Concrete	Reinforced In-situ Concrete (General)	32/40 MPa	m3	6812.5	3519.245		5%	Removed	Local		HGV	Local		50		
TidaEA6357	Steel Foundations	Steel	General - UK (EU) Average Recycled Content	N/A	t	5522.6	12702.054	2.300000	2%	Recycle	National		HGV	National		300		
TidaEA6358	Cladding	Bricks	General (Bricks)	N/A	m3	3126.9	1332.079		5%	Removed	Local		HGV	Local		50		
NaviEA3459	Entrance Lock	Steel	General - UK (EU) Average Recycled Content	N/A	m3	222.8	2536.677		2%	Recycle	National		HGV	National		300		
PathEA4160	Road Raising	Roads	Asphalt road - Hot construction method	Construction	m2	690.0	22.632		5%	Removed	Local		HGV	Local		50		
FlooEA7062	New Floodgates	Steel	General - UK (EU) Average Recycled Content	N/A	m3	230.6	2626.073		2%	Recycle	National		HGV	National		300		
							0.000											
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							0.000											
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							0.000											
							27826.371											

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Transport - (A2/A4) 1,481.64

Method Used: Summary

Summary

Transport of materials - (A2)

Mode of Transport	Distance (km)	Total Co2e (t)
Road	1200	286.17
Aeroplane - Freight	0	0.00
Freight Train	0	0.00
Barge	0	0.00
Cargo Ship	0	0.00
		286.17

Transport of non-contractor people - (A4)

EA staff	Consultants
0.00	0.00

Transport of contractor people - (A4)

Labour	Management staff
871.35	328.33

Transport of plant - (A4)

Transport of plant
1.68

Detailed

Transport contractor/sub contractor people - (A4)

Vehicles	1-5 km	6-10 km	11-20 km	21-50 km	51+ k	CO2e (t)
Car						0.00
Car Share						0.00
Motorbike						0.00
Bicycle						0.00
Walking						0.00
Van						0.00
Rail						0.00
Bus						0.00
						0.00

Transport of plant - (A4)

Vehicles	1-5 km	6-10 km	11-20 km	21-50 km	51+ k	CO2e (t)
Tractor						0.00
Asphalt Paver						0.00
Crane						0.00
Excavators						0.00
Piling Plant						0.00
Rollers						0.00
Dozers						0.00
Dumpers						0.00
						0.00

Installation - (A5) 1,268.91

Method Used: Summary

Summary

Site Establishment - (A5)

Size of Project	CO2e (t)
Large (18 months+)	540.40

Plant use - (A5)

Plant fuel	Measure (Litres)	CO2e (t)
Petrol		0.00
Biodiesel [Standard]		0.00
Diesel [Red]	208000	705.18
		705.18

Detailed

Site Establishment - (A5)

Fuel Type	Unit	Consumption	CO2e (t)	Electricity emissions factor (kgCO²e/kWh - overwrite
Electricity	kWh		0.00	
Natural Gas	m3		0.00	
Gas Oil [Red Diesel]	litres		0.00	
Petrol	litres		0.00	
Diesel	litres		0.00	
Water	litres		0.00	
BioFuel	litres		0.00	
LPG	litres		0.00	
HVO	litres		0.00	
			0.00	

Plant use - (A5)

Sub-Asset Ref.	Sub-Asset description	Plant	Plant type	Activity	Hours on site	Fuel type	Utilisation	Utilisation (Manual Input)	Consumption l/hr	Total ltrs of fuel used	CO2e (t)	Total ltrs of fuel used - Overwrite
							#N/A					
							#N/A					
							#N/A					
							#N/A					
							#N/A					
							#N/A					
							#N/A					
							#N/A					
											0.00	

Add Row

Materials waste - (A5)

Reused / Recycle / Removed	Distance Travelled	CO2e (t)
Reused	50	0.00
Recycle	900	9.61
Removed	250	13.72
		23.33

Other construction waste - (A5)

Material	Quantity (t)	Reused / Recycle / Removed	Distance to waste disposal	Distance	CO2e (t)
					0.00

Add Row

Lifecycle carbon 9,695.27

+ - **Operational carbon** **5,853.26**

Use - (B1) **0.36**

Asset Ref.	Asset Description	Use description	Mode of transport	Fuel type	No. of people traveling by	No. of days manned per year	Return distance to manned asset (km)	CO2e (t)
FlooEA70	Floodgates	Opening and closing	Car	Petrol	2	1	10	0.004
								0.000
								0.000
								0.000
								0.000
								0.000
								0.000
								0.004

