Shropshire Council

NORTH WEST RELIEF ROAD

Carbon Management Report

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Carbon Management Report

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WSP

4th Floor
6 Devonshire Square
London
EC2M 4YE

Phone: +44 20 7337 1700

Fax: +44 20 7337 1701

WSP.com

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Prepared by	Ana Dias		
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Signature	Signed electronically by James Peet		
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CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

This report presents the work undertaken within the carbon management assessment of the Shrewsbury North West Relief Road (NWRR) Project.

A separate greenhouse gas (GHG) assessment has been conducted as part of the Environmental Statement (ES) (Chapter 9: Climate Change).

1.2 CARBON AND CLIMATE CHANGE

There is an overwhelming scientific consensus that the major increase in the atmospheric concentration of greenhouse gases (GHGs) from anthropogenic sources, in particular the combustion of fossil fuels, is contributing to climate change.

The principal gases responsible for climate change are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The impact that these have on the climate is different for each gas; this is known as their Global Warming Potential (GWP). By using GWP, it is possible to quantify the climate change effect of the emissions of these gases relative to carbon dioxide. For instance, CO_2 has a GWP of 1.0, but methane is around 34 times more effective at warming the atmosphere than CO_2. The combination of these results is therefore expressed in the unit of metric tonnes of carbon dioxide equivalent, i.e., tCO_2e, which is used throughout this report.

Given that increasing the concentrations of GHGs in the atmosphere results in climate change, it is possible to quantify the impact of a given human activity on the climate. For example, we can quantify the carbon emissions from construction and operation to be able to assess impacts on those key stages of the proposed project. Thus, the carbon quantification process follows the key steps outlined below:

- Scoping – determining the sources of carbon emissions to be included in the assessment;
- Collecting activity data – for example, electricity consumed (in kilowatt hours, kWh);
- Identifying the correct or relevant 'emissions' factor' – for example the factor that needs to be used to convert a unit of electricity (kWh) into kg of CO2e;
- Calculation – by multiplying the activity or consumption data by the emissions factor, it is possible to estimate the emissions from each source to express the GHG emissions in kgCO2e;
- Aggregation – by adding up the emissions from all the sources included, it is possible to quantify the total emissions from the whole Project; and
- We would also express assumptions made in this calculation process and the boundary conditions of such.

Once aggregated, it is possible to identify carbon 'hotspots' – areas of the design that result in the most emissions, and therefore have greater climate change effects. These hotspots can then be used to prioritise areas for carbon reduction interventions, for example, reducing material quantities, changing materials for lower embodied carbon alternatives, or reducing energy consumption. By implementing such actions, the GHG emissions associated with the Project can be minimised.

The full methodology is further described in section 2.

1.3 ASSESSMENT AIMS

During the development of the NWRR Project, Shropshire Council declared a 'climate emergency'. This has focused attention onto reducing carbon emissions from the construction of the Project. The carbon management assessment of the NWRR Project aims to demonstrate any savings of carbon emissions having been delivered for the project wherever possible within the design. To achieve this, the design will seek to reduce the carbon associated with the Project in accordance with PAS 2080 Carbon management in infrastructure verification[1].

A separate greenhouse gas (GHG) assessment has been conducted as part of the Environmental Statement (ES) (Chapter 9: Climate Change). The GHG assessment as part of the ES included GHG emissions from the use-phase of the scheme, including traffic emissions, which have been excluded from this assessment. In addition, the GHG assessment as part of the ES included a high-level analysis of construction emissions. This study provides a more in-depth analysis of the GHG emissions relating to the construction phase of these scheme, including a more detailed assessment of construction materials and their associated GHG emissions.

1.4 REPORT STRUCTURE

This report is divided into four sections as follows:

1. Introduction – this section provides background to the Project and assessment;
2. Methodology – describes the methodology used to deliver the assessment;
3. Results – provides the results of the assessment; and
4. Conclusions and recommendations – this section presents the outcome of the study and provides recommendations for further potential carbon reductions during the subsequent stages of procurement and construction.

[1] BSI (2016) PAS 2080: Carbon management in Infrastructure
https://shop.bsigroup.com/ProductDetail?pid=000000000030323493

2 METHODOLOGY

2.1 OVERVIEW

This section details the methodology used to deliver the aims of the assessment, as outlined in section 1.3. The assessment covered two key activities:

- Carbon quantification; and
- Low carbon engagement.

The carbon quantification elements of the assessment focus on the effects of constructing and operating the project, and to inform the design during current and future stages of the Project.

The low carbon engagement elements of the assessment were used to raise awareness of low carbon requirements for the design and to identify low carbon opportunities to be included in it.

2.2 CARBON QUANTIFICATION

The carbon quantification tasks were undertaken using best practice carbon management methods, professional judgement, and guidance including ISO 14064[2], the GHG Protocol[3], BS EN 15978[4] and PAS 2080. The Project was assessed over a Project's reference lifespan of 60 years, which is considered standard for road infrastructure projects.

