Leicestershire County Council

A511 MRN GROWTH CORRIDOR SCHEME

Carbon Management Plan

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EXECUTIVE SUMMARY

Leicestershire County Council commissioned WSP UK Ltd. to prepare a Carbon Management Plan (CMP) to support their A511 MRN Growth Corridor scheme.

The scheme is designed to tackle longstanding congestion and traffic related problems on the A511 between Leicester and the A42 via the M1 Junction 22, which is forecast to be exacerbated by the level of housing and employment growth in North West Leicestershire and adjacent counties.

This Carbon Management Plan assesses in detail the likely carbon impact over the scheme's lifecycle. The carbon assessment can be found in Appendix A- Carbon Zero Appraisal Summaryand Section 4- Baseline Carbon Impact.

The findings of the whole-life carbon assessment indicate that of the 7 assessed scheme elements; the net carbon impact over its full life cycle will be a net increase in carbon emissions to the magnitude of 67,826 tCo2e (tonnes of carbon dioxide equivalent). Of the 67,826 tCo2e, user emissions contribute 63,600 tCo2e and embodied carbon 4,226 tCo2e.

A review and update of the Carbon Management Plan and emissions hot spot analysis should be undertaken prior to submission of Full Business Case and completion of detailed design. The key actions are those relating to further carbon management and mitigation opportunities which include carbon specific workshops, early contractual involvement and target emissions hot spots. This will validate the scale of carbon reduction which is achievable through successful implementation of the Carbon Management Plan.

1 INTRODUCTION

1.1 BACKGROUND

1.1.1. WSP were commissioned by Leicestershire County Council (LCC) to prepare an Outline Business Case (OBC) for targeted highway and active mode improvements along the MRN. The OBC was submitted and approved by Department for Transport (DfT) to inform an application for funding under available Major Road Network (MRN) funding.

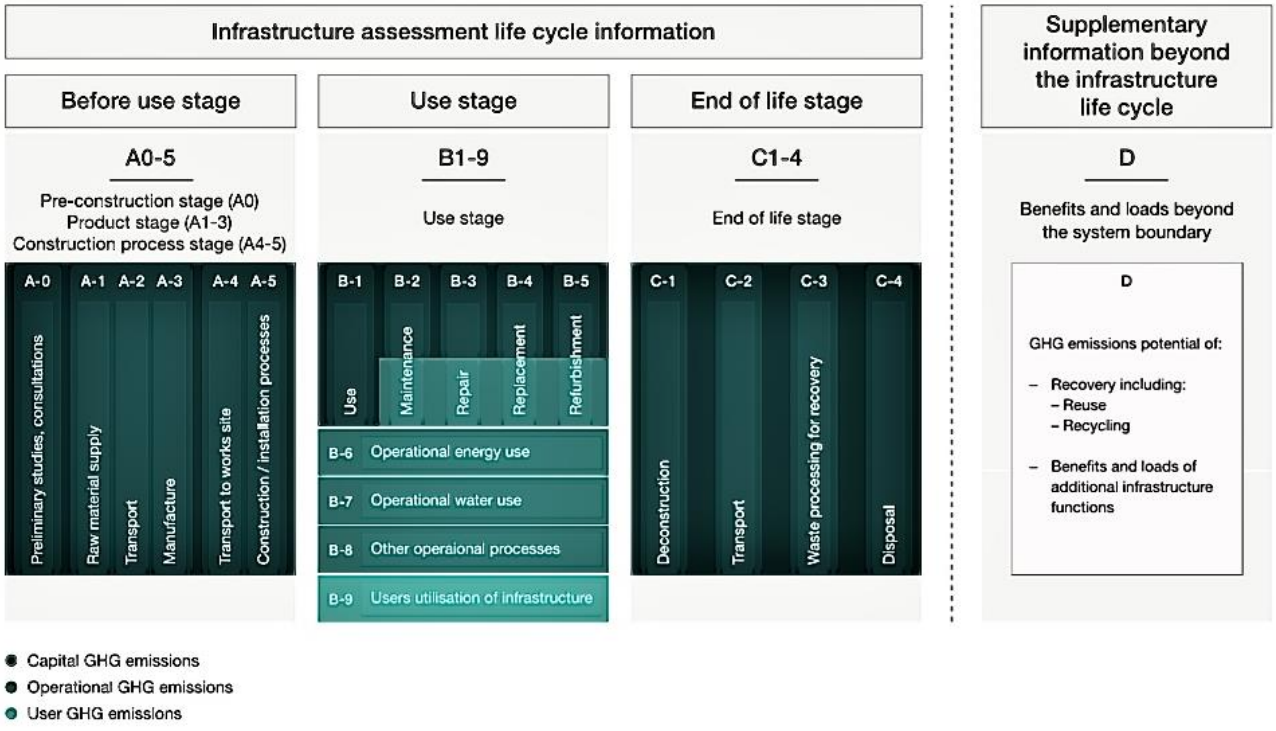
1.1.2. This Carbon Management Plan (CMP) is a standalone document.

1.1.3. The carbon management standard, PAS2080, defined carbon management as an "Assessment, removal and reduction of Greenhouse Gas (GHG) emissions during the delivery of new, or the management of existing, infrastructure assets and programmes". (Department for Transport, Carbon Management Guidance –Management Case, November 2021).

1.1.4. The purpose of the carbon management process is to manage and reduce Greenhouse Gas (GHG) emissions (shorthand: carbon) over the course of the project lifecycle. This can be achieved through taking actions that maximise emission reduction impacts (e.g., modal shift) and minimise impacts that increase emissions (i.e., embodied carbon). These actions must be informed by carbon assessments that provide an understanding of whole-life carbon impact.

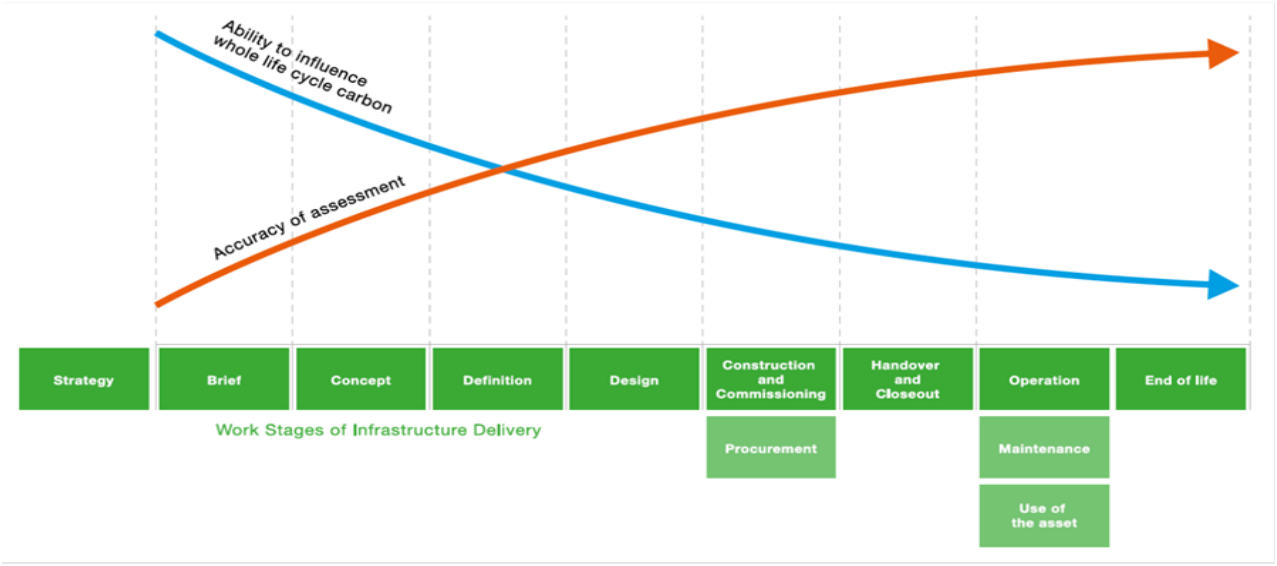
1.1.5. Whole-life thinking involves considering all life cycle stages of an asset from raw material extraction, product manufacturing, transport, and installation on site through to the operation, maintenance and eventual material disposal. Figure 1-1 shows the life cycle stages and individual modules for infrastructure GHG emissions quantification.

Figure 1-1 - PAS2080 Framework for Emissions Quantification



1.1.6. As made clear in PAS2080 and acknowledged in the DfT's Carbon Management Guidance (November 2021) having an effective carbon management system in place is essential to managing and reducing carbon emissions over the course of the project life cycle. This must occur from the earliest stages of the project lifecycle when there is the greatest ability to influence whole-life carbon outcomes. In the context of the UK's legal decarbonisation commitment and Leicestershire County Council's local carbon neutral commitment, it is critical that transport infrastructure is designed to support decarbonisation pathways and minimise any impacts that act contrary to these pathways (Figure 1-2).

Figure 1-2 - PAS2080 – Influencing Carbon Emissions



1.2 PURPOSE OF THIS DOCUMENT

1.2.1. This CMP has been prepared to detail the carbon management process being implemented for the Proposed Scheme. In presenting the results of the carbon assessment and related actions to manage carbon outcomes, this document adheres to the principles in PAS2080.

1.2.2. This document has been prepared to guide and communicate the project team's planning and delivery of the Proposed Scheme, and their ability to manage carbon emissions throughout.

1.2.3. It is intended that this document will be updated iteratively at key stages of the project lifecycle. Each iteration will provide the latest description of the status of carbon management measures.

1.3 STRUCTURE OF THIS DOCUMENT

1.3.1. The structure of this CMP is as follows:

- Description of the Proposed Scheme
- Carbon Management Process, aligned with PAS2080
- Carbon Baseline
- Carbon Reduction Targets
- Carbon Management Plan

2 THE PROPOSED SCHEME

2.1 INTRODUCTION

2.1.1. This section provides a summary description of the Proposed Scheme covered within this CMP. Further details are available in the Outline Business Case.

2.1.2. The scheme description presented in this section reflects the current scheme design that has been assessed as part of the MRN OBC Development.

2.2 DESCRIPTION OF THE PROPOSED SCHEME

2.2.1. The A511 MRN Growth Corridor is a 15km, mainly single carriageway road that extends from the A50 Field Head junction (just west of the M1 Junction 22) to the A42 Junction 13 near Ashby-de-la-Zouch. The current road forms a bypass round the north of the town of Coalville in North West Leicestershire.

2.2.2. The preferred scheme for the A511 MRN Growth Corridor scheme will see improvements made to 7 locations between the A42 Junction 13 at Ashby to the Field Head roundabout to the east of Junction 22 of the M1, including upgrading a section of Stephenson Way from a single to a dual carriageway. These improvements are listed below:

- Hoo Ash Roundabout Improvement;
- Thornborough Road Roundabout / Stephenson Way Dualling / Whitwick Road Roundabout;
- Broom Leys Road Junction Improvement;
- Bardon Road Junction Improvement/Link Road;
- Birch Tree Road Roundabout Improvement;
- Flying Horse Roundabout Signalisation / Turning Restrictions; and
- Field Head Roundabout Part Time Signalisation.

2.2.3. The scheme objectives are as follows:

- Improve journey time & reliability;
- Provide safety & resilience;
- Improve reliability & capacity for freight;
- Supporting North West Leicestershire District Council's growth objectives;
- Improve connectivity for road users;
- Supporting the SRN; and
- Improve air quality & traffic noise.

2.2.4. These objectives were informed by:

- A review of existing policy and strategy documents;
- A review of existing evidence and technical analysis undertaken; and
- Engagement with stakeholders.

2.2.5. Figure 2-1 (below) illustrates the locations of the proposed improvements, whilst Table 2-1 (below) details the key scheme elements. The scheme is currently at the detailed design stages.

Figure 2-1 - Map of the A511 MRN Scheme Elements

Table 2-1 - Overview of Scheme Elements

Scheme Elements	Description of Improvements
1- Hoo Ash Roundabout Improvement	▪ Widened entry and exit to the roundabout allowing two ahead lanes for the A511 in both directions.
2- Thornborough Road Roundabout	▪ Widened entry and exit to the roundabout allowing two ahead lanes for the A511 in both directions. The existing crossing on the western (McDonalds) side of the A511 will be retained.
2- Stephenson Way Dualling	▪ Alter the existing single lane road to a dual carriageway on Stephenson Way between the Thornborough Road and Whitwick Road roundabouts.
2- Whitwick Road Roundabout	▪ Widened approaches and exits allowing two ahead lanes for A511 in both directions, with proposal for a signalised pedestrian crossing on the junction's eastern side (Morrisons). This will aid walking and cycling movements between Whitwick and Coalville.
3- Broom Leys Road Junction Improvement	▪ Modify the existing traffic signal junction by altering the existing left turn lane on Stephenson Way into Broom Leys Lane (Eastbound) to enable ahead and left traffic. Removing some of the verge and footway to provide two ahead lanes for traffic travelling northbound on Stephenson Way. This will require the existing right turn onto Broom Leys Road (Westbound) to be banned. ▪ This should enable improved vehicle throughput, reduced queuing and thus reduced pollution within the AQMA that contains this junction.
4- Bardon Road Junction Improvement/Link Road	▪ This scheme upgrades the existing roundabout at the A511 Stephenson Way / Bardon Road to allow a new southern arm and road connection to the Bardon Link Road through to south of the railway embankment. This will adjoin with the developer's spine road.
5- Birch Tree Roundabout Improvement	▪ This scheme will see the delivery of widened entry and exit lanes allowing three lanes and keeping the two lanes on the exit towards Coalville, supporting better traffic flow and reducing the risk of collision, as well as providing signalisation on the A511 approaches to the junction, supporting easier movement to and from the Bardon Lane industrial estates.

