Live Labs 2: Carbon Report

A382 - MRN
Carbon Negative Project

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Contents

Nomenclature

A382 Carbon Calculator	The bespoke carbon tool used on this Live Labs 2 Project, developed using data from both the Devon Carbon Calculator and C-Est.
ADEPT	The Association of Directors of Environment, Economy, Planning & Transport
Baseline 1a	The initial project carbon baseline, as calculated in 2021 as part of a draft carbon management plan for the Full Business Case. This was calculated using the Devon Carbon Calculator.
Baseline 1b	The initial project carbon baseline, as calculated in 2022 by Milestone Infrastructure using the C-Est tool.
Baseline 2	The revised project carbon baseline following the DCC/Milestone carbon workshop, as calculated in 2023 using C-Est and based on the bill of quantities. This figure has been used as the ECI stage baseline.
Baseline 3	The final project carbon baseline, to be calculated and confirmed shortly prior to site works commencing at the end of the ECI stage.
CCAS	Carbon Calculation & Accounting Standard
C-Est	An in-house carbon calculator tool developed by Milestone Infrastructure and based on relating carbon factors to an associated bill of quantities.
DCC	Devon County Council
Decision Board	A panel formed from individuals from DCC and Milestone who are not directly involved with the A382 MRN Project. They vote on approval for innovations presented to them by the A382 Live Labs Project Team, thus ensuring a level of internal governance on Live Labs expenditure.
Devon Carbon Calculator	A tool for calculating carbon outputs for general maintenance activities, based on contractor data and ICE values. Developed by DCC, associated contractors, and the UoE.
Devon Carbon Capture Tool	A tool for calculating carbon outputs for specific construction and maintenance activities carried out by DCC contractors. Emissions are calculated via data inputted directly by contractors and broken down into the following categories: materials, plant, waste, and operative travel.
DfT	Department for Transport
ECI	Early Contractor Involvement
EPD	Environmental Product Declaration

FBC	Final Business Case
FHRG	Future Highways Research Group
ICE	The Inventory of Carbon and Energy
LCA	Life Cycle Assessment
Life Cycle Analysis Period	The 40-year period in which the estimated carbon of repeated project maintenance activities will be accounted for. This time period has been informed by academic literature.
Live Labs 2	A three-year, UK-wide £30 million programme funded by the DfT that aims to decarbonise the local highway network.
Module A	LCA emissions involved with the product and construction process. These include the emissions of raw material supply (A1), material transport (A2), manufacturing (A3), product transport (A4), and the construction and installation process (A5).
Module B	LCA emissions involved with the product use and maintenance.
Module C	LCA emissions involved with the end of life stages of a product.
Module D	LCA emissions involved with the benefits and loads beyond a product's life cycle. These include emissions for reuse/recovery and a product's recycling potential.
MRN	Major Road Network
M&E Period	The five-year monitoring and evaluation period as part of Live Labs 2, in which live carbon data will continue to be captured and assessed.
OBC	Outline Business Case
PAS 2080	A global specification for reducing and managing whole-life carbon in infrastructure, last updated in 2023.
tCO2e	Tonnes of carbon dioxide equivalent
UoE	University of Exeter

1 Introduction

1.1 Report Outline

This report is a live document presenting the overall outcomes of the A382 MRN Carbon Negative Project in relation to its stated carbon aims and that of the Live Labs 2 programme in general. This current version documents the progress made during the first year of Live Labs 2 and the development of our carbon strategy, including our aims, our tools for carbon calculation and analysis, and the lessons learned so far in the process.

1.2 Main scheme background

As set out in the Outline Business Case (OBC), the A382 MRN Carbon Negative Project uses the existing main A382 Major Road Network (MRN) scheme as a basis to trial a number of carbon-reducing interventions with the aim of achieving a carbon negative project. The main A382 MRN scheme, which is currently in its third and final phase (see Figure 1) received programme entry in May 2021 with the aim of improving road safety and traffic congestion into Newton Abbot, as well as encouraging more active travel through the development of new shared-use pathways. Phase 3, on which the Live Labs 2 programme is based, was approved by Devon County Council (DCC) for full business case submission to the Department for Transport (DfT) in November 2023.