The carbon quantification task involved the carbon assessment of the February 2021 Planning Application design Bill of Quantities (BoQ).

2.2.1 SCOPE

Based on discussions with the Project team, professional judgement and guidance, the sources of carbon emissions for constructing and operating the Project were identified and collated. This was based on the expected magnitude of carbon emissions from each emissions source and the ability of the design team or contractor to influence them. This enabled each emissions source to be either scoped-in for inclusion, or scoped out, for exclusion. The sources are presented in Table 2-1.

[2] ISO (2006) Greenhouse gases https://www.iso.org/standard/38381.html
[3] World Resources Institute (2004) GHG Protocol Corporate Standard https://ghgprotocol.org/corporate-standard
[4] BS1(2011) Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method https://shop.bsigroup.com/ProductDetail/?pid=000000000030256638

Table 2-1 – Scoping Determination

Source no.	Potential source of emissions	PAS 2080 lifecycle reference	Scoped in/out	Scoping justification
1	Emissions 'embodied' within the construction materials	A1-3	In	Emissions from the construction of the Project are expected to have a large magnitude and will fall within the design team and contractor's direct control.
2	Transport of materials to site	A4	In	Emissions from the transport of materials to site are expected to have a large magnitude and will fall within the design team and contractor's direct control.
3	Plant use on site	A5	In	Emissions from the use of plant and equipment on site are expected to be a large proportion of emissions and will fall within the contractor's direct control.
4	Transport of construction waste	A5	In	Emissions from the transport of construction waste from the Project are expected to have a small magnitude but will fall within the contractor's direct control.
5	Disposal of construction waste	A5	Out	Emissions from the disposal of construction waste, which is expected to be predominantly inert, are expected to be small, and not within the design team and contractor's direct control.
6	Land use change – removal of biomass	A5	Out	Emissions from the removal of biomass are expected to be negligible.
7	Maintenance/repair	B2-3	Out	The Project will be maintained. However, this is not expected to result in a large magnitude of emissions, and the control over maintenance activities only fall partially within the design team and contractor's control.
8	Replacement/refurbishment	B4-5	In	During the reference lifespan, Project elements will need to be replaced, potentially several times. This is expected to result in large magnitude emissions and will fall within the design team's control.
9	Operational energy use	B6	Out	Data regarding lighting was not available at the time of writing. Lighting is only anticipated to be situated on the junctions therefore emissions from lighting are not considered to be large.

Source no.	Potential source of emissions	PAS 2080 lifecycle reference	Scoped in/out	Scoping justification
10	Operational water use	B-7	Out	Water consumption has low associated carbon emissions. It is not expected that large quantities of water will be used to operate the Project. As such, this is not expected to be a large magnitude source of emissions, and the use of water only fall partially within the design team and contractor's control.
11	Land use change – biomass growth	B-8	Out	The Project is not expected to add or remove any large carbon sinks and therefore land use change emissions are not expected to be a source of large magnitude of emissions.
13	End-of-life	C1-4	Out	Expected timescales for decommissioning are so far into the future that there is insufficient certainty about the likelihood, type or scale of emissions activity to determine their likely magnitude, even if they take place at all. In addition, the influence of the design team and contractors on this emissions source is limited.
14	End user emissions (regional traffic flows)	B-9/D	Out	As the concept of the design has already been fixed the influence of the design team and contractors on this emissions source is limited. As such the quantification of the emissions from this source is not considered necessary to contribute to the workstream aim as set out in section 1.3

2.2.2 EMISSIONS DATA COLLECTION

Data has been collected for the Project from the sources listed in Table 2-2.

Table 2-2 – Data Sources

Data	Source
Activity data: Source numbers 1, 2, 3 and 4	February 2021 Planning Application design BoQ
Activity data: Source numbers 8	WSP Design team
Emissions factors	Bath ICE[5], CESSM4[6], BEIS 2018 – Company Reporting[7], BEIS 2018 – Green book[8]

2.2.3 EMISSIONS CALCULATION

Emissions calculations require activity data (e.g. kWh of electricity consumption) and an emissions factor (e.g. $kgCO_2/kWh$). By multiplying the activity data by the emissions factor, the total GHG emissions (in $kgCO_2e$) are estimated. The result of this can then be aggregated with other calculations to provide a grand total. It may be necessary to undertake additional calculations, depending on the data available. Calculations are presented below by emissions source.

2.2.3.1 Source 1 – Emissions 'embodied' within the construction materials

Emissions 'embodied' within the construction materials are calculated as follows:

- Quantity of material (t) X emissions factor (tCO2e/t) = GHG emissions (expressed in tCO2e)

However, for some construction materials, emissions factors are only available on a mass or volume basis. As such, where only volumes are available, these have required conversion to mass using densities.