Add Row

Maintenance - (B2) **5,833.44**

Sub-Asset Ref.	Sub-Asset description	Maintenance category	Maintenance description	Mode of transport	Return transport distance (km)	Materials	Plant	Waste	Overhead	Annual intervention fequency	Interventions per year	Exceptional intervention year	CO2e (t) per intervention
FlooEA7062	New Floodgates	Minimum Need	Monthly inspection	Van	50	Low	Low	Not used	Not used	> 1 per year	12		2.679
FlooEA7062	New Floodgates	Minimum Need	MEICA PPM	Van	50	Low	Low	Not used	Not used	Every year			2.679
FlooEA7062	New Floodgates	Minimum Need	uctural and Mechanical Inspect	Van	50	Low	Low	Not used	Not used	Exceptional		10	2.679
TidaEA6354	RC Floodwall	Minimum Need	Wall and flap valve inspect	Van	50	Low	Low	Not used	Not used	Every year			3.664
TidaEA6354	RC Floodwall	Minimum Need	alkway/bolt/cable inspection/te	Van	50	Low	Low	Not used	Not used	Every year			3.664
TidaEA6354	RC Floodwall	Minimum Need	etation removal from walls, clea	Van	50	Low	Low	Not used	Not used	Every year			3.664
TidaEA6354	RC Floodwall	Minimum Need	Outfall system CCTV	Van	50	Low	Low	Not used	Not used	Every 5 years			3.664
TidaEA6354	RC Floodwall	Minimum Need	RC wall joint compound	Van	50	Medium	Low	Not used	Not used	Every 5 years			35.576
EmbaEA1553	New Embankments	Minimum Need	Embankment grass cutting	Van	50	Low	Low	Not used	Not used	> 1 per year	4		0.963
EmbaEA1553	New Embankments	Minimum Need	Inspection	Van	50	Low	Low	Not used	Not used	Every year			0.963
TidaEA6354	RC Floodwall	Minimum Need	Outfall jet	Van	50	Low	Low	Not used	Not used	Exceptional		10	3.664
								Not used	Not used				0.000
								Not used	Not used				0.000
													63.858

Add Row

Repair - (B3) **19.4596**

Sub-Asset Ref.	Sub-Asset description	Repair category	Repair description	Mode of transport	Return transport distance (km)	Materials	Plant	Waste	Overhead	Annual intervention fequency	Interventions per year	Exceptional intervention year	CO2e (t) per intervention
TidaEA6354	RC Floodwall	Not used	Walkway/bolt/cable renewal	Van	50	Low	Low	Not used	Not used	Exceptional		10	3.664
TidaEA6354	RC Floodwall	Not used	Outfall flap replace	Van	50	Low	Low	Not used	Not used	Exceptional		10	3.664
TidaEA6354	RC Floodwall	Not used	RC wall repairs	Van	50	Low	Low	Not used	Not used	Exceptional		10	3.664
EmbaEA1553	New Embankments	Not used	:mbankment top up of low spot:	Van	50	Low	Low	Not used	Not used	Exceptional		10	0.963
		Not used						Not used	Not used				0.000
													11.954

Add Row

Energy - (B1) **0.00**

Sub-Asset Ref.	Sub-Asset description	Name plate (kW)	Overall efficiency rating (%)	Load rating (%)	Use factor (%)	Power absorbed (KW)	Hours / Year	Annual power consumed (kWh)	CO2e (t)	Annual power consumed (kWh) - Overwrite	Emissions factor kgCO2e/kWh - overwrite
									0.000		
									0.000		
									0.000		
									0.000		
									0.000		
									0.000		
									0.000		
									0.000		
									0.000		
									0.000		

Add Row

Replacement carbon - (B4) **3,969.02**

Materials **3,622.52**

Transport **205.42**

Installation **141.09**

Refurbishment carbon - (B5) **950.56**

Demolition carbon - (C1-C2) **770.93**

Material waste **326.75**

Plant **160.04**

People **284.14**

Tool for setting a carbon budget for projects prior to construction

Instructions

This form should be used to enter asset level information for the project being assessed in to one or a combination of the options sections below.
Based on the data entered, the calculations will derive the project's carbon budget to be entered in to the project's business case carbon appendix.
This step should be repeated for each gateway stage, and during construction if a Compensation Event or Contract Extension is greed, to update the project's budget such that any change in asset make up or scale is tracked
Carbon budgets will be set based on the potential savings that can be achieved across emissions stages A1-5
An annualised breakdown of the carbon budget will be provided on the righthand side of the form, and should be copied and pasted in to the Carbon Impacts Tool ('PV Carbon Costs' worksheet columns F and G)