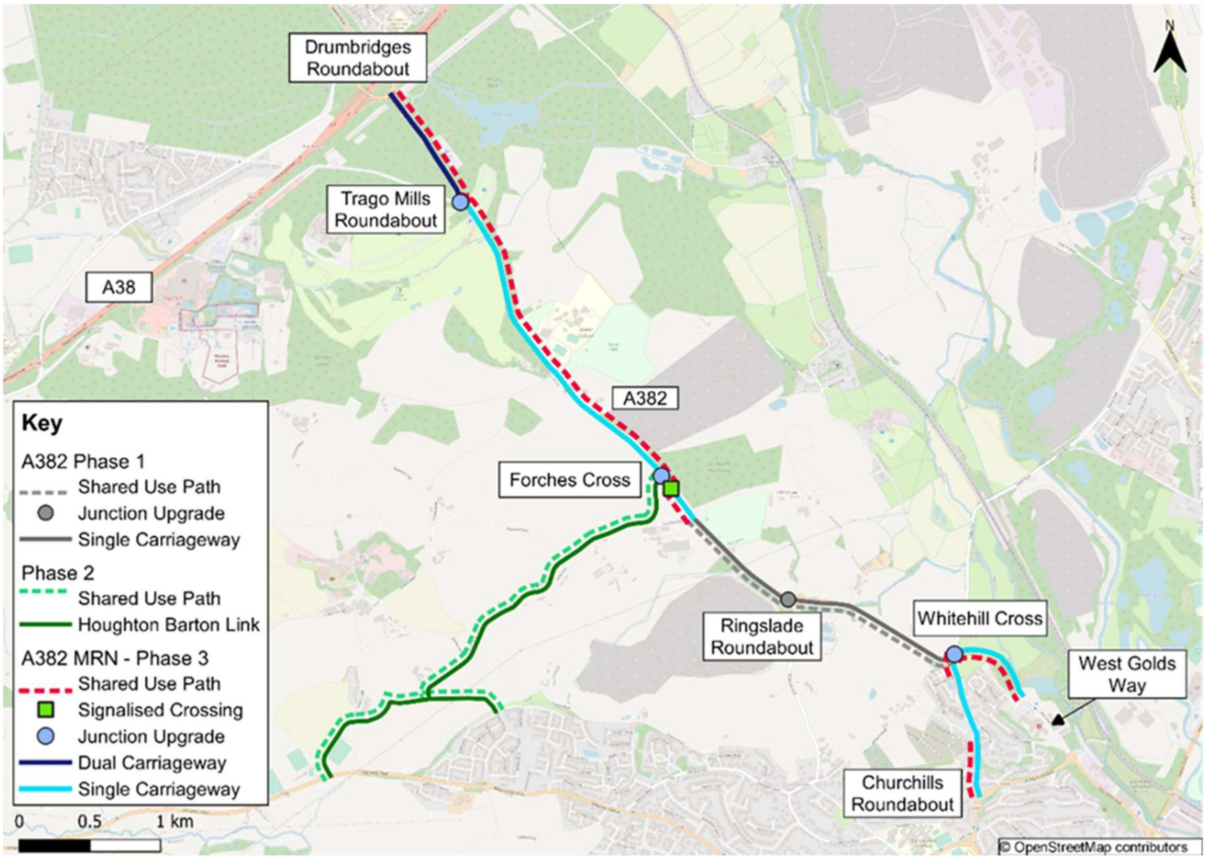

Figure 1. The 3 distinct phases of the A382 MRN scheme.

Phase 3 of the A382 MRN scheme is what is referred to in this document going forward as the main scheme and its constituent elements can be found in Table 1. It consists of approximately £40 million of construction costs, with total project costs reaching £60 million.