Scheme Elements	Description of Improvements
6- Flying Horse Roundabout Signalisation/Turning Restrictions	▪ This scheme will see the current partially signalised roundabout altered so that traffic from Stanton Road and traffic from Copt Oak Road can only turn left onto the A511. Traffic travelling on the A511 will not be able to turn right into Stanton Lane. This signalisation aids in regulating traffic flow and thus reducing the potential for accidents at this location which currently shows a large number of Personal Injury Collisions (PICs). The scheme will also see the existing pedestrian crossings kept with an additional crossing provided on Stanton Lane.
7- Field Head Roundabout Part Time Signalisation	▪ It is proposed to introduce part time signals on the A50 approaches to the roundabout. A two-lane exit is proposed on Launde Road. This adjustment enables regulation of the traffic flow across the roundabout, as well as improving traffic control at a junction that shows a considerable number of PICs over the last five years.

2.3 CARBON INFLUENCE TO DATE

2.3.1. The carbon impact of the scheme was considered during the OBC stage. The evaluation of the impact on carbon was provided within both the 'One Year After' Report and the Final Report.

2.3.2. Changes in the volume of traffic and their speeds were analysed to identify any significant differences between outturn flows/and or speeds compared to those forecast for the scheme.

2.3.3. The process involved calculating the impact of the scheme on Co_2 emissions; the road based Co_2 emissions related to fuel consumption for the pre-construction (inc counterfactual scenario) 'without scheme' situation, and post construction periods were estimated using the DMRB 11.3.1 air quality screening spreadsheet. This calculated the difference in carbon emissions based on the observed traffic flows and journey times.

2.3.4. Opening and design year Co_2 emission has been calculated using the Emission Factor Toolkit (version 9.0) for all the roads in the transport model, and the changes in Co_2 emissions between the Do Nothing and Do Something scenarios extrapolated for the full 60 years appraisal period.

2.3.5. Calculations indicated that there would be an increase of 63,600 tonnes of carbon over 60 years, with a proposed scheme opening year increase of 572 tonnes, when compared to a do-nothing scenario.

2.3.6. Future iterations of this document and their associated carbon-centric design commitments will be recorded in this section.

2.4 EMISSIONS CONTEXT

2.4.1. At a national level, transport is the largest contributor to the UK's domestic greenhouse gas (GHG) emissions, responsible for 27% in 2019[1]. Where emissions from other sectors have fallen in the last 30 years, domestic transport GHG emissions have remained relatively static, with improvements in efficiency of new cars largely offset by their increased use.

2.4.2. In 2020, transport emissions saw a decrease of 19% from 2019. This decrease is attributed to the impact of the COVID-19 pandemic and travel restrictions which impacted travel patterns. Despite this, the sector remained the largest contributor to the UK's domestic GHG emissions; responsible for 24%[2]. As a result, the more representative 2019 data is used as the baseline for this report.

2.4.3. In Leicestershire, 36% of Carbon Dioxide (Co_2) emissions were from Transport in 2019[3], significantly higher than the total emissions from transport (27%) for the UK.

2.4.4. In 2019, LCC declared a Climate Emergency and pledged to make the county carbon neutral by 2030. This has led to the development of Leicestershire Net Zero Carbon Roadmap which identifies actions LCC are taking to reduce emissions across the county. The high-level actions aim to reduce

[1] BEIS (2021). 2019 UK Greenhouse Gas Emissions [Online]. Available at: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics1990-to-2019 =

[2] BEIS (2022). 2020 UK Greenhouse Gas Emissions [Online]. Available at: 2020 UK Greenhouse Gas Emissions, Final Figures (publishing.service.gov.uk)

[3] https://data.gov.uk/dataset/723c243d-2f1a-4d27-8b61-cdb93e5b10ff/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2019

vehicle mileage through increased supply of public transport, maximising efficiency of the logistics sector, the promotion of active travel and encouraging uptake of EVs by increasing charging infrastructure. The plan was produced in collaboration with a number of partnership organisations within Leicestershire's Net Zero Partnership.

2.4.5. The council is committed to decarbonising the transport system by encouraging sustainable and cleaner transport.

3 CARBON MANAGEMENT PROCESS

3.1 INTRODUCTION

3.1.1. This section sets out the process through which scheme-level carbon monitoring, reduction and mitigation will be managed. It addresses the aspects of carbon management detailed in *Section 3.2* – Applicable Guidance – below, to guide the management processes and the carbon calculations.

3.1.2. The CMP includes guidance and information on the baseline results (*Section 4 – Carbon Baseline*), the carbon reduction target and options identification (*Section 5 – Carbon Reduction Targets*), and clearly defines the overarching management plan and next steps to progress the carbon assessment and reduction activities (*Section 6 – Carbon Management Plan*).

3.2 APPLICABLE GUIDANCE

3.2.1. This Carbon Management Plan has been prepared to align with the principles of the following guidance:

- PAS2080
- DfT Carbon Management Guidance – Management Case (November 2021)
- IEMA, Delivering Quality Development (2016)
- Construction Playbook
- Transport Appraisal Guidance: Unit A3 environmental impact appraisal

3.3 THE PROCESS

3.3.1. The carbon management process to be adopted will be aligned to the principles of PAS2080. An illustration of this conceptual carbon management process is presented in Figure 3-1, as taken from PAS2080. The key stages and associated activity are summarised in Table 3-1 below.

3.3.2. It should be noted that these stages will be applied iteratively at key work stages of the Proposed Scheme. *Section 3.4* sets out what this looks like in the specific context of the workstreams that comprise delivery of this Proposed Scheme.

Figure 3-1 - PAS2080 Carbon Management Process

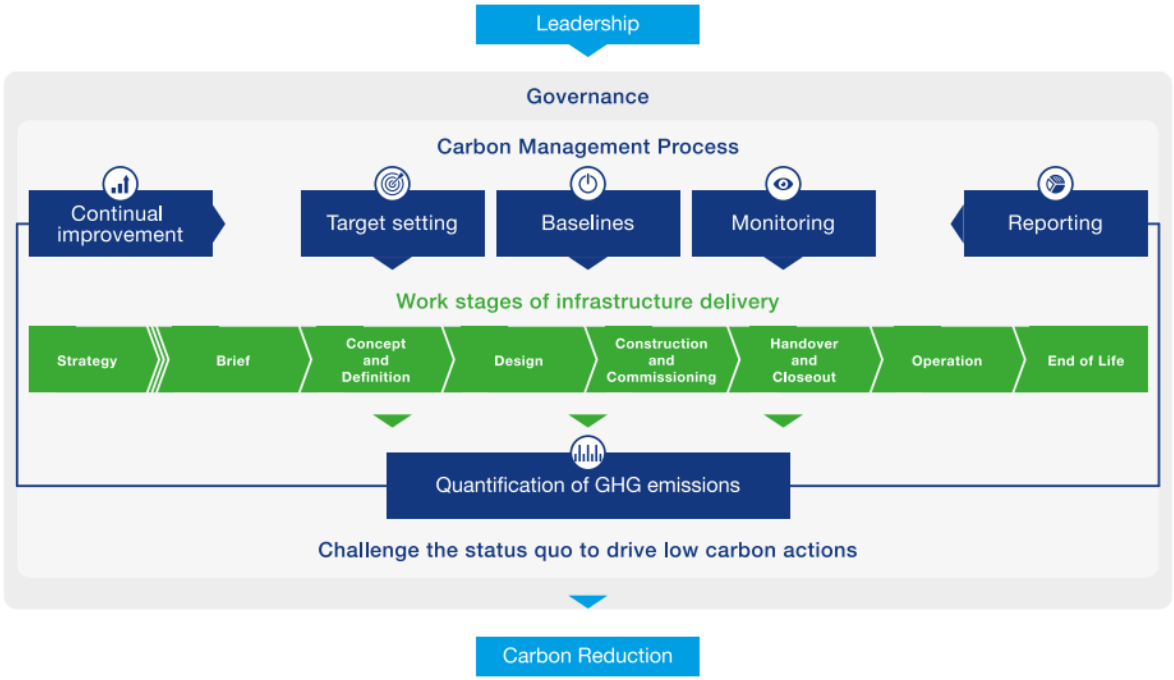


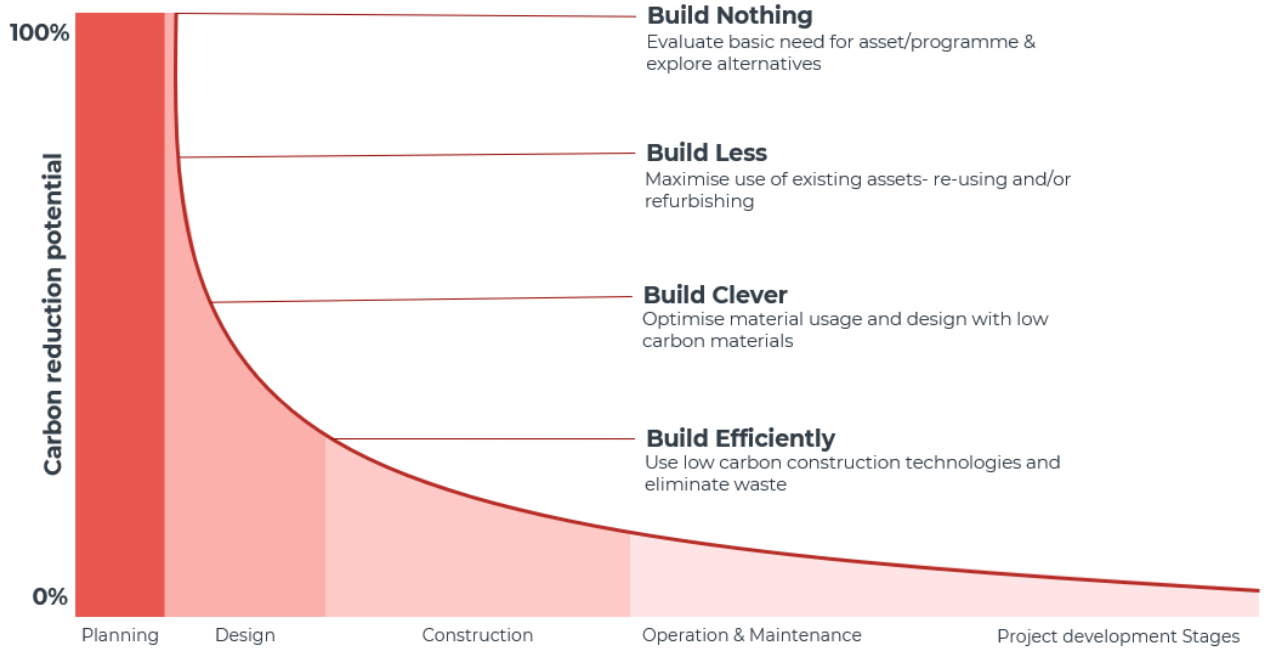
Table 3-1 - Carbon Management Phases and Activities

Phase	Description	Activities
Quantification	▪ Quantification of whole-life carbon emissions with sufficient frequency to inform decision-making throughout the project lifecycle. ▪ Principles in PAS2080 should be followed, such as defining modules for quantification and use of a chosen study period (i.e., appraisal period)	Quantification prepared to date is summarised in *Section 4* of this report. The latest carbon assessment is presented in full as *Appendix A* using WSP's Carbon Zero Appraisal Framework summary template.
Baselines	▪ A reference against which future performance can be compared with respect to the desired outcome. ▪ Assist with finding carbon emissions hotspots, on which to focus efforts to reduce emissions. ▪ Transparently state any assumptions used to fill data gaps and the limitations this may have on the relevance of the baseline ▪ Accepting that the quantified baseline established at earliest stages will be least accurate, the baseline carbon impact will be iteratively updated with the latest and thereby most accurate available carbon assessment of the Proposed Scheme. Changes from previous assessments will be recorded as part of the monitoring phase. The final baseline, which should no longer be adjusted and which against which targets will be set, should be confirmed at the current detailed design stage when sufficient design information is available.	The current baseline is established in this document in *Section 4 – Carbon Baseline.*

Phase	Description	Activities
Target setting	▪ Targets can be set for specific elements such as infrastructure, operational (infrastructure and/or user emissions) and/or whole-life carbon. ▪ Targets should relate to a desired outcome and use a fixed timescale by which that outcome is achieved. ▪ Where appropriate, targets should align with sector-level or wider national/international carbon reduction targets	Carbon reduction targets are defined in *Section 5 – Carbon Reduction Targets* of this report.
Monitoring	▪ KPIs to monitor carbon emissions ▪ PAS2080 recommends these are at a minimum monitored during all infrastructure work stages or at key points where decisions are made that influence whole-life carbon reduction.	Whole-life carbon in tCo_2e should be monitored at each business case assurance stage. As this scheme is past Outline Business Case – the preliminary assurance stage – further formal opportunities for carbon monitoring are limited. Furthermore, monitoring will be achieved through a design review prior to and during this bid's current detailed design process, to assess potential changes to maximise carbon savings. The monitoring of carbon and wider impacts is also important in both the construction and operational phases to inform development of future similar schemes.
Reporting	▪ Reporting should make carbon reduction performance visible at different infrastructure work stages and inform decision-making in managing whole-life carbon. ▪ Impact should be reported with sufficient frequency to enable progress to be monitored against targets and continuous improvement over the duration of the project.	At this stage, carbon impact is reported within a whole-life assessment presented within WSP's Carbon Zero Appraisal Framework. This is included as Appendix A and summarised in *Section 4.1* of this CMP.
Continuous improvement	▪ This should allow lessons to be learned from applying this carbon management process to improve the delivery of future programmes of work. ▪ Acknowledging that comprehensive carbon data or low carbon solutions will not be available at the outset, adopting continuous improvement allows promoters to commence carbon management while gradually improving.	WSP's Carbon Zero Appraisal Framework as used in this process utilises a databook and other records for continual improvement of a carbon evidence base. Additionally, WSP undertake continual improvement in technical tools, capabilities, and skills.

3.3.3. To optimise design and maximise carbon reduction benefits, PAS2080 guidance clearly defines a carbon reduction hierarchy (detailed below in Figure 3-2) and found in clause 6.1.4 of PAS:2080:2016).

Figure 3-2 - Carbon Reduction Hierarchy



3.3.4. The hierarchy indicates that building nothing is the preferred option because this guarantees no carbon emissions resulting from the construction process. It escalates iteratively depending on the needs of the scheme and ensures carbon-centric thinking is embedded in scheme design and that emissions are not unnecessarily emitted with superfluous construction.