2.2.3.2 Source 2 – Transport of materials to site

Emissions due to the transport of materials are calculated as follows:

- Tonne kilometres (tonne.km) X emissions factor (tCO2e/tonne.km) = emissions (tCO2e)

The quantification of transport emissions requires tonne kilometres – this is a unit for the transport of one tonne over one kilometre. This is calculated by multiplying the mass of materials by distance. Transport distances were estimated using assumptions from RICS[9].

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[5] Hammond and Jones (2011) Inventory of Carbon & Energy (ICE) V2

[6] Institution of Civil Engineers (2012) CESMM4: Civil Engineering Standard Method of Measurement, Fourth edition

[7] Department for Business, Energy & Industrial Strategy (2018) Greenhouse gas reporting: conversion factors 2018 https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018

[8] Department for Business, Energy & Industrial Strategy (2018) Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

[9] RICS (2017) Whole life carbon assessment for the built environment

2.2.3.3 Source 3 – Plant use on site

Plant use emissions were calculated using emissions factors provided by CESSM4 as follows:

- Activity (e.g. tonnes excavated) X emissions factor (tCO2e/t) = Emissions (tCO2e)

2.2.3.4 Source 4 – Transport of construction waste

Emissions from the transport of construction waste are quantified as per Source 2 (in section 2.2.3.2 above).

2.2.3.5 Source 5 – Replacement/refurbishment

Emissions from replacement/refurbishment are quantified as follows:

- Number of replacements over the project reference lifespan (no.) X emissions from Sources 1 and 2 (tCO2e) = emissions (tCO2e)

2.2.4 ASSUMPTIONS

To quantify emissions from the Project some assumptions were required, for example to convert some of the items in the BoQ into mass or volume. All assumptions are presented in Appendix A – Assumptions.

2.2.5 EXCLUSIONS

Some elements of the BoQ were excluded in order to limit the administrative burden of manually assessing each individual row in each BoQ. These items and the justifications for exclusion are presented in Table 2-3.

Table 2-3 - Exclusions

Exclusion	Justification
Site clearance activities, tree planting and breaking out	Changes in emissions from site clearance activities, tree planting and breaking out are expected to be small.
Allowances	Allowances are cost set asides. As such they were excluded due to insufficient data, and because they may not be included in the final design.
Re-use of existing items (including repositioning)	Emissions from the re-use of existing assets are expected to be small, with a high degree of uncertainty associated with the quantification.

2.2.6 LIMITATIONS

The primary limitations of the assessment are presented below:

- The assessment is based on information from the February 2021 Planning Application design Bill of Quantities (BOQ). As such, the assessment will not reflect the design at the very beginning and end of the design process. No BoQ data was available for the concept design stage before Stage 1 design work commenced.

- Professional judgement has been used when applying densities and emissions factors from ICE[10] and CESSM4[11] to items in the BoQ.
- Where the dimensions of an item within the BoQ have been unknown, a literature review has been undertaken to identify appropriate assumptions. Where no source has been identified, professional judgement has been used.

2.3 LOW CARBON ENGAGEMENT

A workshop was held with the design team in April 2020. This workshop explained the need to reduce emissions from the Project, and how to reduce emissions from the Project using the PAS 2080 carbon reduction hierarchy of:

1) Build nothing
2) Build less
3) Build clever; and
4) Build efficiently

Carbon reduction interventions were identified for the Project. The interventions identified at the workshops can be found in Section 6.

[10] Hammond and Jones (2011) Inventory of Carbon & Energy (ICE) V2
[11] Institution of Civil Engineers (2012) CESMM4: Civil Engineering Standard Method of Measurement, Fourth edition

3 RESULTS

3.1 OVERVIEW

This chapter outlines the results of this assessment.

3.2 CARBON EMISSIONS RESULTS

This section provides the results in terms of GHG emissions due to the Project, Table 3-1 (Current Design).Table 3-1 – Carbon Emissions by Discipline/Structure and Lifecycle Stage – February 2021 Planning Application design Bill of Quantities (BOQ)

	Embodied emissions (A1-3)	Transport to site (A4)	Plant use on site (A5)	Replacement (B4)	Total (tCO_2e)
Fencing	733.35	18.10	0.00	212.87	964.32
Road Restraint Systems	123.41	3.57	0.00	357.06	484.04
Drainage and Service Ducts	1030.98	3.71	0.00	1025.95	2,060.64
Earthworks	2603.50	2421.38	825.23	0.00	5,850.11
Pavements	5883.48	788.38	24.70	10007.79	16,704.35
Kerbs, Footways and Paved Areas	1212.37	89.90	0.00	1953.40	3,255.67
Traffic Signs and Road Markings	83.59	0.52	0.00	100.93	185.05
Road Lighting Columns and Electrical Works	117.59	1.55	0.00	142.97	262.11
B5260 Shepherds Lane Overbridge	208.93	7.21	18.58	56.99	291.70
Oxon Culvert	106.27	25.06	1.02	66.44	198.78
Clayton Way Retaining Wall	16.23	0.62	0.00	0.17	17.02
B5257 Equestrian Culvert East of Holyhead	107.55	18.85	0.51	42.09	169.00
B5256 Shelton Rough River Severn Viaduct	23694.01	841.01	1779.61	8776.25	35,090.88
Ivy Cottage Retaining Wall (Berwick Road)	13.91	0.54	0.00	0.15	14.59
B5254 Willow Pool Wildlife Culvert	66.50	9.26	0.38	35.30	111.44