Location	Description
Drumbridges to Trago Mills Roundabout	Widening to 2 lane dual carriageway. Adjacent shared pedestrian and cycle path.
Trago Mills Roundabout	Improvements to existing roundabout junction.
Trago Mills Roundabout to Forches Cross	Realignment and widening to 8.3 metre single carriageway. Adjacent shared pedestrian and cycle path.
Forches Cross	New roundabout junction and short section of road widening, connecting to Phase 1. Signalised pedestrian and cycle crossing.
Whitehill Cross	Construction of new roundabout junction.
Whitehill Cross to West Golds Way	Jetty Marsh Link Road, a new 6.5 metre wide single with adjacent shared pedestrian and cycle path carriageway on an embankment.
Whitehill Cross to Churchills Roundabout (Exeter Road)*	Widening to 6 metre single carriageway. Widening of the footway to 3.5 metres to accommodate a shared pedestrian and cycle path. New pedestrian refuge island north of Whitehill Close.

Table 1. The different elements of phase 3 of the A382 MRN scheme.

*The Exeter Road section is not covered by the current main scheme works or the Live Labs Project.

Prior to involvement with Live Labs 2, DCC, as part of the Final Business Case (FBC) development, had prepared a draft carbon management plan in accordance with DfT guidelines. This process required the setting of a baseline and a target for carbon reduction across the life of the project. A target of a 25% reduction was chosen on the basis that, without comparable data from similar projects, this could be an achievable target at no cost to the project.

The earliest baseline figure (Baseline 1a) was generated by using the DCC Carbon Calculator, which resulted in a figure of 7,777 tCO2e. As part of the tender for the early contractor involvement (ECI) process, Milestone also undertook a baseline calculation using their C-Est tool; this resulted in a figure of 9,280 tCO2e (Baseline 1b). Once the ECI process started, Milestone and DCC held a carbon workshop which compared their baseline figures to understand the basis for the differences as well as scrutinising the assumptions made and elements included. This exercise resulted in a recalculation (Baseline 2), which is outlined in more detail in both later sections of this report and in the Appendix.

For further information on the main scheme itself then please refer to the OBC submitted for the Live Labs 2 programme.

1.3 Live Labs 2

The Devon Live Labs Project has been one of seven projects to receive a share of £30 million of DfT funding through the Live Labs 2 programme run by the Association of Directors of Environment, Economy, Planning & Transport (ADEPT). Devon's A382 Live Lab is in partnership with Milestone Infrastructure and the University of Exeter (UoE).

With the £3.68 million awarded, Devon's Live Lab has aimed for an ambitious target of carbon negative across the whole life cycle of the project. This means that for the construction and maintenance period of the scheme, the aim is for more carbon to be removed from the atmosphere than emitted to it.

The project applies a carbon reducing focus through the design stage and on to the construction of all aspects of the scheme, such as the new road, widened sections, footway/cycleway, junction improvements, and the installation and modification of bridges and culverts. Reducing carbon in the ongoing maintenance of these assets will also be included in this process.

1.4 Project carbon aims

The scope of this Live Labs Project includes all the materials, products and processes involved with the construction and maintenance of a highway improvement scheme. The carbon focus has already resulted in changes to the scheme design and carbon impacts influencing decision-making throughout the A382 MRN Project. Road-user carbon is not within the project's scope.

1.5 Carbon baseline background

As stated previously, a baseline (Baseline 1a) was required for the FBC from which our reductions could be measured. This was taken from the design in 2016 at which point DCC received planning approval for the scheme. It was also the basis on which the programme entry was accepted. With the design status being preliminary at that stage, the baseline included assumptions derived from similar projects and design/construction experience. In alignment with PAS 2080 it has always been understood that, as the scheme progressed, the level of detail available for carbon calculation would improve so that the baseline was likely to change throughout the process. As such a revised baseline would be prepared prior to start on site. The submission of the FBC includes Baseline 2 to align with the Live Labs project.

On reaching site, whist design changes are still possible and can be recorded against the baseline the focus will switch to carbon reporting. This will be done using the Devon Carbon Capture Tool developed by DCC and the UoE and will take all raw data from site, such as fuel use, distances travelled, vehicle types and activities, to determine the actual carbon emissions for comparison against the calculated baseline. Further information on this capture tool is contained in the following sections of this report.