3.3.5. The proposed scheme does not consider the 'build nothing' scenario because doing so would not deliver the scheme's objectives. The scheme is required to support housing and employment growth in the area, tackling the longstanding congestion and traffic related problems on the A511 between Leicester and the A42 via the M1 Junction 22.

3.3.6. As the 'build nothing' scenario is not being considered, the remaining opportunities to manage the infrastructure carbon (see *Section 5)* are 'build less' 'build clever' and 'build efficiently' - i.e., low carbon solutions to minimise resource consumption should be utilised wherever possible, alongside techniques to reduce resource consumption throughout the proposed works.

3.4 CARBON MANAGEMENT WITHIN WORKSTREAMS

3.4.1. Carbon management will be embedded within the wider scheme development process to influence design and decision-making throughout the project lifecycle. The key workstreams relevant to the proposed scheme are as summarised in Table 3-2.

Table 3-2 - Carbon Management Activities Across Workstreams

Workstream	Description	Current Status	Carbon Management Activities (current and planned)
Business case assurance	Combination of Major Road Network Funding from the Department for Transport (85%) and Local Contribution (15%) secured through the Coalville Transport Strategy.	FBC stage	▪ Update GHG TAG worksheet and Appraisal Summary Table. ▪ Integration of carbon narrative and implications in strategic and management case of the FBC. ▪ Preparation of this Carbon Management Plan. ▪ A further detailed design review prior to, and as part of, the detailed design process. This will target the carbon hot spots identified in this carbon management plan to seek the further carbon mitigation possibilities.
Design	Design of the scheme across disciplines including highways, landscape, drainage and more.	Detailed Design	▪ Adoption of carbon hierarchy and PAS2080 principles within design, informed by carbon assessment. ▪ The baseline assessment of carbon (see Section 4 – Carbon Baseline and Appendix A for the Carbon Zero Appraisal Summary) creates a reference level to understand the whole-life carbon impact of the proposed works. ▪ The baseline presented in this carbon management plan can also be used as a reference to target a final round of carbon mitigation through the design process, which will be integrated into the current detailed design stage.
Development consent	Planning Applications for Bardon Link Road application submitted 24/05/22	Awaiting Decision	▪ EIA not required, as determined during screening phase.

3.4.5. These workstreams inter-relate and carbon management activities will operate efficiently across these workstreams to achieve common outcomes.

3.5 DOCUMENT MANAGEMENT

3.5.1. It is anticipated this Carbon Management Plan will be updated and maintained as circumstances of the proposed scheme and its carbon management evolve. It is also anticipated that the carbon management actions log in *Section 6.4* will be reviewed and updated as the scheme design evolves - most notably following a recommended carbon review during the current detailed design (see *Section 5 – Carbon Reduction Targets*).

3.5.2. The scheme is beyond OBC assurance stage, meaning there are limited opportunities to mitigate carbon further, any findings from this CMP should be reflected in future documents. The next

iterative update will occur during the Full Business Case (FBC) development stage. With further iterations upon completion of detailed design and/or on completion of contractor tendering to inform subsequent construction process: to maximise carbon savings and embed PAS2080 with all relevant parties and activities.

3.5.3. As noted, this document should be continually evolving and as such, where carbon management actions and commitments have been actioned or completed, they will be included in future iterations of this report and logged in Section 6 – Carbon Management Plan.

4 CARBON BASELINE

4.1 BASELINE CARBON IMPACT

Approach to Baseline

4.1.1. This section expands in detail upon the total carbon baseline and the specific elements which comprise the baseline figures of the A511 MRN, as well as summarising the impact of the package of the 7 schemes. This information is available in greater depth in Appendix A – Carbon Zero Appraisal Summary.

4.1.2. The carbon impact of the scheme was assessed using industry standard methods and organised and presented within WSP's Carbon Zero Appraisal Framework. A supplementary methodology note is provided alongside Appendix A.

4.1.3. PAS2080 advises that a carbon baseline should:

- Create a reference level against which future performance can be compared with respect to the desired outcome;
- Assist with finding carbon emission hotspots, on which to focus efforts to reduce emissions;
- Transparently state any assumptions used to fill data gaps and the limitations this may have on the relevance of the baseline;
- Follow the principles of GHG emissions quantification; and
- Follow a process of continual improvement to ensure future baselines reflect current good practice in GHG emissions quantification.

Summary of Baseline

4.1.4. The full assessment that comprises the baseline can be viewed in Appendix A. This estimates the proposed scheme will have an impact of **+67,826 tCo_2e over 60 years**, i.e., a net carbon increase. A summary of key impacts is provided in Table 4-1 below.

Table 4-1 - Baseline Carbon Breakdown

Impact Category	Key modules/impacts	Quantitative assessment
User Emissions	Operational utilisation of infrastructure (B-9), comprising of: **Changes to General Traffic Flows** The EFT v9.0 model as reported in the OBC produces outputs of+63,600 tCo2e over a 60-year	**+63,600 tCo_2e over 60 years**
	Modal shift (Active Modes) Mode shift to active modes has not been active travel and public transport improvements. Therefore, carbon savings from modal shift are anticipated to be negligible and not proportionate to model.	**N/A**

Impact Category	Key modules/impacts	Quantitative assessment
Infrastructure Carbon	**Before Use Stage (A)** including Raw Material Supply (A-1), Transport (A-2), Manufacture (A-3), Transport to Works Site (A-4) and Construction (A-5). A1-A5 emissions will be released before 2050, we have most certainty over A1-A5 emissions data, typically the majority of embodied carbon of assets is associated with A1-A5. **Use Stage (B)** The manufacture and transportation of materials required for construction of the scheme will emit carbon emissions. Use (B1) - Carbon emissions released from building elements and the impact of potential carbon absorption should be accounted for. Maintenance (B2) – Maintenance has not been quantified in this carbon assessment due to the nature of the scheme which primarily consists of upgrades to the existing network. The 450m Bardon Link Road is the only exception to this, however the carbon impact is expected to be negligible. Repair (B3) - A reasonable allowance for repairing unpredictable damage over and above the maintenance regime should be included. Allowance should be made in facilities and management strategy reports. Replacement (B4) - Appropriate life cycle scenarios can be developed using actual life expectancies of different elements/specific items, product service life (years) from guidance or international standards. Some expected lifespans are provided by RICS for building elements/components. It should be assumed that items will be replaced on a like for like basis and full replacement (100%) of the item is assumed once the specified lifespan is reached. Refurbishment (B5) - Planned alteration or improvement to the physical characteristics of the infrastructure in order for it to cater for the desired future function identified and quantified at the outset. This would typically involve a predetermined change of use at a point during the service life of the project. **After Use Stage (C)** The disposal and waste, and transport for disposal will also contribute to an increase in carbon emissions.	**+3,850 tCo_2e over 60 years** **Not Yet Quantified**

Impact Category	Key modules/impacts	Quantitative assessment
	According to RICS, Deconstruction (C1) will be equal to 75% of Construction (A5) carbon emissions. Transport (Disposal) (C2) will be equal to 50% of Transport to Works Site (A-4). Pre-planned action is required to ensure all Waste Processing for recovery (C3) is implemented to avoid Disposal (C4) at landfill.	**+51tCo_2e over 60 years** **+325 tCo_2e over 60 years**
Additional Impacts	**Module D**: Supplementary Information (Benefits & loads beyond the system boundary): Tree Loss/Gain Tree Loss/Gain has yet to be quantified as the number and species of tree to be removed are not known at this stage. This information is required at the FBC stage. Any tree loss will lead to the release of stored carbon and avoidance of future carbon sequestration. It is therefore recommended that the scheme mitigates any loss by compensatory tree planting.	**Not Yet Quantified**
TOTAL		**+67,826 tCo_2e over 60 years**

4.1.5. Table 4-2 provides an overall summary breakdown of the embodied impact (A1-A5) for All 7 Scheme components as calculated in WSP's Carbon Tool. Appendix B outlines the methodology of the Carbon Zero Appraisal Framework. A further detailed breakdown of each individual Scheme component is summarised in Appendix C.

Table 4-2 - Provides an overall summary breakdown of the embodied impact (A1-A5) for All 7 Scheme components as calculated in the WSP's Carbon Tool

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Bulk Materials	Ready Mix Concrete	36m^3	12	1		13	0%
	Asphalt	13,148	727	128		855	22%
	Fill Aggregate and Sand	9,362	70	91		161	4%
Earthworks	Imported Soil	11,166	268	109		377	10%
	Site Won Soil or Much Shift	18,978	0.00	185		185	5%
Fencing Barriers	Fence	222m	1	<1		1	0%
	Road Restraint System or Safety Barrier	290m	18	<1		18	0%
Drainage	Plastic Pipework HDPE	9,929m	76	2		78	2%
	Precast Concrete Manholes	42 no.	1	<1		1	0%
	Precast Concrete Inspection Chambers	13m	2	<!		2	0%
	Plastic Inspection Chambers	72	89	1		90	2%
	Gullies	53 no.	12	1		13	0%
	Headwalls	3 no.	<1	<1		<1	0%
	Channel & Slot Drains	31m	2	<1		2	0%
Road Pavements	Kerb	6,703	60	4		64	2%
Street Furniture	Traffic Signs	89 no.	12	<1		13	0%
	Variable Message Signs	4 no.	13	<1		13	0%

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
	Road Lighting and Columns	194 no.	145	3		148	4%
	Cable	6,127m	8	<1		9	0%
	Marker Posts or Signs	9 no,	<1	<1		<1	0%
	Cabinets	6 no.	3	<1		3	0%
Civil Structures	Steelwork	32 tonnes	49	2		51	1%
	Precast Concrete	465 tonnes	57	5		61	2%
Waste	Mixed Construction & Demolition Waste	13,057	1216	69		1284	33%
	Concrete Brick Tiles & Ceramics	299	<1	2		2	0%
	Bituminous Mixtures	3,471	4	18		23	1%
	Mixed Metals	92	2	<1		2	0%
	Hazardous Waste	3,330	285	18		302	8%
	Aggregate & Soil Exported Offsite	2,011	0.00	11		11	0%
Construction					**68**	**68**	**2%**
Total			**31,312**	**650**	**68**	**3,850**	**100%**

Figure 4-1 - Embodied Carbon Breakdown

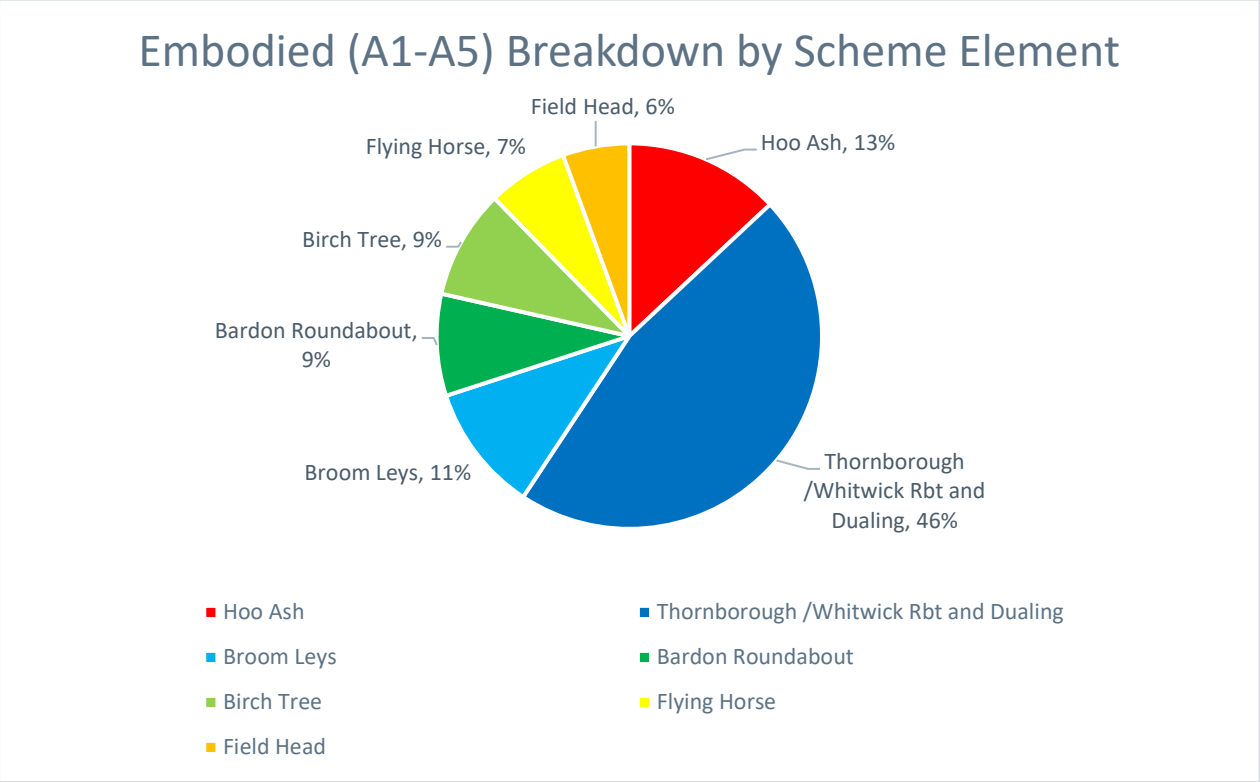
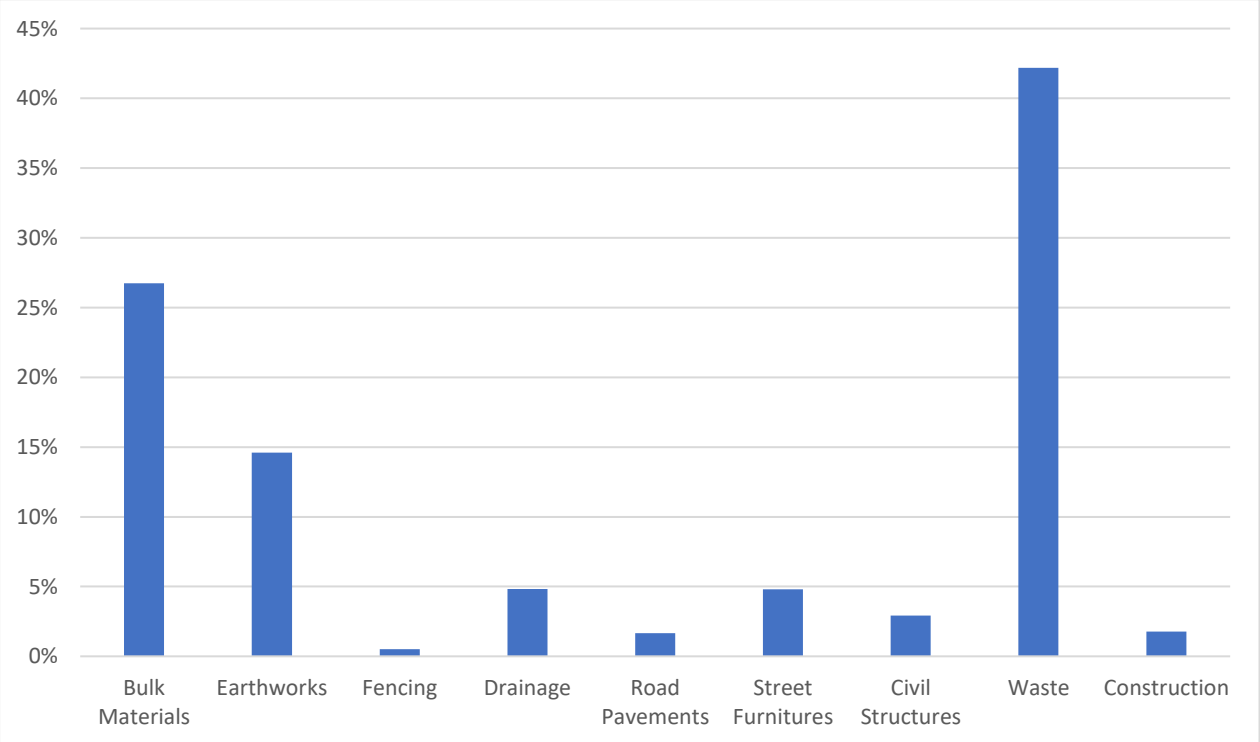