	Embodied emissions (A1-3)	Transport to site (A4)	Plant use on site (A5)	Replacement (B4)	Total (tCO_2e)
B5253 Alkmund Park Culvert	146.06	23.72	0.76	67.12	237.66
B5251 Hencott Railway Bridge	642.45	34.10	20.48	436.52	1,133.55
B5250 Hencott Pool Culvert	68.55	9.15	0.38	42.68	120.76
B5258 Clayton Way Accommodation Bridge	504.74	36.16	2.03	235.49	778.42
B5252 Marches Way Accommodation Overbridge	239.74	17.31	0.00	123.51	380.57
Total	37,603.20	4,350.10	2,673.68	23,683.70	68,310.68
Proportion	55.05%	6.37%	3.91%	34.67%	**100%**

3.3 ANALYSIS

This section provides analysis of the emissions results presented in Section 3.2.

In terms of the February 2021 Planning Application design, the embodied carbon of construction materials A1-3 and the replacement stage B4 are the stages with the largest emissions (55% and 35% respectively of the total scheme). The February 2021 Planning Application design emissions are primarily due to the pavements (24%), earthworks (9%) and the B5256 Shelton Rough River Severn Viaduct (51%),.

From an embodied carbon perspective (A1-3), B5256 Shelton Rough River Severn Viaduct is the largest contributor to emissions (63% of A1-3), followed by pavements (16% of A1-3), earthworks (7% of A1-3) and then kerbs footways and paved areas (3%).

Appendix B provides a range of potential carbon reduction interventions that were identified during the workshops.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 OVERVIEW

This section presents the conclusions of the assessment, and further recommendations.

4.2 CONCLUSIONS

The construction and replacement of materials over the reference lifespan of the Project are expected to result in approximately 68,311 tCO_2e of emissions. This is <0.001% of one year of the current five-year UK carbon budget[12] (the majority of emissions occur during the 12 months duration construction phase). The principal sources of emissions are associated with earthworks, pavements and the B5256 Shelton Rough River Severn Viaduct structure.

Carbon management activities were undertaken on the Project, and a range of low carbon opportunities were identified. Several areas of the design have reduced emissions due to the raw material quantities or the use of lower carbon materials.

4.3 RECOMMENDATIONS

Based on the assessment reported here, the following recommendations are made with reference to the remaining design stages, and construction/procurement stage.

Specifically:

- Given that embodied emissions from the structures in the project are significant, efforts should be made to procure concrete with a high percentage of cement replacement (for example Ground-Granulated Blast-Furnace Slag (GGBS)).
- Given that embodied emissions from pavements are also significant, the procurement of low temperature asphalt (for example ULTILOW) should also be considered.
- In addition, given the significant embodied emissions from earthworks, site won materials should, where possible, be re-used to reduce the quantity of imported earthworks and resultant impacts associated with extraction and transport of material.
- The designer and contractor should review the opportunities presented in Appendix B.

In general:

- Design optimisation to reflect the carbon reduction hierarchy (detailed below):
  - Reduce the elements required for the Project;
  - Reduce the requirement for construction materials;
  - Substitute construction materials for lower-carbon alternatives; and
  - Use efficient construction processes, such as design for manufacture and assembly.
- During construction, use low-carbon emission plant.
- As far as possible, incorporate material resource efficiency and waste minimisation best practice into design, in particular improving the cut/fill balance of the project;

[12] The current UK carbon budget is Budget three (2018-2022) and is 2,544$MtCO_2e$ - https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/

- Specify materials and products with reduced embodied GHG emissions including through material substitution, recycled or secondary content and from renewable sources;
- Select and engage with key material suppliers and construction contractors taking into account their policies and commitments to reduction of GHG emissions, including embodied emission in materials;
- The contractor should implement a Construction Environmental Management Plan (CEMP), incorporating a Site Waste Management Plan (SWMP) and Materials' Management Plan (MMP) which will contain advice, guidance and recommendations on reducing GHG emissions,
- Minimise energy consumption including fuel usage by, for example, closely measuring and monitoring fossil fuel consumption but also using on site renewable generation during construction,
- Maximise the local sourcing of materials and local waste management facilities;
- Design, specify and construct the Project with a view to maximising the operational lifespan and minimising the need for maintenance and refurbishment (and all associated emissions);
- Design, specify and construct the Project with a view to maximising the potential for reuse and recycling of materials/elements at the end-of-life stage;
- Specify high efficiency mechanical and electrical equipment such as lighting;
- Operate, maintain and refurbish the Project using best-practice efficient approaches and equipment;
- Consider the potential of onsite renewable electricity production during operation; and
- Ensure designs are focussed upon reduction of emissions from end-user vehicle movement (traffic) for example by:
  - Providing opportunities for electric vehicle charging;
  - Ensuring that signalling maximises the efficient use of the junction; and
  - The active travel infrastructure is maintained and useable.