2 Carbon Calculation

2.1 Calculation tool overview

The project benefits from the prior work undertaken by all three project partners. Prior to Live Labs 2, DCC, the UoE and DCC contractors had jointly developed a simple carbon calculator tool for a range of repeatable maintenance activities based on job-specific information provided by contractors and normalised for each job type. From this, DCC and the UoE jointly developed an online carbon capture tool for contractors to input data on live projects, based on the categories developed in the simple tool. DCC and the UoE also worked closely with ADEPT and the Future Highways Research Group (FHRG) in developing the sector wide Carbon Calculation & Accounting Standard (CCAS) and the associated Carbon Analyser Tool. Although the latter is not being used on the A382 Project, the team are confident that the level of output will be compatible, with a higher level of detail to those provided by the Carbon Analyser Tool.

Separately Milestone had developed a detailed tool called C-Est, which was based on applying carbon factors to a bill of quantities structure. The C-Est tool is a large spreadsheet. It comprises a large lookup sheet (referred to onwards as the 'database') with single hard coded carbon factors split into two types, upstream and transport, and summed for onward use in the calculator. The emissions from a project are obtained by multiplying these factors to items that have been quantified in the bill of quantities. The template turns to approximately 14,000 rows of potential build-ups, though only a small fraction of these is used in practice. Each bill item comprises multiple elements (e.g. materials, equipment, people, fuel), related to the emission factors (and cost factors) to calculate carbon emissions. This level of detail is hugely valuable, though also poses a significant challenge in terms of data gathering and complexity.

It was decided to proceed with a hybrid approach, starting with C-Est. This was better suited to the scale of the project and could be developed further to meet the Live Labs objectives. This would then be supplemented by learnings from the DCC tools where appropriate.

2.2 Development of A382 carbon calculator

2.2.1 Changes to C-Est

To date, the C-Est tool has been significantly developed. Initially, emission factors were hard coded in, from a range of openly accessible sources (e.g. ICE, UK Conversion Factors for Company Reporting etc.), and in some cases combined with assumptions (e.g. travel distances, freight masses, shift duration etc.). Work was undertaken to review these and make them dynamic, by introducing an upstream emission factor sheet and then linking this to the database of overall items in the tool. This helps ensure consistency and will enable rapid changing of parameters in response to design decisions.

All emission factors were updated to the most recent sources, and all assumptions were set to be dynamic inputs (linked to the database with named cells). A facility was included to select the year of analysis, which would then update all emission factors where available. Within the database, the emission factors were expanded out into specific factors for each of Modules A1-3, A4, and A5 within the standard LCA reporting framework. In addition, factors for Module D and an unofficial “Avoided Carbon” category were included. There are no Module C emissions as the lifetime of the asset is in excess of the Life Cycle Analysis Period. Any waste during maintenance will be allocated to Module B (see Section 2.2.3). The inclusion of an unofficial “Avoided Carbon” category allows for the optional quantification of savings where suppliers claim reductions due to, for example, use of materials preventing their incineration, though this would be for demonstration only. We are aware that the cost values in the database still require updating and this work is linked with the main project programme.

2.2.2 Baseline and modelling

The initial C-Est tool enables calculation of a single scenario. This has been used to estimate the emissions of the planning-approved scheme prior to any detailed design changes or Live Labs funding – Baseline 2. Currently, this is 10,279 tCO_2e for Module A (see Figure 2 and Appendix for more detail). This information can be separated into LCA stage (A1-3, A4, A5), Bill Element (13 headline categories), Resource Type (labour, equipment and fuel, materials, and subcontracting of either surfacing, VRS, or other), and in any combination or for any individually named item.