Figure 4-2 - Proportion of Embodied Emissions (A1-A5) Assigned to Each Category



4.2 HOT SPOTS

4.2.1. Emission hot spots (priority areas for carbon reduction) are summarised in Table 4-3 below based on the quantities and activities identified in section 4.1 Summary of Baseline above.

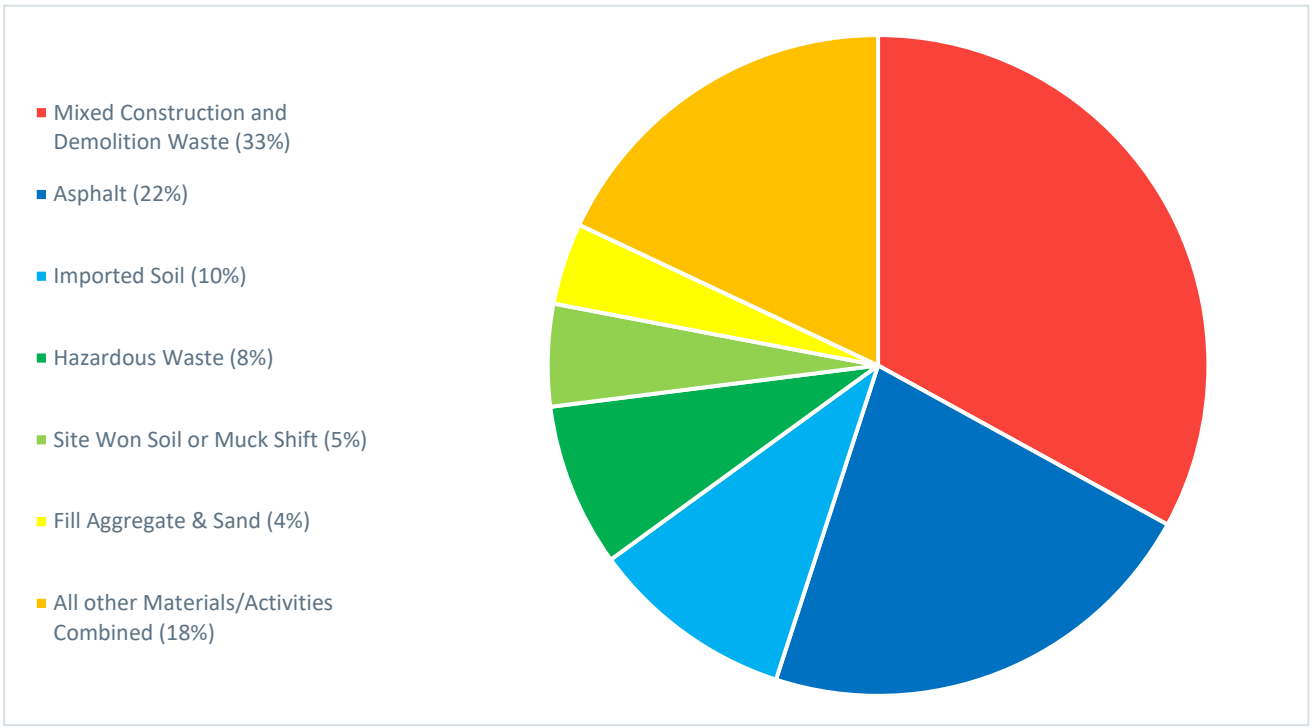
Table 4-3 - Emission Hot Spots

Hot Spot	Description	Carbon Impact
User Emissions – Changes in traffic flows **(B-9)**	User emissions associated with the scheme have been calculated using EFT v9.0 as reported in the OBC. The EFT model calculated road vehicle pollutant emission rates for NOx, PM10, PM2.5 and CO2 for a specified year, road type, vehicle speed and vehicle fleet composition. The scheme is forecast to reduce traffic congestion on the A511. This has the effect of reassigning vehicles from nearby roads (such as the M1) onto the A511, creating shorter journeys and potentially lower emissions per vehicle. However, the net decrease in congestion may result in induced demand with a net increase in the number of trips being made. The overall result of this is an increase in tailpipe emissions.	**+63,600 tCo_2e** over 60-year appraisal period and construction time.
Waste: **(A-4)**	42% of total embodied emissions associated with the scheme This includes the following items: • Mixed construction and demolition waste • Concrete brick tiles and ceramics • Bituminous mixtures • Mixed Metals • Aggregate and soil exported offsite • Hazardous Waste Waste accounts for 57% of Bardon Roundabout embodied emissions (A1-A5), 95% of which is from mixed construction and demolition waste. If recycling or re-use is implemented to the accumulated waste, then tCO_2e would be approximately 20% of the current waste carbon impact. As it is currently assumed that any waste produced would go to landfill.	**+1,624 tCo_2e** over 60-year appraisal period and construction time.

Hot Spot	Description	Carbon Impact
Bulk Materials: **(A1-A3)**	27% of total embodied carbon associated with the scheme.	**+ 1,029 tCo_2e** over 60-year appraisal period and construction time.
A) Asphalt	22% of total embodied carbon associated with the scheme	**+855 tCo_2e** over 60-year appraisal period and construction time.
B) Fill Aggregate and Sand	4% of total embodied emissions associated with the scheme.	**+161 tCo_2e** over 60-year appraisal period and construction time.
C) Ready Mix Concrete	0.33% of total embodied emissions associated with the scheme.	**+13 tCo_2e** over 60-year appraisal period and construction time.
Earthworks: **(A-4)**	15% of total embodied emissions associated with the scheme. This includes the following items: • Imported Soil • Site won soil or muck shift Accounts for 22% of embodied emissions (A4) associated with Thornborough /Whitwick Roundabout & Dualling and 10% of embodied emissions (A4) associated with Hoo Ash & Flying Horse.	**+562 tCo_2e** over 60-year appraisal period and construction time.

4.2.2. Figure 4-3 below illustrates the impact of each of the above-identified hot spots as a percentage of the collective infrastructure A1-A5 carbon impact of the scheme (the total of which is +3,850 tCo_2e as shown in Table 4-3 above). This indicates the impact of each hot spot relative to the assessed infrastructure impact of the collective scheme as a whole.

Figure 4-3 - Whole Scheme Package Collective A1-A5 Emissions Hot Spots



4.3 LIMITATIONS AND UNCERTAINTIES

4.3.1. Key assumptions and limitations relevant to the interpretation of these results are as follows:

4.3.2. At this stage, we are assuming that the traffic data inputs from the transport model and EFT v9.0 outputs are correct. The robustness of the carbon assessment is highly dependent on the validity of the traffic model and EFT outputs. We therefore recommend that this analysis is updated at FBC stage to incorporate the updated v11.0. These are detailed further in Appendix A.

There is a large degree of uncertainty when forecasting future years emissions. It's important to acknowledge the limitations of the traffic model outputs used and the inaccuracies in projecting future years emissions.

- The margin of error is expected to reduce in future assessments as the availability and quality of data improves. For example, TAG data, which will accurately reflect updated national fleet composition, especially low- or zero-carbon vehicles. This may reduce the carbon associated with the proposed scheme over the project lifecycle.
- Induced demand is currently unquantified, further modelling is required to confirm assumptions that the carbon emissions associated with additional trips will add to the carbon impact associated with the proposed scheme.
- Bill of Quantities were unavailable for two further components of the scheme: Punch Through and Underbridge. A benchmarking exercise was undertaken based on their costs compared to the costs and carbon emission output of the above seven scheme components. It was estimated that the total carbon emissions produced during the construction period from Punch Through (2,532 tCo2e) and Underbridge (1,960 tCo2e). Therefore, the overall embodied carbon impact of the

scheme is likely to underrepresented by approximately 106%. These estimations have been excluded from the Carbon Management Plan, however, should be re-calculated once more accurate data analysis is undertaken as part of the FBC.

- Transport distances for materials and waste were assumed in line with RICS guidance, for example it is assumed that materials such as steel are transported 300km from depot to site.
- Construction (A5), Deconstruction (C1) & Transport (Disposal) (C2) emissions have also been assumed using the RICS calculation method[4].
- Tree Loss and Tree Planting are currently unquantified and will be included within future iterations of the CMP once further designs and analysis are available.

[4] Royal Institution of Chartered Surveyors (RICS) assumption of 1.4 tCo2e per £100k of project value. This figure can be used as an average for building construction site emissions, in absence of more specific information. The cost figure is based on the date of publication, March 2015, and should be adjusted to current value in accordance with CPI. Source: https://www.rics.org/globalassets/rics-website/media/news/whole-life-carbon-assessment-for-the--builtenvironment-november-2017.pdf

5 CARBON REDUCTION TARGETS

5.1 INTRODUCTION

5.1.1. Section 5 identifies the scale and necessary rate of decarbonisation to meet the Government's Net Zero 2050 commitments and identifies the potential scope for further carbon reduction opportunities associated with the specific scheme in question.

5.2 DECARBONISATION COMMITMENTS

5.2.1. Commitments to mitigate climate change applicable to LCC include the following:

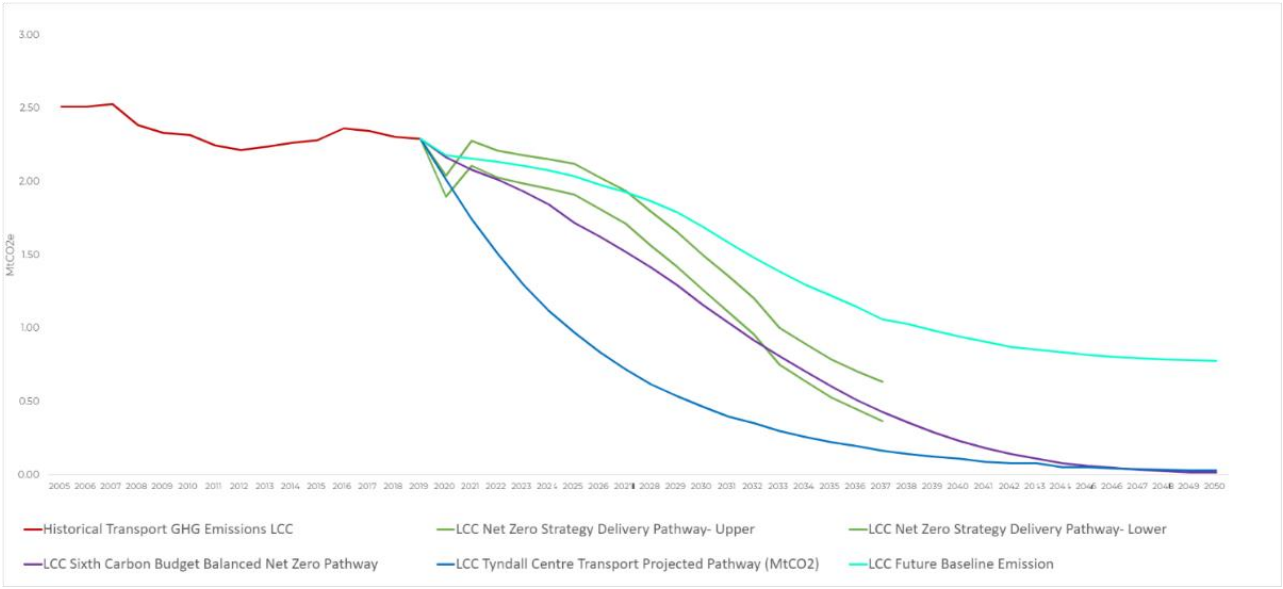
- Carbon budgets aligned to the United Nations Paris Agreement (see Committee for Climate Change website[5] for an explanation of carbon budgets and relation to Paris Agreement).
- National commitment to Net Zero by 2050.
- Leicestershire County Council's 2030 Carbon Neutral Target.
- Leicestershire County wide 2045 Net Zero Target.

5.2.2. In response to climate change targets, various organisations have published proposed emission pathways. Organisations such as LCC can adopt one or more of the proposed pathways to guide the scale and pace of emission reduction required to adhere to national carbon budgets and achieve Net Zero by 2050.