5 APPENDIX A – ASSUMPTIONS

Description	Assumption	Source
Transport Distances		
Locally manufactured (e.g. concrete, aggregate, earth)	50 km	RICS (2017) Whole life carbon assessment for the built environment
Nationally manufactured (e.g. plasterboard, blockwork, insulation)	300 km	RICS (2017) Whole life carbon assessment for the built environment
European manufactured (e.g. CLT, façade modules, carpet)	1500 km	RICS (2017) Whole life carbon assessment for the built environment
Design Life		
Drainage and service ducts	60 years	CG 501 Design of highway drainage systems
Earthworks	120 years	Specification for Highway Works (SHW) Series 600
Pavements	40 years	Design Engineers / Professional Judgement
Waterproofing	25 years	CD 358 Waterproofing and surfacing of concrete bridge decks
Structural concrete	120 years	CD 350 The design of highway structures
Kerbs, footways and paved areas	40 years	CD 239 Footway and cycleway pavement design
Street furniture	20 years	Design Engineers / Professional Judgement
Traffic signs and road markings	50 years	CD 350 The design of highway structures
Road lighting columns and electrical works	50 years	CD 350 The design of highway structures
Fencing	30 years	Specification for Highway Works (SHW) Series 600
Road restraint systems	20 years	Specification for Highway Works (SHW) Series 400
Structural steelwork	120 years	CD 350 The design of highway structures
Building works	60 years	Design Engineers / Professional Judgement
Brickwork, blockwork and stonework	60 years	Design Engineers / Professional Judgement
Embodied		
Fencing		
Post and rail fencing	Assumed 1.10m	CESSM4
Gate	Assumed width 1m and height 0.9m	CESSM4
Footway stile	Assumed single gate width 1m	CESSM4

Fence along top of structure	Assumed timber post and 4 rail	CESSM4
Road Restraint Systems		
Safety barrier containment level N2 designed to be impacted on one side only	Assumed weight is 22.29kg/m	Highways England Tool
Double rail open box beam	Assumed thickness of 0.25m * 0.05m	https://www.berrysystems.co.uk/en-GB/car-park-products/beam-profiles/m/product/view/13
Terminal type P1	Dimensions: Assumed 3470x200x280 and steel. Assumed dimensions of steel beam	https://www.vegvesen.no/fag/teknologi/Rekkverk+og+master/Sok+etter+godkjent+produkt/Vegutstyr/_attachment/1888655?_ts=15c8be8c9a0
Terminal type P4	Dimensions: Assumed 5840x200x280 and steel. Assumed dimensions of steel beam	https://www.vegvesen.no/fag/teknologi/Rekkverk+og+master/Sok+etter+godkjent+produkt/Vegutstyr/_attachment/1888655?_ts=15c8be8c9a0
Transition from safety barrier containment level N2 to N1 parapet	Assumed length of 7m, 0.25mx 0.25m x 2	https://www.tatasteelconstruction.com/static_files/Tata%20Steel/content/products/Highway%20Engineering/New%20files/Protect%20365%20Parapets/P365-T-108-06%20_%20Protect%20365%20N2%20Safety%20Fence%20to%20N2P%20Transition%20=%20110km_h%20car%20-%20Layout.pdf
Parapet connections	Assumed length of 1m, 0.25mx 0.25m x 2	https://www.tatasteelconstruction.com/static_files/Tata%20Steel/content/products/Highway%20Engineering/New%20files/Protect%20365%20Parapets/P365-T-108-06%20_%20Protect%20365%20N2%20Safety%20Fence%20to%20N2P%20Transition%20=%20110km_h%20car%20-%20Layout.pdf
Parapet type H4a	Assumed H4a is equivalent to P6	http://bridgedesign.org.uk/bridgedesigns/components/parapets.php
Parapet type N2	Assumed N2 is equivalent to P1	http://bridgedesign.org.uk/bridgedesigns/components/parapets.php
Parapet type N1	Assumed N1 is most similar to N2	http://bridgedesign.org.uk/bridgedesigns/components/parapets.php
Drainage and Service Ducts		
900mm internal diameter piped culvert	Assumed depth exceeds 4m	CESSM4
Ditch	Assumed cross sectional area	CESSM4
Gully with grating and frame	Assumed dimensions	CESSM4
Headwall	Assumed large precast concrete headwall, weight 4,740kg. Similar to precast concrete slabs	https://fpmccann.co.uk/resources/downloads/headwalls/
300mm internal diameter pipe in wildlife crossing	Assumed depth of 1.5-2m	CESSM4
Outlet chamber as HD119/06 to grassed surface water channel	Assumed to be concrete, dimensions of 3000mm*900mm*1500mm - thickness of 20mm	CESSM4