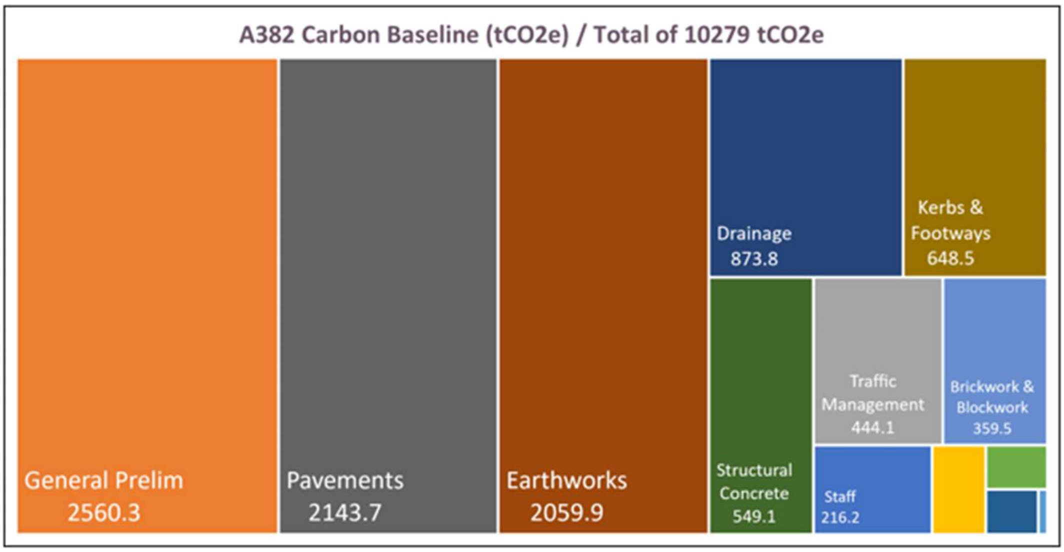

Figure 2**. Graphical breakdown of baseline by activity.**

The key aim of the analysis is to be able to use the modelling to understand the impact of various design decisions. Innovation options were identified within seven categories totalling over 100 measures. Whilst a number of these were scoped out prior to more detailed modelling for various reasons, for the remainder there is a need to compare scenarios with the intervention(s) to those without.

As the project has progressed, it was apparent that Baseline 2 was not totally comprehensive of all items going into the scheme (for example, streetlights were not initially present in the baseline model, so comparison of innovation options would not have been possible). The modelled baseline in essence was dynamic and so the approach has had to adapt to this. Rather than undertaking individual bespoke calculations for each innovation option, it was decided to modify the C-Est tool to be able to handle these different scenarios. This has a twofold advantage. Firstly, it overcomes the potential issue of the baseline changing (with individual calculations, these would need to be updated each time a change was made), and secondly it retains all the rich detail within the C-Est model.

The model was developed to enable 'clones' of scenarios to be created which would enable the modelling of scenarios. For example, the baseline scenario (scenario 0) could be copied (scenario 1), and changes reflecting the innovation option made to scenario 1. These changes include things like changing quantities, removing or adding items, replacing materials or products with other materials etc. To capture this, an innovation option tracker spreadsheet was created and this was linked to the C-Est tool.

For each innovation option, critical information about that change was requested. This includes things like quantities, affected bill of quantity items, emission factors and sources. Obtaining this information to feed the model is an ongoing process and is being led by DCC; this is covered in more detail elsewhere in the report.

Initially a hierarchy approach was taken, with data gathering prioritised in line with the programme of the site works and the need to have actionable information available for critical Decision Board meetings. This has led to items associated with site clearance and set up being calculated early on. However, the delay to the start of site works has enabled a shift to those items which may have a larger carbon impact but which appear later in the works programme, such as surfacing.

The model is in a position where it has been demonstrated to work and has been tested on three innovation options shown in Table 2.

Scenario Reference	Innovation Option	Carbon Reduction tCO2e (Module A only)
2	Reduction of carriageway width from 10 m to 8.3 m	282
4	Use of graphene in asphalt	33
5	Change from diesel to HVO for site plant and vehicles	3,448

Table 2. Modelled innovation options.

Figure 3 provides a graphical representation of the reductions from Table 2 for the modelled scenarios (2, 4 and 5) with the breakdown by Module A resource type. The remaining scenarios are the baseline with 1, 3, 6 and 7 to be updated as data becomes available.