5.2.3. Figure 5-1 below shows historical GHG emissions within LCC depicting the scale of the challenge which needs to be addressed in order to reach Net Zero by 2050. The graph also shows various decarbonisation pathways for LCC compared against a Business as Usual (BaU) future baseline. The future baseline demonstrates how emissions from the transport sector are expected to change if no mitigation policies or measures are implemented beyond those that are already in force and/or legislated. Notably, the future baseline is underpinned by TAG V1.19 Fleet assumptions which do not account for the 2030 ban on new ICE cars and vans.

[5] Committee for Climate Change, Advice on reducing the UK's emissions [Online]. Available: https://www.theccc.org.uk/about/our-expertise/advice-on-reducing-the-uks-emissions/

Figure 5-1 - LCC Decarbonisation Pathways



5.3 SCHEME CARBON REDUCTION TARGETS

Embodied Carbon

5.3.1. Embodied carbon is a primary source of the overall emission impact, the carbon reduction target would be isolated to reducing the embodied carbon emissions of the scheme.

5.3.2. Based on the identified major hotspots, reduction targets should consider the following PAS2080 modules, as detailed in *Appendix A* – Carbon Zero Appraisal Summary.

- A1- A3 – embodied carbon associated with materials
- A4 – transport to works site
- A5 – construction & installation process
- B2-B5 – embodied carbon associated with maintenance, repair, replacement, and refurbishment.

5.3.3. There is no set industry standard for targets of embodied carbon reduction. However, based on previous experience and depending on the stage of the project, a target of between 20-40% is considered to be appropriate. Given the more advanced stage of this project, moving through detailed design and towards FBC submission, an embodied carbon reduction target of between 20-25% is proposed. This reduction will be sought by following the carbon management actions as illustrated in *Table 6.1.*

5.3.4. This carbon reduction target will be measured against the baseline established in *Section 4* of this Carbon Management Plan. Reductions in carbon are expected to be achieved using available opportunities outlined in *Section 5.4*.

5.3.5. Using an appropriate target range at this stage is the best approach as the current baseline is subject to change and will have some inherent inaccuracy due to the availability of data at this stage. The carbon reduction target should not be fixed to this calculation as it is an indicative estimate only.

5.3.6. During the following scheme development stage, this carbon reduction target should be reviewed. A final target should be proposed based on the baseline, which could be updated to include more accurate data or incorporated construction and installation processes.

5.3.7. A final target will be developed through analysis of the baseline and opportunities identification which will demonstrate the scale of carbon reduction which can be achieved.

5.3.8. A major carbon source for this scheme, any reduction in the embodied carbon associated with construction will benefit the scheme's net life-cycle impacts.

User Emissions

5.3.9. Beyond embodied carbon, a carbon reduction target specifically for the identified user emissions sources has not been set at this stage. As Leicestershire County Council are committed to decarbonising the transport system by encouraging sustainable and cleaner transport all future work on this scheme should adopt PAS2080 principles and seek to reduce carbon impacts wherever possible.

5.3.10. User emissions form an important part of the whole-life carbon assessment conducted within the Carbon Zero Appraisal Summary- Appendix A of this Carbon Management Plan. However, given the uncertainty of current TAG data and the (as yet not fully understood) impacts of the national Government ban on new ICEV sales from 2030 and PHEVs from 2035, it is not prudent and is too difficult to set a realistic target for reducing user emissions at this stage.

5.3.11. User emissions, and the consideration of an appropriate carbon reduction target, will continue to be monitored with each iteration of this Carbon Management Plan and the key design stages of the scheme.

5.3.12. At this stage it is important to raise that highway schemes which increase the attractiveness of travelling by car have the potential to act counter to LCC carbon targets. The carbon savings from improved traffic efficiencies (improved journey times, less congestion and less stop start traffic) are insufficient to offset the carbon disbenefits from locking in car dependency. This results in a significant net gain in emissions across the schemes life cycle.

5.4 SCHEME CARBON REDUCTION OPPORTUNITIES IDENTIFICATION

5.4.1. Identifying carbon reduction opportunities for the scheme is a vital step to developing a suitable carbon reduction target.

5.4.2. It is recommended that this activity is carried out after the OBC phase and before the FBC, with the key findings being referenced in the next iteration of the Carbon Management Plan. This activity is separate to the development of the CMP, because it requires additional carbon calculation and feasibility assessment of carbon reduction opportunities for materials, transport, and construction activities.

5.4.3. The following steps detail the opportunities identification process:

- **Step 1** – Carbon reduction workshop with key stakeholders to discuss the carbon hotspots in the baseline and discuss all opportunities (e.g., Opportunity to update EFT to v11.0).

- **Step 2** – Record the opportunities in the 'Carbon Reduction Opportunities Tracker'.
- **Step 3** – Assess the opportunities in terms of carbon quantification, impacts on costs, and feasibility of implementation. Analyse these results and from this, produce an estimated carbon saving in terms of percentage saving from the baseline.
- **Step 4** – Final workshop to agree the scheme carbon reduction, using the estimated potential carbon saving as a guide for an appropriate carbon reduction target.

5.4.4. Documentation of this identification activity, including assumptions and the tracker of opportunities, should be created to transparently record the process.

Current Examples of Carbon Reduction Opportunities

- Maximise the local sourcing of materials to reduce impacts from transporting materials and sourcing from local waste management facilities
- Use more efficient construction plant and delivery vehicles, and/or those powered by alternative fuels including electric or hydrogen.
- Use low carbon road surface options with greater longevity to reduce frequency of maintenance and replacement.

6 CARBON MANAGEMENT PLAN

6.1 ROLES AND RESPONSIBILITIES

6.1.1. It is the responsibility of all within the project team to deliver this CMP. As best practice, the appointment of an assigned Carbon Co-ordinator should be explored to take ownership of the coordination and delivery of this plan in line with PAS2080.

6.1.2. In addition to the Carbon Co-ordinator, it is recommended that key stakeholders are identified to cover the following areas (these are PAS2080 aligned):

- **Leadership and Governance** - working with the Carbon Coordinator to embed carbon management into the scheme processes, whilst liaising with key project leaders and the DfT where necessary. The Carbon Coordinator should report the carbon baseline and savings updates to this key stakeholder for wider dissemination if necessary – primarily at the next carbon review during detailed design.
- **Scheme Design (Detailed Design)** – Design experts will be required for the carbon reduction workshop and feasibility assessment during detailed design to ensure that suitable opportunities are assessed. Additionally, they should ensure that the opportunities identified are included in the scheme package.
- **Procurement Team** – To ensure the carbon reduction targets are cascaded across the value chain, and suitable suppliers are selected who can support the scheme carbon requirements. Where early contractor involvement has taken place, input into the carbon reduction workshop during detailed design will be useful.

6.1.3. Carbon management action owners are referenced in *section 6.4* below - those who own responsibility for reviewing and implementing (where feasible) the referenced opportunity for carbon reduction.

6.2 VALUE CHAIN ENGAGEMENT

6.2.1. Early value chain engagement will take place, including early contractor involvement in the detailed design to explore the feasibility of carbon actions referenced in *Section 6.4*. This should be ongoing in order to work collaboratively and share best practice to ensure the successful delivery of this carbon management plan. This will include early discussion on low carbon solutions for design and construction to reduce embodied carbon in a cost-effective manner.

6.3 SKILLS

6.3.1. It is recognised that a degree of upskilling may be required across the parties involved in delivery of the detailed design and construction of the proposed scheme. Required skill levels will vary subject to roles and responsibilities.

6.3.2. Key actions required to ensure the necessary level of skills for delivery of this Carbon Management Plan are listed below. This should be reviewed with the parties involved to identify any further gaps in skills or capabilities. If appointed, the following upskilling actions would be owned by the Carbon Coordinator, who works with the stakeholders (identified in *Section 6.4*) in each area.

Leadership and Governance

- Brief the detailed design and construction teams on any opportunities to limit waste associated with construction, highlight opportunities to recycle waste materials effectively, and contribute to the circular economy wherever possible, following suitable processes to do so.

Design Team

- Brief the detailed design team on the principles of PAS2080 and this Carbon Management Plan to ensure consistency and adherence throughout the design phases.
- Brief the design team of the carbon management opportunities and hot spots identified in this carbon management plan to ensure that the quantitative assessment of materials, and *changes to traffic flows and journey lengths* is updated regularly as new and more accurate data is available which reflects more likely pathways.
- Brief the design team of the carbon management opportunities and hot spots identified in this carbon management plan to ensure carbon management opportunities are both adhered to and maximised. It is crucial that this is adopted into the current design stage to maximise carbon reduction savings, as explained in *Table 3-2* - PAS2080 Hierarchy, above – which is especially significant given the predominance of embodied carbon on this scheme.

Procurement

- Actively seek partners for the construction stage with low-carbon construction technical expertise and practice and supply chains.
- Regularly review carbon expertise in the contractor's team to identify those who can support and advise regarding low carbon solutions, in particular the procurement of services and materials relating to the construction and embodied phases of the proposed scheme.

6.4 CARBON MANAGEMENT – NEXT STEPS

6.4.1. The Carbon Management next steps for the proposed scheme are detailed in Table 6-1 below.

6.4.2. These compromise a list of actions to carry out as the project evolves overtime and updates are required to achieve Full Business Case, as well as those yet to complete as the scheme package undergoes any further changes, or where updates are required.

6.4.3. The key actions are those relating to further carbon management and mitigation opportunities which will be sought throughout the following detailed design stage.

6.4.4. For this scheme at this point in its development, the critical next step is an immediate design review to identify further carbon mitigation opportunities as soon as possible. Given that this scheme is past OBC assurance stage, further carbon management opportunities are constrained, as is the ability to influence carbon (see section 3, Carbon Management Process). Therefore, a review and update of the Carbon Management Plan and emission hot spots (Section 4.4) should be undertaken during the current detailed design stage and prior to commencement of Full Business Case.

6.4.5. The Carbon Coordinator referenced in *Section 6.1.1* should take ownership of these actions, liaising with the appropriate people to conduct them. The outcomes should be included in the next iteration of the CMP. The opportunity references have no bearing to the urgency of actions.

Table 6-1 - Carbon Management Actions

Opportunity Ref.	Measure	Responsible Person	When to be completed	Detail	Potential impact
X1	Carbon reduction workshops prior to FBC & during detailed design.	Project Manager	Ongoing. Prior to FBC & during detailed design Stage.	Identification of further carbon mitigation opportunities ahead of FBC & during detailed design to address emissions hot spots – conducted through workshops with relevant stakeholders, as detailed in *Section 5 - Carbon Reduction Targets*.	The crucial carbon management activity associated with this scheme is to review the potential for further carbon mitigation prior to commencing FBC and during the detailed design.Improved accuracy of the baseline, i.e., more robust carbon assessment. Further scheme-level carbon savings if mitigation opportunities are identified.

Opportunity Ref.	Measure	Responsible Person	When to be completed	Detail	Potential impact
X2	Target *Hot Spots* for further carbon reduction opportunities and understand feasibility of doing so.	Project Manager, to be completed by Planners.	During iterative carbon review During detailed design.	Identify and action further carbon reductions during the detailed design workshops which specifically target the hot spots identified in Section 4.4 – Hot Spots.	The best chance to maximise the impact of the pre-FBC and during detailed design carbon reduction workshops – any opportunities to mitigate the carbon hot spots will yield the strongest additional carbon savings.
X3	Update Scheme's Carbon Assessment (Appendix A) if more accurate data becomes available or to reflect outcomes of the next carbon review.	Project Manager, to be completed by Planners.	Following carbon review during Full Business Case & detailed design process.	As above, if further carbon mitigation opportunities are identified during the detailed design process following the Full-Business Case submission, then the baseline figures (Section 4 – Carbon Baseline and Appendix A) will be updated to reflect these changes	Improved accuracy of the baseline, i.e., more robust carbon assessment. Likely reduction in the carbon impact if mitigation opportunities are identified.
X4	Monitor and update forecasts including projected future EV uptake, vehicle growth & national fleet composition rates– i.e., TAG data & EFT v11.0 - and apply this to the Carbon Assessment (Appendix A).	Carbon Coordinator	Regular updates through planning phase and regular monitoring through life of scheme.	A qualitative assessment indicates that this magnitude of carbon saving is highly sensitive to reasonably foreseeable alternative futures (see Section 3.7) Current TAG data (Nov 2021) does not account for the ban on the sale of new petrol and diesel cars and vans in 2030 and is therefore considered to be an underestimate of the rate of electrification / decarbonisation of the national vehicle fleet. This contributes to an overestimate of the carbon *savings* derived from traffic flow efficiencies.	Highlight the extent of the qualitative assessment, which indicates a potential adverse net carbon impact of the scheme due to sensitivity to future scenarios. Understand the true carbon impacts and the (potential) need for more ambitious carbon reduction targets & mitigation actions to balance any detrimental change in net impacts.

Opportunity Ref.	Measure	Responsible Person	When to be completed	Detail	Potential impact
X5	Calculate the infrastructure carbon emissions associated with construction of Punch Through & Underbridge based on finalised Bills of Quantities.	Project Manager, to be completed by Planners.	Planners awaiting BOQ. To be incorporated into the FBC and at detailed design stage.	Understanding the relative impact of construction activities (embodied carbon of fuel used) associated with the design	Greater depth and accuracy of understanding regarding true infrastructure carbon impacts associated with the proposed scheme - enabling more ambitious and more accurate target to mitigate carbon impacts.
X6	Calculate the infrastructure carbon emissions associated with maintenance and replacement.	Project Manager, to be completed by Planners.	ASAP	Understand the frequency of maintenance and replacement activities and the associated carbon impact.	Greater depth and accuracy of understanding regarding true embodied carbon impacts associated with the proposed scheme. Enabling more ambitious and more accurate targets.
X7	Calculate the user emissions associated disruption to general traffic flows due to future highway maintenance activities.	Project Manager, to be completed by Planners.	ASAP	Understand how future maintenance activities are going to impact general traffic flows and the associated carbon due to reducing the number of lanes, temporary speed limits and single lane shuttle operations.	Greater depth and accuracy of understanding regarding true embodied carbon impacts associated with the proposed scheme. Enabling more ambitious and more accurate targets.
X8	Design optimisation to reflect the carbon reduction hierarchy (detailed below and found in clause 6.1.4 of PAS2080: 2016): Building Nothing, Build less, Build Clever and Build Efficiently.	Scheme designer / Principal Contractor	To be incorporated into design at detailed design stage. To also be confirmed prior to construction.	The construction phase of the proposed scheme is anticipated to generate GHG emissions, including embodied emissions due to the selected construction materials, and emissions resulting from use of plant and equipment, and transport of materials. There is potential to reduce this impact through the measures outlined in this table.	Reduce GHG emissions (including infrastructure emissions) during the construction phase, and eliminate unnecessary carbon emissions.