Project overview - complete peach cells below

Project name	SOP number	National project number	Project stage / gateway	Price date
Bristol Avon Flood Strategy	NA	NA	Initial assessment (pre-SOC)	2028
Field completed	Field completed	Field completed	Field completed	Field completed

Results

Capital carbon baseline (tCO2e)
129167.06

Detailed project information - complete peach cells below

Date of budget estimate	Duration of benefits (yrs)	Construction spend £	Construction start date	Construction finish date	Construction mid-point	Budget setting option used	Project Assessment Whole Life Carbon (tCO2e) estimate
29/11/2023	50	£239,000,065.78	01/04/2029	31/12/2036	2030/31	Approach 1	40266
Checked	Field completed	Costs match	Field completed	Field completed	Field completed	Field completed	Field completed

Asset level breakdown - enter estimated capital carbon emissions data by asset type into peach cells below

	Approach 1 - using asset value benchmarks			Approach 2 - using asset size benchmarks			
Asset type	Total value of assets £ (undiscounted)	Capital carbon baseline estimate (tCO2e)	Decarbonised capital carbon target - max carbon reduction + uplift	Total size of assets (UoM)	Unit of measure	Capital carbon baseline estimate (tCO2e)	Decarbonised capital carbon target - max carbon reduction + uplift
Barrier	0	-		0	m2	No benchmark to estimate	No benchmark to estimate
Barrier - Demountable	0	-		0	m2	-	
Barrier - Tidal	0	-		0	m2	No benchmark to estimate	No benchmark to estimate
Beach recharge	0	-		0	m3	-	
Beach structures	0	-		0	m2	-	
Bridge - Pedestrian	0	-		0	m2	No benchmark to estimate	No benchmark to estimate
Bridge - vehicle access	0	-		0	m2	-	
Building	0	-		0	m2	-	
Channel	0	-		0	m3	-	
Control Building	0	-		*Use 'Building' category instead*		No benchmark to estimate	No benchmark to estimate
Culvert	0	-		0	m3	-	
Culvert Inlet/Outlet Works	0	-		0	m2	-	
Drainage - Clay Pipe	0	-		0	m3	No benchmark to estimate	No benchmark to estimate
Drainage - Concrete Pipe	0	-		0	m3	-	
Drainage - Plastic Pipe	0	-		0	m3	-	
Drainage -Land/Field	0	-		0	m3	-	
Dredging works	0	-		0	m3	-	
Dune Stabilisation	0	-		0	m3	-	
Electricity Supply	0	-		0	kWh	No benchmark to estimate	No benchmark to estimate
Embankment - Modify	0	-		0	m3	-	
Embankment - New	4568133.085	**2,884.33**	1,170.27	18969.416	m3	1,282.99	520.55
Environmental Enhancements	0	-		0	m2	-	
Erosion Protection	0	-		0	m2	-	
Erosion Protection - Geotextile	0	-		0	m2	-	
Erosion Protection - Grasscrete	0	**No benchmark to estimate**	No benchmark to estimate	0	m2	-	
Fish Pass - Larinier - Through Weir	0	-		0	m3	-	
Flap valve	0	-		0	mm dia	-	
Flood gates	12570532.13	**1,827.51**	817.57	230.6	m2	No benchmark to estimate	No benchmark to estimate
Flow Measurement - Control Channel Section	0	-		0	m3	-	
Habitat Creation	0	-		0	m2	-	
Headwall	0	-		0	m2	-	
Landscaping - Grassland	0	-		0	m2	No benchmark to estimate	No benchmark to estimate
Landscaping - Hard	0	-		0	m2	-	
Landscaping - Shrubs/Tress	0	-		0	m2	No benchmark to estimate	No benchmark to estimate
Misc/other	0	-		0	*n/a*	*No benchmark to estimate*	No benchmark to estimate
Motor Control Centre	0	-		0	kW	No benchmark to estimate	No benchmark to estimate
Navigation Lock	8395658.751	**713.55**	364.30	222.75	m2	29.25	14.93
NFM - Habitat Creation	0	-		0	m2	No benchmark to estimate	No benchmark to estimate
Non-tidal Wall - Retaining - Concrete	0	-		0	m3	-	
Non-tidal Wall - Retaining - Masonry	0	-		0	m3	-	
Non-tidal Wall - Retaining - Sheetpiled	0	-		0	m2	-	
Outfall structure	0	-		0	mm dia	-	
Path/Track/Road	1197573.272	**224.19**	120.81	690	m2	43.66	23.53
Pumping Station - Land Drainage	0	-		0	kWh	-	
Pumping Station - Surface Water	0	-		0	kWh	-	
Revetment Works - PCC	0	-		0	tonnes	-	
Revetment Works - Rock Armour	0	-		0	tonnes	-	
Revetment Works - Soft/geotextile	0	-		0	m2	-	
River Gauging Station	0	-		0	m2	-	
River restoration	0	-		0	m2	-	
Sea Wall - Retaining - Concrete	0	-		0	m3	-	
Silt removal	0	-		0	m3	-	
Single Property Protection Measures	1171105.977	**No benchmark to estimate**	No benchmark to estimate	60	nr.	No benchmark to estimate	No benchmark to estimate
Sluices/penstocks	0	-		0	m2	-	
Soft landscaping - Grassland	0	**No benchmark to estimate**	No benchmark to estimate	0	m2	-	
Storage Reservoir - Gravity	0	-		0	m3	-	
Telemetry Link	0	-		0	m	-	
Tempory Works	0	-		0	*n/a*	*No benchmark to estimate*	No benchmark to estimate
Tidal Gate	0	-		0	m2	-	
Tidal Wall - Retaining - Concrete	211097062.6	**123,517.49**	23,377.22	18684.82138	m3	39,487.00	7,473.41
Tidal Wall - Retaining - Masonry	0	-		0	m3	No benchmark to estimate	No benchmark to estimate
Tidal Wall - Retaining - Sheetpiled	0	-		0	m2	-	
Trash Screen	0	-		0	tonnes	-	
Tunnelling	0	-		0	m3	No benchmark to estimate	No benchmark to estimate
Wall Raising	0	-		0	m2	-	
Weir	0	-		0	m2	-	
Total	£239,000,066						