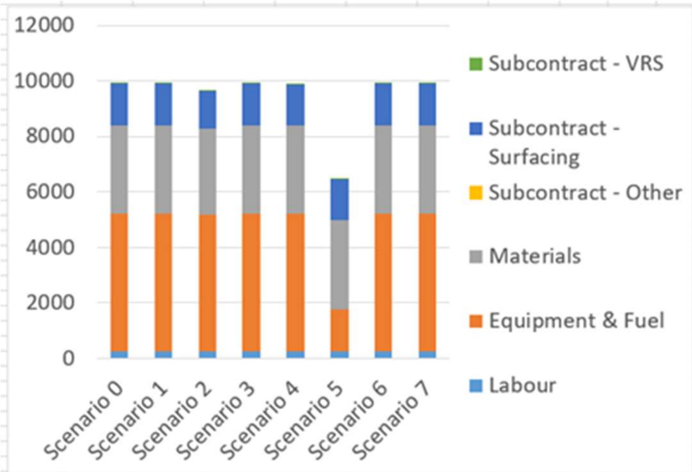

Figure 3. Graph showing emissions by Module A resource type (scenarios 2, 4, & 5 are changes as per Table 2. The remainder are repeats of the baseline).

The model also returns cost uplifts and abatement costs, though as the input cost data needs to be refreshed these cannot be reported now. Next steps on this modelling will be to input the data for the remainder of the innovation options individually, and then build up combination scenarios.

2.2.3 Next steps

Work has commenced on developing a Module B calculator. At present this is a standalone tool, though the intent will be to work it into the modified C-Est tool when it is fully developed, so that all scenario LCA stages can be analysed and reported together. As there is much more uncertainty about ongoing maintenance, the inputs will be much higher-level and will utilise the prior work undertaken on the Devon Carbon Calculator where relevant.

The modelling approach is to identify the time period of repeating maintenance tasks over the 40-year Life Cycle Analysis Period of the road. As discussed in the OBC, this length of time has been chosen after a review of academic literature. Presently, there are 18 repeating maintenance tasks identified by the design team for the baseline scenario. The calculator has been set up to enable inputs of emissions per maintenance cycle, and cycle period, to automatically calculate a time series of emissions. The emissions per maintenance cycle will be calculated on an individual basis for the baseline scenario, and then modified for each innovation option/scenario depending on any identified impacts on maintenance requirements.

Location	Item	Notes	tCO2e/ instance	Frequency (years)	Years from Opening: 0	1	2	3	4	5	6	7	8	9	10	11
Upfront Emissions	Module A emissions	From main C-Est tool			10500											
Structures	Forches Bridge: Minor paint repairs	On a 12 year cycle to address any corrosion points. Note Bridge now remo	100	12	0	0	0	0	0	0	0	0	0	0	0	0
	Forches Bridge: Complete repaint	Complete repaint every 25 years	1	25	0	0	0	0	0	0	0	0	0	0	0	0
	Forches Bridge: Replacement of the antiskid surfacing		100	10	0	0	0	0	0	0	0	0	0	0	100	0
	Replacement of culverts	Designed for 120 year life require minimal maintenance if designed and cor	1	120	0	0	0	0	0	0	0	0	0	0	0	0
	Stover Bridge: Replacement of bridge	120 year design life	1	120	0	0	0	0	0	0	0	0	0	0	0	0
	Stover Bridge: Waterproofing system	Replaced on a cycle of 30 years - spray applied waterproofing	50	30	0	0	0	0	0	0	0	0	0	0	0	0
	Stover Bridge: Replacement of vehicl	Every 10 years	1	10	0	0	0	0	0	0	0	0	0	0	1	0
Highways	Streetlighting - columns	Column replacement 10 years 79 columns across the scheme	1	10	0	0	0	0	0	0	0	0	0	0	1	0
	Streetlighting - lamps	Lamp replacement 22 years 79 columns across the scheme	1	22	0	0	0	0	0	0	0	0	0	0	0	0
	Kerbs replacement	(also design change to reduce kerbs) 20 years - 7100 m	1	20	0	0	0	0	0	0	0	0	0	0	0	0
	Lines	5 years - approx. 13,500 m	40	5	0	0	0	0	0	40	0	0	0	0	40	0
	Gullies (cleaning)	yearly - 130 gullies assumed	50	1	0	50	50	50	50	50	50	50	50	50	50	50
	SUDS	10 years - excavator for 2 weeks	1	10	0	0	0	0	0	0	0	0	0	0	1	0
	Signs and posts	20 years - 195 assumed	1	20	0	0	0	0	0	0	0	0	0	0	0	0
	Resurfacing	(design change reduced width) 30 years - same as current surfacing valu	35	30	0	0	0	0	0	0	0	0	0	0	0	0
	Vegetation	Every 5 years, 5 km of clearance	1	5	0	0	0	0	0	1	0	0	0	0	1	0
	High friction surface	8 years - 830 sq.m	1	8	0	0	0	0	0	0	0	0	1	0	0	0
	Tactile paving	10 years - 76 sq. m	20	10	0	0	0	0	0	0	0	0	0	0	20	0
TOTALS	TOTALS PER YEAR				10500	50	50	50	50	91	50	50	51	50	214	5[illegible]
RUNNING TOTALS	Module A				10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	10500	105[illegible]
	Module B				0	50	100	150	200	291	341	391	442	492	706	75[illegible]