Opportunity Ref.	Measure	Responsible Person	When to be completed	Detail	Potential impact
X9	Organise Carbon Reduction Opportunities identification workshop as mentioned in *Section 5.4.3*.	Scheme designer / Principal Contractor	To be incorporated into design at detailed design stage.		
X10	Engage with the supply chain to identify low-carbon alternatives.	Scheme designer / Principal Contractor	To be incorporated into design at detailed design stage. To also be confirmed prior to construction.	Minimise embodied carbon in supply chain by specifying materials and products with reduced embodied GHG emissions. This would include material substitution, recycled or secondary content and from renewable sources.	Maximise carbon savings associated with infrastructure emissions – a significant hot spot for the proposed scheme.
X11	A Construction Traffic Management Plan that minimises congestion and rerouting.	Scheme Designer / Principal Contractor	To be incorporated into the design at detailed design stage and confirmed prior to construction.		Minimise adverse traffic flow impacts associated with construction activities and minimise associated tailpipe emissions from stop-start traffic and short-term increases in journey times.
X12	Maximise appropriate tree planting to offset tree loss. Should be explored both in volume and appropriate tree species to ensure longevity of tree life and sequester as much carbon as possible across scheme's life.	Scheme Designer / Principal Contractor	To be incorporated into design at detailed design stage. To also be confirmed prior to construction.	Carbon sequestration from tree planting is a key feature of the proposed scheme. Beyond volume of trees to ensure carbon offsetting and sequestration is maximised, an appropriate mix of specifies of trees for the local area should be fully understood and planted. Then the baseline figures (Section 4 – Carbon Baseline	Opportunity to sequester more carbon and reduce the long-term additional GHG impacts. Additionally supports broader target of 10% net biodiversity gain minimum statutory target.

Opportunity Ref.	Measure	Responsible Person	When to be completed	Detail	Potential impact
				and Appendix A) will be updated to reflect these changes.	
X13	Arboriculture maintenance commitments should be sought, and ownership of that task identified for the life of the scheme.	Carbon Coordinator Partner TBD			Ensures long term survival of planted trees – rather than dying out due to unsuitable local environment. Additionally supports broader target of 10% net biodiversity gain minimum statutory target.
X14	Maximise local recycling opportunities, considering the circular economy wherever possible, by seeking suppliers and partners with a closed-loop recycling model, especially for road surface and construction materials.	Scheme Designer / Principal Contractor	To be incorporated into design at detailed design stage.	Limit landfill waste and associated transportation emissions for shipping waste materials long distances.	Reduce carbon associated with transporting waste goods, and reduce the overall embodied impact by circulating materials for re-use. Especially impactful for this scheme given the significant embodied carbon.
X15	Maximise the local sourcing of materials relative to the Scheme's location - to reduce impacts from transporting materials and sourcing from local waste management facilities.	Carbon Coordinator / Scheme Designer / Principal Contractor	Considered as part of pre FBC and during detailed design carbon reduction workshop	Waste and transport of materials to the works site (A1-A4) is the primary emissions hot spot for the collective scheme – contributing 33% of the whole adverse carbon impact.	Contribute to minimising the infrastructure carbon impact of hot spots identified in Section 4.4 – Hot Spots.
X16	Use more efficient construction plant and delivery vehicles, and/or those powered by alternative fuels including electric or hydrogen.	Carbon Coordinator / Scheme Designer / Principal Contractor	Considered as part of pre FBC and during detailed design carbon reduction workshop	Minimise Construction (A5) emissions during construction and maintenance.	Contribute to minimising the infrastructure carbon impact of hot spots identified in Section 4.4 – Hot Spots.
X17	Use low carbon road surface options with greater longevity	Carbon Coordinator /	Considered as part of pre FBC	Asphalt is the secondary emissions hot spot for the	Contribute to minimising the infrastructure carbon impact of hot spots identified in

Opportunity Ref.	Measure	Responsible Person	When to be completed	Detail	Potential impact
	to reduce frequency of maintenance and replacement.	Scheme Designer / Principal Contractor	and during detailed design carbon reduction workshop	collective scheme – contributing 22% of the whole adverse carbon impact.	Section 4.4 – Hot Spots. Minimising materials and activities related to road surfacing will likely yield strong carbon savings. Potential for significant mitigation of adverse carbon impacts – potentially improving scheme elements to a net-carbon saving and improving the net-impact of the scheme package.
X18	Promote compatible policy in line with this scheme.	Local Authority	Ongoing.	Directly consider this scheme as a target for any soft policy measures which aim to increase modal shift to active and shared modes.	Unlock additional user emissions savings on account of this scheme by maximising policy measures which favour active and shared modes and will therefore enable further carbon savings by user's utilisation of the proposed assets.

Appendix A

CARBON ZERO APPRAISAL SUMMARY

CARBON ZERO Summary Report

Carbon Zero Appraisal Summary Report:

Appendix A - A511 MRN Growth Corridor Scheme

CARBON ZERO

Date of Appraisal: 21/10/2022

Scheme Promoter: Leicestershire County Council

Stage of development: Outline Business Case (OBC)

Scheme Details

The scheme is designed to tackle longstanding congestion and traffic related problems on the A511 between Leicester and the A42 via the M1 Junction 22, which is forecast to be exacerbated by the level of housing and employment growth in North West Leicestershire and adjacent counties. The preferred scheme for the A511 MRN Growth Corridor scheme will see improvements made to 7 locations between the A42 Junction 13 at Ashby to the Field Head roundabout to the east of Junction 22 of the M1, including upgrading a section of Stephenson Way from a single to a dual carriageway. Improvements include signalisation, turning restrictions and junction improvements.

Summary of Carbon Impact

Carbon assessment of the A511 scheme has quantified a net carbon impact of +67,826 tCO2e over the 60-year appraisal period. The largest proportion of emissions are associated with user emissions on the route (+63,600 tCO2e) whilst infrastructure carbon contributes +4,226 tCO2e.

Quantified predicted change: 67826 tCo2e

Predicted change in tonnes of carbon dioxide equivalent emissions (CO2e) produced during a 60 year appraisal period + construction

Milestone	Impact (tCo2e)	Timescale of Quantified Impact
4th Carbon Budget	7,086	2023-2027
5th Carbon Budget	4,175	2028-2032
6th Carbon Budget	5,114	2033-2037
Leicestershire County Council 2045 Net Zero Target	25,455	2023-2045
National 2050 Net Zero Target	31,130	2023-2050
60 year Appraisal Period + Construction & End of Life	67,826	2023-2085

-135,652		Equivalent Trees	Indicative number of trees you'd need to plant to remove this amount of carbon from the atmosphere in the same
-84,334		Equivalent Trips	Equivalent car trips, based on an average trip length of 7.9 miles and average emissions per km (updated 2021).
1,426	CCR	Carbon Cost Ratio	The carbon impact per £1mil of scheme cost (£47.57m)
Low	11,010,432	Carbon Value	Based on Treasury Green Data Book (Low, Central & High Estimates of Carbon Value). The monetary cost/savings associated with the scheme to the scheme promoter.
Central	22,020,865		
High	33,031,297		

Key:

- Quantified
- Relevant but not quantified
- Not relevant
- Reduction in Carbon Emissions (tCo2e)
- Increase in Carbon Emissions (tCo2e)

Summary of Scheme Impact on Carbon Emissions:

User Emissions

Modal Shift: Car-Walking	Modal Shift: Car-Cycling	Modal Shift: Car-Bus/Mass Transit	Modal Shift: Car-Rail	Changes in Traffic flows during Construction Stage	Changes in General Traffic flows	Induced Demand	Electric Vehicle Charging Infrastructure	Increase in Carbon Emissions (tCo2e)	63,600

Changes In Traffic Flows During Construction Stage: The quantified predicted change above does not account for traffic management and diversions which may increase journey lengths and congestion during the construction stage. However, some increase in emissions may occur due to increased stop-start traffic and reduced fuel efficiency due to congestion, which would likely increase the carbon emissions during construction. Optimising traffic management and implementing a robust construction management plan would reduce this impact. Regardless, this impact will cause some increase in the overall adverse impact of the construction stage, and add to the total emissions figure if quantified.

Modal Shift, Car To Both Walking & Cycling : The scheme is likely to have little to no impact on modal shift due to limited active travel and public transport measures. The new 450 metre section of highway, with provision of a shared foot/cycleway is likely to have little to none impact on carbon savings from modal shift, therefore is anticipated to be negligible.

Changes In General Traffic Flows, +63,600 tCo2e: The quantitative assessment indicates that the proposed works are anticipated to improve traffic flows by increasing the efficiency at key junctions, including signalisation, turning restrictions, roundabout improvements and upgrading the A511 Stephenson Way link from a single to a dual carriage, with aims to reduce congestion and improve connectivity. Opening and design year Co2 emissions were calculated using the Emission Factor Toolkit (EFT) v.9.0 for all roads in the transport model. Results quantitatively predict a carbon impact of approximately 63,600 tCo2e (traded and non-traded) over the 60-year appraisal period, with a proposed scheme opening year increase of 572 tCo2e. The carbon savings from improved traffic efficiencies (improved journey times, less congestion and less stop start traffic) are insufficient to offset the carbon disbenefits from locking in car dependency. Therefore, as per the EFT v9.0 model outputs, as reported in the OBC, this will result in a significant net gain in emissions across the scheme's life cycle.

Induced Demand: The scheme is forecast to reduce traffic congestion on the A511. This can make private transportation more attractive and therefore facilitates 'induced demand'. Although currently unquantified, induced traffic is of greatest importance where users response to changes in journey time and costs is high- i.e. where trips are suppressed by congestion and then released when the network is improved. This has the effect of reassigning vehicles from nearby roads (such as the M1) onto the A511, creating shorter journeys and potentially lower emissions per vehicle. However, the net decrease in congestion may result in induced demand with a net increase in the number of trips being made. The overall result of this is an increase in tailpipe emissions.

Modelling Methodology Note: The Emission Factor Toolkit (EFT) v9.0 was used to calculate the opening and design year Co2 emissions for all roads in the transport model, as reported in the OBC. Prior to more detailed modelling runs being undertaken as part of the full business case (FBC), the EFT has been used to calculate the user emission carbon output for the carbon management plan.
The tool allows users to calculate road vehicle pollutant emission rates for oxides of nitrogen (NOx) and particulate matter (PM - PM10 and PM2.5), for a specified year, road type, vehicle speed and vehicle fleet composition. Carbon dioxide (Co2) exhaust emission rates can also be calculated for petrol, diesel and alternative fuelled vehicles, with additional output provided for calculation of non-exhaust Co2 equivalent (Co2e) emissions related to the charging of electric and plug-in hybrid vehicles.

ASSUMPTION: At this stage, we are assuming that the traffic data inputs from the transport model and EFT outputs are correct. We recommend that this analysis is updated at FBC stage to incorporate the updated V11.0.

Infrastructure Carbon

Capital Carbon

Pre-Construction	Raw Material Supply	Product Transport	Product Manufacture	Transport to works/site	Construction & Installation Process	De-Construction & Demolition	Disposal & Waste	Transport for Disposal

Operational Carbon

Maintenance	Operational Energy Use	Operational Water Use	Other Operational Processes	Increase in Carbon Emissions (tCo2e)	4,226

Construction is due to commence in 2023, becoming operational in 2025, and the scheme is assumed to have a 60-year life-cycle.

Infrastructure Carbon, +4,226 tCO2e: Infrastructure carbon comprises both capital carbon (emissions associated with construction of the infrastructure asset) and operational carbon (the asset's energy use and maintenance).
As directed by PAS2080, the global carbon management standard, all life-cycle stages of the asset are considered: Before Use Stage (A) - including raw material supply, transportation manufacture - Use Stage (B) - which considers maintenance and energy use - and finally, End of Life Stage (C) - waste and disposal of materials.

Before Use Stage (A)
Raw material supply (A1), transport (A2), manufacturing (A3) and transportation to works (A4) account for 98% (+3,782 tCo2e). This impact has been quantified using WSP's Carbon Tool and material estimates produced as part of the cost estimation process. 46% of embodied emissions associated with A1:A5 are attributed to Thornborough &Whitwick Roundabout and Dualling (+1,781 tCo2e), 13% from Hoo Ash (+502 tCo2e), 11% from Broom Leys (+412 tCo2e), 9% from Birch Tree (+352 tCo2e), 9% from Bardon Roundabout (+329 tCo2e), 7% from Flying Horse (+259 tCo2e) and 6% from Field Head (+215 tCo2e).
42% of A1-A5 embodied emissions are attributed to waste. Carbon emissions from waste, most notably mixed construction and demolition waste, make up 57% of A1-A5 carbon emissions for Bardon Roundabout, 51% for Birch Tree, 49% for Broom Leys and 42% for Hoo Ash. Other embodied carbon hotspots include bulk materials (Birch Tree (32%), Hoo Ash (31%) and Bardon Roundabout (29%) . Earthworks make up 15% of total embodied emissions.
Construction (A5) accounts for approximately. 2% (+68 tCo2e) of embodied emissions associated with the scheme.

Use Stage (B)
Whilst operation, maintenance and repair will require new materials and construction processes which will increase carbon emissions some of the maintenance activities would occur in a do-nothing scenario. The carriageway renewals proposed as part of the MRN scheme also intend to reduce the frequency and duration of future highway maintenance and so the impact is likely to be reduced significantly. The new 450 metre Bardon Link Road is the only exception to this, however the carbon impact is expected to be negligible. Therefore, it has not been quantified in this carbon assessment.