Pipe connection from grassed surface water channel outlet chamber to carrier drain	Assumed nominal bore of 300, in trenches with depth not exceeding 1.5m	CESSM4
Type 6 fin drain along length of grassed surface water channel	Assumed nominal bore 150mm and in trenches not exceeding 1.5m	CESSM4
Sandbag headwall in vegetated drainage ditch	Assumed dimensions of 300mm*900mm*2250mm as per design team's drawings	WSP Design Team
Stoned drainage grips within cutting slopes	Assumed pvc gutter, nominal size 150mm	CESSM4
Stone in drainage grips	Assumed limestone, area 0.0177 m2	CESSM4
Catchpit	Assumed 1500m diameter and depth of 2-3m	CESSM4
Attenuation pond (excluding earthworks) at chainage 3700, 5000, 6600 and 7450 (including flow control, inlet and outlet headwalls and outlet headwall. Outlet pipe to existing watercourse included under item 4.6)	Assuming outlet and inlet chamber same dimensions and same as item 4.25. Assumed one of each in each attenuation pond	CESSM4
Precast concrete box culvert unit, 5.20m wide x 4.50m high internal dimension	Dimensions assumed 5.2m*4.5m*37m long. Assumed thickness of 250mm	Expert judgement
Precast concrete box culvert unit, 3.00m wide x 2.53m high internal dimension	Dimensions assumed 3m*2.5m*29m long. Assumed thickness of 250mm	Expert judgement
Precast concrete box culvert unit, 4.00m wide x 2.85m high internal dimension	Dimensions assumed 4m*2.85m*67m long. Assumed thickness of 250mm	Expert judgement
Precast concrete box culvert unit, 2.80m wide x 2.45m high internal dimension	Dimensions assumed 2.8m*2.45m*30m long. Assumed thickness of 250mm	Expert judgement
Precast concrete box culvert unit, 4.00m wide x 3.90m high internal dimension	Dimensions assumed 4m*3.9m*36m long. Assumed thickness of 250mm	Expert judgement
End precast unit	Assumed dimensions	Expert judgement
Otter pipe in accordance with HA 81/99	Internal diameter 900mm and assumed concrete	https://cieem.net/wp-content/uploads/2019/07/ha8199.pdf
Earthworks		
Cement / lime stabilisation treatment of soft soil	Assumed 300mm thick	CESSM4
Pavements		
Regulating	Assumed to be base course, hot rolled asphalt 150mm thick	CESSM4
Road Hump	Assumed 25kg weight	https://www.therampppeople.co.uk/blog/product-guide-speed-bumps-speed-cushions/
Bitumen surface course 50mm thick	Assumed 14mm nominal size aggregate	CESSM4
Kerbs, Footways and Paved Areas		
CKD combined kerb drainage system	Assumed 150x155mm	CESSM4

CKD combined kerb drainage system outfall	Assumed PVC - thickness 10mm, length 1m	CESSM4
EF precast concrete footway edging	Assumed 50*250mm edgings	CESSM4
TF timber footway edging	Assumed 50mm x 100mm	Expert judgement
Cellular type material	Assumed weight 4.8kg/m2	https://www.groundtrax.com/cellpave-40-porous-plastic-pavers/
Flight of steps	Assumed flight of 12 stone steps. Each step assumed to be 2mx40mmx200mm for each stone step	Expert judgement
Precast concrete transition / dropped kerb straight or curved exceeding 12 metres radius	Assumed 125x255mm; conventional concrete bed and backing (worst case)	CESSM4
Bitumen surface course	Assumed dense asphalt concrete surface course (worst case), assumed 40mm thick as above	CESSM4
Combined footway, cycleway and equestrian route comprising well drained stone construction (40mm to dust)	Assumed cement bound granular mixture	Expert judgement
Kerb	Assumed 150x305mm, conventional concrete bed and backing (worst case)	CESSM4
Footway	Assumed footway with foamed concrete bed	Expert judgement
Foamed concrete bed	Assumed density of 700kg/m3, assumed thickness of 50mm	Expert judgement
Concrete verge infill	Assumed strength c25/30	CESSM4
Marches Way footpath (within culvert)	Assumed dimensions	https://www.standardsforhighways.co.uk/ha/standards/dmrb/vol7/section2/CD%20239%20Footway%20and%20cycleway%20pavement%20design-web.pdf
Precast concrete flags	Assumed dimensions of 600x450x50mm	CESSM4
Road Lighting Columns and Electrical Works		
Proposed road lighting galvanised steel column of 10m nominal height with a planted base and a post top mounted (0 tilt) specified neutral white (4000 kelvins) LED luminaire with a 21.97KLM output and G4 glare rated	Assumed each one is 153kg	http://www.abacuslighting.com/pdf/brochure-lighting-columns.pdf
2x100mm diameter duct	Assumed copper and 6.0mm2	CESSM4
Sockets for lighting columns and chambers for electrical cables (one each per column)	Assumed to be steel. Shallow foundation retention socket. Weight 22.5kg	www.retentionsystem.com
Traffic Signs and Road Markings		
Chevron as lit unit, 3m long on posts	Assumed 3m2	CESSM4
Road markings	Assumed 150mm wide	CESSM4