Capital carbon budget (tCO2e)	Indicative annualised capital carbon budget (tCO2e/yr)
25850.17	3332.85

Exception / efficiency tCO2e	-4726.75

Project Assessment Capital Carbon (tCO2e) estimate	Project Scope Operational Carbon (tCO2e)
30577	9689
Review capital carbon scope	

Approach 3 - estimated carbon assessment (e.g. from CMT / CC)	
Baseline estimated capital carbon emissions (tCO2e)	**Decarbonised capital carbon target - max carbon reduction + uplift**

Cells below to be copied and pasted in to Carbon Impacts Tool

Year	Capital carbon (tCO2e)	Operational carbon (tCO2e)
2022	-	-
2023	-	-
2024	-	-
2025	-	-
2026	-	-
2027	-	-
2028	-	-
2029	2,970.21	-
2030	3,942.27	-
2031	3,942.27	-
2032	3,942.27	-
2033	3,942.27	-
2034	3,942.27	-
2035	3,942.27	-
2036	3,942.27	193.78
2037	-	193.78
2038	-	193.78
2039	-	193.78
2040	-	193.78
2041	-	193.78
2042	-	193.78
2043	-	193.78
2044	-	193.78
2045	-	193.78
2046	-	193.78
2047	-	193.78
2048	-	193.78
2049	-	193.78
2050	-	193.78
2051	-	193.78
2052	-	193.78
2053	-	193.78
2054	-	193.78
2055	-	193.78
2056	-	193.78
2057	-	193.78
2058	-	193.78
2059	-	193.78
2060	-	193.78
2061	-	193.78
2062	-	193.78
2063	-	193.78
2064	-	193.78
2065	-	193.78
2066	-	193.78
2067	-	193.78
2068	-	193.78
2069	-	193.78
2070	-	193.78
2071	-	193.78
2072	-	193.78
2073	-	193.78
2074	-	193.78
2075	-	193.78
2076	-	193.78
2077	-	193.78
2078	-	193.78
2079	-	193.78
2080	-	193.78
2081	-	193.78
2082	-	193.78
2083	-	193.78
2084	-	193.78
2085	-	193.78
2086	-	-
2087	-	-
2088	-	-
2089	-	-
2090	-	-
2091	-	-
2092	-	-
2093	-	-
2094	-	-
2095	-	-
2096	-	-
2097	-	-
2098	-	-
2099	-	-