End of Life Stage (C)
The end of life stage involves de-construction and demolition after the 60 year appraisal period of the scheme. Deconstruction (C1) has been calculated in line with DfT guidelines of 75% of Construction (A5) emissions, equalling +51 tCo2e and Transport (C2) is 50% of Transport emissions (A4) equalling +325 tCo2e.

Assumptions
Bill of Quantities were unavailable for two further components of the scheme; Punch Through and Underbridge. A benchmarking exercise was undertaken based on their costs compared to the costs and carbon emission output of the above seven scheme components. It was estimated that the total carbon emissions produced during the construction period from Punch Through (+2,532 tCo2e) and Underbridge (+1,960 tCo2e). These estimations have been excluded from the Carbon Appraisal Workbook, however should be re-calculated once more accurate data analysis is undertaken as part of the FBC. With this assumption, the estimated total carbon emissions over the whole-life carbon assessment would increase the total by +4,492 tCo2e.

Additional Impacts and Opportunities

Tree Loss	Tree Planting	Other Carbon Stores	Increase in Carbon Emissions (tCo2e)	N/A

The number and species of tree to be removed are not known at this stage but will lead to the release of stored carbon and avoidance of future carbon sequestration. However, this is likely to be minor in the context of user and embodied impacts and can be expected to be mitigated by compensatory tree planting. Carbon sequestration from compensatory tree planting however, can take many years to offset the adverse impacts of carbon released from felled mature trees.

Summary of Predicted Net-Impact

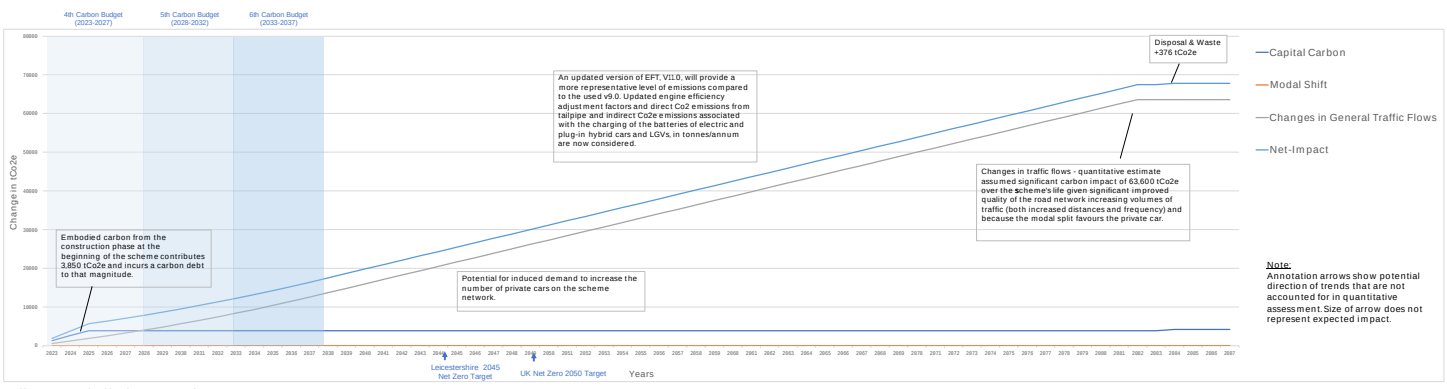
Adverse Impact on Carbon Emissions

The quantified predicted change (net carbon impact) of +67,826 tCo2e over the 60-year appraisal period represents a major carbon disbenefit associated with this scheme.

A carbon disbenefit of +63,600 tCo2e is derived from user emissions, as the carbon savings from improved traffic efficiencies (improved journey times, less congestion and less stop start traffic) are insufficient to offset the carbon disbenefits from locking in car dependency. Therefore, as per the EFT v9.0 model outputs as reported in the OBC, this will result in a significant net gain in emissions across the schemes life cycle.
The infrastructure carbon impact contributes an adverse impact of +4,226 tCo2e (excluding Punch Through and Underbridge).

Overall, increases in emissions from these impacts are predicted to outweigh any potential carbon savings resulting from anticipated congestion relief, as no modal shift is anticipated as well as tree planting yielding a negligible impact at this stage. It is considered likely that the scheme may result in a larger induced demand to private car impact. This offers some support to Leicestershire County Council's EV strategy but positive impacts will not be sufficient to balance the carbon impact of the scheme. As such, this scheme is likely to have a significant net-increase in carbon emissions.

Cumulative Change in Carbon Emissions



Influence of Likely Scenarios...

Summary of Predicted Net-Impact (Likely Future Scenarios)

Accelerated Zero Emissions Vehicle (ZEV) Uptake	Given decarbonisation commitments at national and regional levels it is realistic to expect more accelerated uptake of low and zero emission vehicles than presented in this assessment, which is based upon a business as usual model. The DfT's Transport Decarbonisation Plan defines commitments towards the decarbonisation of the vehicle fleet by 2050. An acceleration in the uptake of ZEV's will deprioritise all vehicles in favour of active travel as the ZEV private car provides a viable and sustainable alternative to walking and cycling. This accelerated uptake of ZEV's would reduce adverse impacts from traffic and therefore the carbon associated with induced demand will be less adverse over time as the fleet electrifies.
Behavioural Change	Given the scheme's lack of developed local public transport and active travel transport facilities, the scheme is unlikely to contribute to significant transportation-based behaviour change. Therefore, contrary to behaviour change, it is likely that the proposed scheme - a highway facilitating private car use - will further entrench habitual behaviour associated with private vehicle use and ownership. While this supports Leicestershire's County Council's strategy to encourage behaviour change in the form of EV adoption it embeds private car ownership rather than behaviour change. To meet local and national decarbonisation targets, behaviour change and modal shift to active models, public transport and decarbonised vehicles needs to take place much more rapidly than current and previous rates. Additionally, ZEVs alone will be insufficient to bridge the gap between current emissions and net-zero.
Adverse	Considering these likely future scenarios, it is unlikely that the potential carbon savings under future scenarios will counteract the significant embodied carbon 'debt' accrued at the Scheme's outset. On the one hand, faster electrification/decarbonisation of the national vehicle fleet will cancel out some of the carbon associated with induced demand. Alongside this, as construction methods become less carbon intensive in the future (and construction vehicles are decarbonised), there is opportunity for the embodied carbon associated with maintenance to reduce. On the other hand, given that current industry standard TAG data does not account for the predicted rate of uptake of (Z)EVs, it overestimates the potential savings derived from changes in general traffic flows. Additionally, the modelled traffic growth assumptions allow for consistently high future traffic capacity growth which may cause an overestimation of the scheme's carbon savings when more realistic future growth is considered. These scenarios could significantly affect the net-impact carbon figure because changes in general traffic flows are the primary source of carbon saving for the scheme, so any change has a major effect on the total net-impact. Upon overall consideration under future scenarios it is unlikely that significant carbon savings will be achieved relative to the user emissions and embodied carbon. Therefore, the already significant debt of carbon associated with this scheme will not be balanced out and under both current and future scenarios, the scheme has a significant adverse carbon impact. The carbon management plan highlights opportunities to mitigate these impacts with the proposed scheme.

Opportunities for Further Mitigation... See Carbon Management Plan for further details on mitigation opportunities

Appraisal Version	Date	Prepared by	Checked by	Authorised by	Project Number
V1	21/10/2022	Josh Hudson-Jaques	Alex Thomas	Jamie King	70056642

Appendix B

METHODOLOGY STATEMENT

Carbon Zero Appraisal Framework - Methodology Statement

Date of appraisal	21/10/2022
Scheme	A511 MRN Growth Corridor Scheme
Stage of design and assurance	Detailed Design & Outline Business Case

Carbon Zero Appraisal Framework - Overview

The Carbon Zero Appraisal Framework comprises a compilation of tools and methods developed by WSP to support the appraisal and management of climate change impacts relating to transport developments and improvements. The appraisal provides a summary of the carbon and resilience impacts as determined by an alternative method to traditional, adopted Transport Appraisal Guidance (TAG) methods.

This statement provides an overview of the methodology used to assess the impacts and provides further assurance in relation to the results and outcomes. Further information can be provided on request.

Relation to TAG

WSP's Carbon Zero Appraisal Framework has been developed to fulfil a need for decision makers to understand the whole-life carbon impacts of developments in a proportionate manner through all stages of the project lifecycle. Compared to traditional, adopted TAG methods, the Carbon Zero tool provides a more accurate reflection of the whole-life impact of the scheme on greenhouse gas emissions (referred to as carbon) and considers the resilience of the scheme to changing climate conditions. In doing so it is intended to provide decision-makers with a more complete and accurate understanding of how a transport project will align with decarbonisation objectives and what action can be taken to improve carbon performance.

WSP's Carbon Zero Appraisal Framework is not an adopted approach within the current TAG. As such, the impacts quantified through the Carbon Zero appraisal have not been included in the Benefit Cost Ratio (BCR) or Value for Money as part of Economic Case of business cases, which instead rely on traditional outputs from tools such as TUBA. The Carbon Zero appraisal instead provides additional, alternative evidence to support the Strategic Case and environmental appraisal of schemes.

Principles of methodology

The following high-level principles have been applied:

- **Whole-life carbon** – the appraisal has considered key aspects of a transport infrastructure scheme's whole-life carbon impact in accordance with categories listed in PAS2080;
- **Quantitative & qualitative** – where data exists and can be proportionately and appropriately applied, quantitative assessment has been undertaken. Non-quantified aspects have been appraised in a qualitative manner; and
- **Reporting net-impact –** the carbon appraisal reports sub-impacts within three summary impact categories: user emissions, embodied carbon and additional impacts. The balance of these impacts (formed by sub-impacts within them) is used to inform an overall conclusion on the net-impact over the scheme lifetime.

Quantitative Appraisal Methodology

Impact Type	Aspect	Input data	Carbon calculation
User Emissions	Changes in general traffic flows	GHG Outputs from EFT v9.0 (tCo2e).	The Emission Factor Toolkit (EFT) v9.0 was used to calculate the opening and design year Co2 emissions for all roads in the transport model, as reported in the OBC. The tool allows users to calculate road vehicle pollutant emission rates for oxides of nitrogen (NOx) and particulate matter (PM - PM10 and PM2.5), for a specified year, road type, vehicle speed and vehicle fleet composition. Carbon dioxide (Co2) exhaust emission rates can also be calculated for petrol, diesel and alternative fuelled vehicles, with additional output provided for

			calculation of non-exhaust Co2 equivalent (Co2e) emissions related to the charging of electric and plug-in hybrid vehicles.
Embodied Carbon	Materials, transport & construction	Material estimates produced as part of the cost estimation process.	Material estimates were input to WSP's carbon tool to estimate emissions associated with key materials.
Additional Impacts	Tree planting/ removal	Proposed number of trees to be planted. – Not Quantified	Assumed each new tree over 60 years will sequester 0.5 tCO2; the average annual emissions of a 'typical' tree species in the Woodlands Carbon Code calculation tool over a 60 year lifespan. Quantified impact of the release of carbon storage associated with tree removal.

Context Metrics

The summary page presents a series of context metrics intended to aid understanding of what the calculated impact in tCO2e means. These metrics are all derived from the stated total quantified predicted GHG change over the scheme lifetime.

Context metric	**Description**	**Methodology**
Trees	The indicative number of trees you would need to plant to remove this amount of carbon from the atmosphere in the same time.	Assumed each tree over 60 years will sequester 0.5 tCO2; the average annual emissions of a 'typical' tree species in the Woodlands Carbon Code calculation tool over a 60 year lifespan.
Trips	Carbon impact is equivalent to this many trips, based on an average trip length of 8.4 miles and average emissions in 2020	Assumes average trip length of 7.9 miles (DfT Mode of travel Statistical data set, NTS0303 - 2020) and average car emissions per km of 131.1 grams CO2e (calculated using TAG data).
Carbon Cost Ratio	The carbon impact per £1mil of scheme cost.	Calculated as: ([predicted carbon impact over 60 years] / [scheme cost]) * 1,000,000.
Carbon value	The monetary value of the predicted carbon impact, based on carbon value scenarios in the Treasury Green Book.	Calculated as: [yearly predicted in emissions] * [yearly Green Book carbon value]. Undertaken for each Green Book scenario (High, Medium and Low) for carbon value. Non-traded carbon values used. In all scenarios the Green Book values carbon more highly in future years, so future scheme emission savings are valued more highly.