Road studs	Assumed 1 ever 18 meters	DMRB
Structures		
In situ concrete	Assumed strength c32/40	CESSM4
Steel bar reinforcement	Assumed nominal size 6mm	CESSM4
Pedestrian handrail	Standard handrail assumed to be 32mm diameter so area 804mm2	https://en.wikipedia.org/wiki/Handrail
Pre-cast reinforced concrete L-shaped wall or a gabion basket wall up to 1.3m high	Assumed thickness of 1m	Expert judgement
Permeable backing	Assumed to be geotextile	CESSM4
Bridge bearing	Assumed steel, thickness of 50mm and 100mmx100mm	https://www.cclint.com/uploads/PDFs/Bridge-Bearings.pdf
Bridge deck expansion joint	Assumed depth of 250-300m	CESSM4
Accommodation tracks 3.5m wide on Berwick Estate	Assumed unbound subbase 250mm - info from design team	WSP Design Team
Clear polycarbonate liquid containment screen to full height of parapet including posts and baseplates	Assumed thickness 5mm and height 1m	CESSM4
Metal mesh panel welded to angle frame fixed to front of abutment gallery including lockable access gate	Assumed height of 2.18	CESSM4
Plant		
Disposal of excavated acceptable material on site	Assumed its stored 100m from excavated	CESSM4
Transport		
Drain in gully connection with bed and surround type Z in trench	Assumed thickness 5mm	Expert judgement
Chamber with cover and frame	Assumed thickness of 10mm	Expert judgement
Catchpit	Assumed 1500m diameter and depth of 2-3m, assumed thickness of 10mm	Expert judgement
Tack coat	Assumed to be 5mm thick	Expert judgement
Traffic sings	Assumed thickness of 5mm	Expert judgement
Road markings	Assumed 5mm thick	Expert judgement
Road studs	Assumed 500g each	Expert judgement
Permanent internally illuminated bollard	Assumed to be aluminium. Dimensions 0.75*0.128*0.18	https://www.tlc-direct.co.uk/Products/GL9917.html?source=adwords&ad_position=&ad_id=415703895072&placement=&kw=&network=u&matchtype=&ad_type=&product_id=GL9917&product_partition_id=824108124455&campaign=shopping_lighting&version=finalurl_v3&gclid=EAIaIQobChMI8pi7kcON6AIVEdreCh0_qweOEAQYAiABEgIUn_D_BwE

450mm diameter surface water steel pipe beneath bridge deck	Assumed thickness of 5mm	Expert judgement
End and intermediate support waterproofing	Assumed thickness of 1mm	Expert judgement
Metal mesh panel welded to angle frame fixed to front of abutment gallery including lockable access gate	Assumed thickness of 20mm	Expert judgement
Precast concrete flags	Assumed 50mm thick	Expert judgement
Formwork - horizontal	Assumed thickness of 300mm	Expert judgement
End support waterproofing	Assumed thickness 1mm	Expert judgement

6 APPENDIX B – POTENTIAL CARBON REDUCTION INTERVENTIONS

Discipline	Intervention	Benefit	Feasibility Justification	Status/Design Stage
Drainage	Filter drains/french drains considered where feasible	Reduced concrete kerbing lowers carbon footprint	The use of filter drains has already been included in the design where feasible. They cannot be used on southern side of project due to requirement for kerb between footway/cycleway and the carriageway. However northern side filter drains have been used wherever a kerb is not required.	Implemented
Drainage	Creation of wetlands as drainage	Carbon offsetting benefits and wetlands act as a carbon sink	Available land. Proposed ponds are already ear marked as wet land areas for mitigation purposes. Whether this can be expanded on a detailed design stage needs to be reviewed by environment team in liaison with drainage team.	Detailed Design
Drainage	PVC pipes not concrete	Plastic pipes are less carbon intensive than concrete	Plastic pipes used extensively as drainage solution and offer more benefits than just carbon offsetting in terms of H&S and ease of laying. Will spec the available use of Table 5/1 from the MCHW which allows the use of various materials at detailed design. Contractor to determine preference which would likely be plastic due to weight and ease of laying for most sections.	Construction
Earthworks	Ironbridge power station - export of large quantity of materials fuel ash	Waste material used and material would be sourced from a local area so decreased transport emissions	This is a totally independent party and we would need to check that the material is of the right grade and that it can be used. We then need to arrange the business collaboration. Fuel ash is a low-quality fill and therefore would be challenging to incorporate into the earthworks. Earthwork side slopes would likely need to be slackened if we were to use fuel ash. In addition, if you are importing material it would make sense for it to be of high quality & locally sourced as there is currently a need to import high quality fill.	Construction
Earthworks	Local granular fill	Material sourced from local area decreasing transport emissions	Desk study and mineral assessment to try and find a local source of material. There are several sources of high-quality granular fill in Shropshire.	Detailed Design
Earthworks	Reuse excavated material	Reduced imported fill needed	Ground investigation currently being undertaken. The preliminary design considers reusing excavated material minimising the amount of fill to be imported	Implemented
Earthworks	Surplus of topsoil removed from site to a local opportunity	Condover Quarry could be an option for restoration in existing mineral workings in the immediate area.	Need to find a location that is in the need of and will accept topsoil.	Detailed Design
Earthworks	Slacken 1 in 2 slopes of noise bunds (Ch500 to Ch1400)	Do not need to import high quality granular fill.	Increased earthwork footprint but by slackening the slopes it reduces the need to import high quality fill.	Detailed Design
Earthworks	Slacken 1 in 2 slopes of false cuttings (Ch800 to Ch1100)	Do not need to import high quality granular fill to reinforce cutting slope.	Increased earthwork footprint & increased span of Shepherds Lane Footbridge but by slackening the slopes it reduces the need to import high quality fill.	Detailed Design

Earthworks	Slacken 1 in 2 slopes of cuttings (Ch1400 to Ch1850)	Do not need to import high quality granular fill to reinforce cutting slope.	Increased earthwork footprint & increased span of Clayton Way Bridge but by slackening the slopes it reduces the need to import high quality fill.	Detailed Design
Pavements	Thickness of pavement	Reduced materials required	Already addressed for the footway using Shropshire council standard not DMRB so couldn't go further with the footway. Pavement durability and materials trade off. Preliminary design is not based on CBR from latest GEO therefore thicknesses currently proposed could be reduced.	Detailed Design
Pavements	Lower temperature asphalt	Decreased embodied CO2	To be looked at in detailed design to offer up to 10% carbon reduction in pavement	Detailed Design
Pavements	Anti-skid surfacing	Decreased embodied CO2	Probably on approach to junctions but not a lot. Any HFS identified is in line with standards and safety overrides carbon reduction.	Closed (not feasible and justified)
Pavements	Process and reuse tar bound material of the existing road	Even if it doesn't benefit a massive carbon saving it has wider sustainability benefits	To be looked at by contractor as to whether feasible.	Construction
Pavements	Using recycled materials on access tracks not the road	Currently using 250mm type 1, using recycled would reduce materials required and therefore decrease embodied CO2	If there is an abundance of available suitable recycled material this could be investigated further by designer / contractor.	Detailed Design
Kerbs, Footways and Paved Areas	Integrated drainage kerbs	Plastic has a lower level of embodied carbon compared to concrete	May be feasible on southern side of NWRR where footway/cycleway is present, kerbing to northern side is only present where positive drainage system is required and the use of plastic kerbs may be feasible at these locations also.	Detailed Design
Kerbs, Footways and Paved Areas	Replace concrete edgings with timber	Decreased embodied CO2	Could only be replaced in rural locations. It's also already been considered in most places. Rural locations and locations identified that could be kept more in keeping with rural setting could have timber edgings applied which could be further reviewed at detailed design.	Detailed Design
Structures	Steel composite structures used throughout the project	Decreased embodied CO2	Already implemented.	Implemented
Structures	Weathered steel used	Decrease maintenance needs	Already implemented.	Implemented
Structures	In situ concrete - GGBS and pulverised fuel ash (PFA) in the spec where required - In situ wingwalls - 2 concrete piers - Deck area	Decreased embodied CO2	Will be implemented during detailed design.	Detailed Design
Structures	Haunched girders	Reduced materials required	Already implemented.	Implemented
Structures	Consider other materials for the retaining wall	Decreased embodied CO2	Wingwalls need to be cast in situ concrete.	Detailed Design

Structures	Glue laminated timber frame footbridge rather than steel	Decreased embodied CO2	Challenges for span and constraints at site	Closed (not feasible and justified)
Structures	Structures changed to single span and abutments moved back	Reduced materials required	Unlikely to be able to reduce road restraint systems further	Implemented
Structures	Include an extended earthwork embankment to reduce viaduct length.	Reduced materials required	To be reviewed at detailed design.	Detailed Design
Contractor	Compound - using existing hard standing as part of the park and ride.	Don't need to build a new compound - reduced materials required	Needs to be in-line with Shropshire Council's decommissioning of the park and ride and in-line with the construction programme.	Detailed Design

4th Floor
6 Devonshire Square
London
EC2M 4YE

wsp.com

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