Appendix C

SUMMARY BREAKDOWN OF THE EMBODIED IMPACT (A1-A5) FOR ALL 7 SCHEMES AS CALCULATED IN THE WSP CARBON TOOL

Table C-1 - Provides a summary breakdown of the embodied impact (A1-A5) for Hoo Ash as calculated in WSP's Carbon Tool

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Bulk Materials	Ready Mix Concrete	0.19 m^3	<1	<1	-	<1	0%
	Asphalt	1,979	109	19	-	129	26%
	Fill Aggregate and Sand	1,420	11	14	-	24	5%
Earthworks	Imported Soil	724	17	7	-	24	5%
	Site Won Soil or Much Shift	2570	0	25	-	25	5%
Fencing Barriers	Fence	75 m	<1	<1	-	<1	0%
	Road Restraint System or Safety Barrier	98 m	6	<1	-	6	1%
Drainage	Plastic Pipework HDPE	234 m	2	<1	-	2	0%
	Precast Concrete Manholes	2 no.	1	<1	-	1	0%
	Precast Concrete Inspection Chambers	2 no.	1	<1	-	<1	0%
	Plastic Inspection Chambers	-	-	-	-	-	-
	Gullies	18 no.	2	<1	-	2	0%
	Headwalls	3 no.	<1	<1	-	<1	0%
	Channel & Slot Drains	-	-	-	-	-	-

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Road Pavements	Kerb	1,047 m	10	1	-	10	2%
Street Furniture	Traffic Signs	38 m^2	5	<1	-	5	1%
	Variable Message Signs	-	-	-	-	-	-
	Road Lighting and Columns	12 no.	6	<1	-	6	1%
	Cable	10 m	<1	>1	-	<1	0%
	Marker Posts or Signs	-	-	-	-	-	-
	Cabinets	-	-	-	-	-	-
Civil Structures	Steelwork	27	42	2	-	43	9%
	Precast Concrete	19	2	<1	-	2	0%
Waste	Mixed Construction & Demolition Waste	1,710	159	9	-	168	34%
	Concrete Brick Tiles & Ceramics	110	<1	<1	-	<1	0%
	Bituminous Mixtures	522	1	3	-	3	1%
	Mixed Metals	6	<1	<1	-	<1	0%
	Hazardous Waste	413	35	2	-	37	7%
	Aggregate & Soil Exported Offsite	-	-	-	-	-	-
Construction					**8**	**8**	**2%**
	TOTAL		**410**	**83**	**8**	**502**	**100%**

Table C-2 - Provides a summary breakdown of the embodied impact (A1-A5) for Thornborough Roundabout/Dual Carriageway/Whitwick Roundabout as calculated in WSP's Carbon Tool

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Bulk Materials	Ready Mix Concrete	11 m^3	3	<1	-	3	0%
	Asphalt	5,616	311	55	-	365	21%
	Fill Aggregate and Sand	4,714	35	46	-	81	5%
Earthworks	Imported Soil	9,108	219	89	-	307	17%
	Site Won Soil or Much Shift	8,045	0	78	-	78	4%
Fencing Barriers	Fence	110 m	<1	<1	-	<1	0%
	Road Restraint System or Safety Barrier	85 m	5	<1	-	5	0%
Drainage	Plastic Pipework HDPE	6,196 m	53	1	-	54	3%
	Precast Concrete Manholes	40 no.	-	-	-	-	-
	Precast Concrete Inspection Chambers	1 no.	-	-	-	-	-
	Plastic Inspection Chambers	2 no.	33	<1	-	33	2%
	Gullies	<1 no.	6	<1	-	6	0%
	Headwalls	-	-	-	-	-	-
	Channel & Slot Drains	-	-	-	-	-	-

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Road Pavements	Kerb	2,719 m	26	2	-	27	2%
Street Furniture	Traffic Signs	-	-	-	-	-	-
	Variable Message Signs	-	-	-	-	-	-
	Road Lighting and Columns	109 no.	74	2	-	75	4%
	Cable	3,865 m	5	<1	-	5	0%
	Marker Posts or Signs	-	-	-	-	-	-
	Cabinets	-	-	-	-	-	-
Civil Structures	Steelwork	4	6	<1	-	6	0%
	Precast Concrete	185	23	2	-	24	1%
Waste	Mixed Construction & Demolition Waste	6,559	611	35	-	645	36%
	Concrete Brick Tiles & Ceramics	189	<1	1	-	1	0%
	Bituminous Mixtures	815	1	4	-	5	0%
	Mixed Metals	40	1	<1	-	1	0%
	Hazardous Waste	279	24	1	-	25	1%
	Aggregate & Soil Exported Offsite	-	-	-	-	-	-

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Construction					**29**	**29**	**2%**
	TOTAL		**1434**	**318**		**1781**	**100%**

Table C-3 - Provides a summary breakdown of the embodied impact (A1-A5) for Broom Leys as calculated in WSP's Carbon Tool

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Bulk Materials	Ready Mix Concrete	0.2 m^3	<1	<1	-	<1	0%
	Asphalt	1,434	79	14	-	93	23%
	Fill Aggregate and Sand	1,028	8	10	-	18	4%
Earthworks	Imported Soil	323	8	3	-	11	3%
	Site Won Soil or Much Shift	2,186	0	21	-	21	5%
Fencing Barriers	Fence	22 m	<1	<1	-	<1	0%
	Road Restraint System or Safety Barrier	35 m	2	<1	-	2	1%
Drainage	Plastic Pipework HDPE	1,674 m	10	<1	-	10	2%
	Precast Concrete Manholes		-	-	-	-	-
	Precast Concrete Inspection Chambers		-	-	-	-	-
	Plastic Inspection Chambers	19 no.	15	<1	-	15	4%

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
	Gullies	15 no.	1	<1	-	1	0%
	Headwalls	-	-	-	-	-	-
	Channel & Slot Drains	-	-	-	-	-	-
Road Pavements	Kerb	851 m	7	1	-	8	2%
Street Furniture	Traffic Signs	-	-	-	-	-	-
	Variable Message Signs	-	-	-	-	-	-
	Road Lighting and Columns	25 no.	14	<1	-	14	3%
	Cable	1135 m	2	<1	-	2	0%
	Marker Posts or Signs	-	-	-	-	-	-
	Cabinets	-	-	-	-	-	-
Civil Structures	Steelwork	-	-	-	-	-	-
	Precast Concrete	53 tonnes	6	1	-	7	2%
Waste	Mixed Construction & Demolition Waste	86	8	<1	-	8	2%
	Concrete Brick Tiles & Ceramics	-	-	-	-	-	-
	Bituminous Mixtures	306	<1	2	-	2	0%
	Mixed Metals	16	<1	<1	-	<1	0%
	Hazardous Waste	1,977	169	10	-	179	43%
	Aggregate & Soil Exported Offsite	2,011	0	11	-	11	3%

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Construction					**9**	**9**	2%
	TOTAL		**330**	**74**		**412**	**100%**

Table C-4 - Provides a summary breakdown of the embodied impact (A1-A5) for Bardon Roundabout as calculated in WSP's Carbon Tool

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Bulk Materials	Ready Mix Concrete	10 m^3	3	<1	-	3	1%
	Asphalt	1,174	65	11	-	76	23%
	Fill Aggregate and Sand	946	7	9	-	16	5%
Earthworks	Imported Soil	33	1	<1	-	1	0%
	Site Won Soil or Much Shift	1,916	0	19	-	19	6%
Fencing Barriers	Fence	-	-	-	-	-	-
	Road Restraint System or Safety Barrier	-	-	-	-	-	-
Drainage	Plastic Pipework HDPE	209 m	1	<1	-	1	0%
	Precast Concrete Manholes	-	-	-	-	-	-
	Precast Concrete Inspection Chambers	-	-	-	-	-	-

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
	Plastic Inspection Chambers	6 no.	5	<1	-	5	1%
	Gullies	10 no.	1	<1	-	1	0%
	Headwalls	-	-	-	-	-	-
	Channel & Slot Drains	31 m	2	<1	-	2	1%
Road Pavements	Kerb	502 m	4	<1	-	4	1%
Street Furniture	Traffic Signs	-	-	-	-	-	-
	Variable Message Signs	-	-	-	-	-	-
	Road Lighting and Columns	8 no.	6	<1	-	6	2%
	Cable	100 m	<1	<1	-	<1	0%
	Marker Posts or Signs	4 no.	<1	0	-	<1	0%
	Cabinets	-	-	-	-	-	-
Civil Structures	Steelwork	-	-	-	-	-	-
	Precast Concrete	11 tonnes	1	<1	-	1	0%
Waste	Mixed Construction & Demolition Waste	1,808	168	10	-	178	54%
	Concrete Brick Tiles & Ceramics	-	-	-	-	-	-
	Bituminous Mixtures	265	<1	1	-	2	1%
	Mixed Metals	2	<1	<1	-	<1	0%
	Hazardous Waste	83	7	<1	-	8	2%

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
	Aggregate & Soil Exported Offsite	-	-	-	-	-	-
Construction					**5**	**5**	**1%**
	TOTAL		**272**	**52**		**329**	**100%**

Table C-5 - Provides a summary breakdown of the embodied impact (A1-A5) for Birch Tree as calculated in WSP's Carbon Tool

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Bulk Materials	Ready Mix Concrete	25 m^3	6	1	-	7	2%
	Asphalt	1,426	79	14	-	93	26%
	Fill Aggregate and Sand	798	6	8	-	14	4%
Earthworks	Imported Soil	404	10	4	-	14	4%
	Site Won Soil or Much Shift	1,855	0	18	-	18	5%
Fencing Barriers	Fence	15 m	<1	<1	-	<1	0%
	Road Restraint System or Safety Barrier	25 m	2	<1	-	2	0%
Drainage	Plastic Pipework HDPE	200 m	1	<1	-	1	0%
	Precast Concrete Manholes	-	-	-	-	-	-
	Precast Concrete	1 no.	<1	<1	-	<1	0%

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
	Inspection Chambers						
	Plastic Inspection Chambers	-	-	-	-	-	-
	Gullies	13 no.	1	<1	-	1	0%
	Headwalls	-	-	-	-	-	-
	Channel & Slot Drains	-	-	-	-	-	-
Road Pavements	Kerb	403 m	2	<1	-	2	1%
Street Furniture	Traffic Signs	-	-	-	-	-	-
	Variable Message Signs	-	-	-	-	-	-
	Road Lighting and Columns	13 no.	10	<1	-	10	3%
	Cable	-	-	-	-	-	-
	Marker Posts or Signs	-	-	-	-	-	-
	Cabinets	-	-	-	-	-	-
Civil Structures	Steelwork	1	1	<1	-	1	0%
	Precast Concrete	34	4	<1	-	4	1%
Waste	Mixed Construction & Demolition Waste	1,666	155	9	-	164	47%
	Concrete Brick Tiles & Ceramics	-	-	-	-	-	-
	Bituminous Mixtures	686	1	4	-	4	1%
	Mixed Metals	13	<1	<1	-	<1	0%

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
	Hazardous Waste	105	9	1	-	10	3%
	Aggregate & Soil Exported Offsite	-	-	-	-	-	-
Construction					**6**	**6**	**2%**
	TOTAL		**288**	**58**	**6**	**352**	**100%**

Table C-6 - Provides a summary breakdown of the embodied impact (A1-A5) for Flying Horse as calculated in WSP's Carbon Tool

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Bulk Materials	Ready Mix Concrete	<1 m^3	<1	<1	-	<1	0%
	Asphalt	937	52	9	-	61	24%
	Fill Aggregate and Sand	202	2	2	-	3	1%
Earthworks	Imported Soil	394	9	4	-	13	5%
	Site Won Soil or Much Shift	1,198	0	12	-	12	5%
Fencing Barriers	Fence	-	-	-	-	-	-
	Road Restraint System or Safety Barrier	47 m	3	<1	-	3	1%
Drainage	Plastic Pipework HDPE	776 m	5	<1	-	5	2%
	Precast Concrete Manholes	-	-	-	-	-	-
	Precast Concrete Inspection Chambers	1 no.	<1	<1	-	<1	0%
	Plastic Inspection Chambers	7 no.	6	<1	-	6	2%
	Gullies	2 no.	<1	<1	-	<1	0%
	Headwalls	-	-	-	-	-	-
	Channel & Slot Drains	-	-	-	-	-	-
Road Pavements	Kerb	838 m	8	1	-	8	3%
	Traffic Signs	-	-	-	-	-	-

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Street Furniture	Variable Message Signs	-	-	-	-	-	-
	Road Lighting and Columns	22 no.	31	<1	-	32	12%
	Cable	840 m	1	<1	-	1	0%
	Marker Posts or Signs	-	-	-	-	-	-
	Cabinets	6 no.	3	<1	-	3	1%
Civil Structures	Steelwork	-	-	-	-	-	-
	Precast Concrete	91	11	1	-	12	5%
Waste	Mixed Construction & Demolition Waste	672	63	4	-	66	25%
	Concrete Brick Tiles & Ceramics	-	-	-	-	-	-
	Bituminous Mixtures	486	1	3	-	3	1%
	Mixed Metals	11	<1	<1	-	<1	0%
	Hazardous Waste	260	22	1	-	24	9%
	Aggregate & Soil Exported Offsite	-	-	-	-	-	-
Construction					**6**	**6**	**2%**
	TOTAL		**217**	**36**	**6**	**259**	**100%**

Table C-7 - Provides a summary breakdown of the embodied impact (A1-A5) for Field Head as calculated in WSP's Carbon Tool

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Bulk Materials	Ready Mix Concrete	1 m^3	0	0	-	<1	0%
	Asphalt	582	32	6	-	38	18%
	Fill Aggregate and Sand	254	2	2	-	4	2%
Earthworks	Imported Soil	180	4	2	-	6	3%
	Site Won Soil or Much Shift	1,208	0	12	-	12	5%
Fencing Barriers	Fence	<1 m	<1	<1	-	<1	0%
	Road Restraint System or Safety Barrier	-	-	-	-	-	-
Drainage	Plastic Pipework HDPE	640 m	4	<1	-	4	2%
	Precast Concrete Manholes	-	-	-	-	-	-
	Precast Concrete Inspection Chambers	2 m	1	<1	-	<1	0%
	Plastic Inspection Chambers	38 m	30	<1	-	31	14%
	Gullies	10 no.	1	<1	-	1	0%
	Headwalls	-	-	-	-	-	-
	Channel & Slot Drains	-	-	-	-	-	-
Road Pavements	Kerb	343 m	3	<1	-	4	2%
	Traffic Signs	51 m^2	7	<1	-	7	3%

Category	Item	Quantity (tonnes)	Materials A1-A3 (tCo_2e)	Transport to/away from site A4 (tCo_2e)	Construction (A5)	Total (tCo_2e)	Proportion of total Co_2e
Street Furniture	Variable Message Signs	4 no.	13	<1	-	13	6%
	Road Lighting and Columns	5 no.	3	<1	-	4	2%
	Cable	177 m	<1	<1	-	<1	0%
	Marker Posts or Signs	5 no.	<1	<1	-	<1	0%
	Cabinets	-	-	-	-	-	-
Civil Structures	Steelwork	<1	<1	<1	-	<1	0%
	Precast Concrete	72	9	1	-	9	4%
Waste	Mixed Construction & Demolition Waste	556	52	3	-	55	25%
	Concrete Brick Tiles & Ceramics	-	-	-	-	-	-
	Bituminous Mixtures	391	<1	2	-	3	1%
	Mixed Metals	4	<1	<1	-	<1	0%
	Hazardous Waste	213	18	1	-	19	9%
	Aggregate & Soil Exported Offsite	-	-	-	-	-	-
Construction					**5**	**5**	**2%**
	TOTAL		**180**	**30**	**5**	**215**	**100%**

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