Figure 4. Module B input sheet with dummy data.

At present, these calculations have not been undertaken and so it is not possible to tell how significant Module B emissions will be. Although, with the maintenance period accounting for the anticipated life of the pavement, these emissions are expected to be comparable with the scheme construction emissions.

3 Progress, Challenges and Learning

3.1 Development of a decarbonisation strategy

3.1.1 Progress

The scope of this Live Labs Project includes consideration of the emissions associated with all the materials, products and processes involved with the construction and maintenance of a highway improvement scheme. The rationale is that there is currently no single solution that will enable the reduction of carbon emissions but that, by combining products and innovations across all elements of the scheme, we can significantly reduce these emissions with the aim of reaching our carbon negative target.

The previous work undertaken by Devon County Council, the University of Exeter and Milestone Infrastructure has enabled an early understanding not only of the carbon baseline of the A382 scheme but also of the carbon hotspots – those elements of the project that make a significant contribution to the total. As set out in more detail in Section 2.2, the ability to sort this data by Series as per the Specification for Highway Works (i.e. pavement, general prelims, drainage etc.) and further split it into Module A resource type (i.e. equipment and fuel, materials, labour etc.) has been a powerful tool in creating a strategy for reduction and enabling a focussed approach to seeking innovations and determining where the budget is best spent. As an example, taking the breakdown in Figure 5, focussing on reduced carbon materials for the pavements would result in greater savings than a focus on equipment and fuel which would be of more benefit to preliminaries and traffic management.

Rank	Category	Subcategory	Subcategory carbon (%)
1	General Prelim	Equipment & Fuel	97.6%
		Labour	0.4%
		Materials	2.0%
2	Pavements	Equipment & Fuel	5.8%
		Labour	0.2%
		Materials	94.0%
3	Earthworks	Equipment & Fuel	50.2%
		Labour	1.8%
		Materials	48.0%
4	Drainage	Equipment & Fuel	49.3%
		Labour	2.1%
		Materials	48.6%
5	Kerbs & Footways	Equipment & Fuel	9.3%
		Labour	1.0%
		Materials	89.7%
6	Structural Concrete	Equipment & Fuel	45.9%
		Labour	0.6%
		Materials	53.5%
7	Traffic Management	Equipment & Fuel	91.3%
		Labour	8.7%
		Materials	0.0%
8	Brickwork & Blockwork	Equipment & Fuel	14.0%
		Labour	1.8%
		Materials	84.2%
9	Staff	Equipment & Fuel	0.0%
		Labour	100.0%
		Materials	0.0%

Figure 5. Breakdown of high carbon contributors by Series and Module A resource type.

3.1.2 Challenges and lessons

The data and breakdown set out in Figure 5 is a useful tool for other projects and will aid them in being able to prioritise early on where key engagements are. This has been one of the challenges that the project has faced in that, whilst we know where we need to target our innovations, many of them are intrinsically linked with the main project programme and the contract's commercial arrangements. As an example, activities such as the vegetation clearance may not make a significant contribution to the baseline but, as they occur early in the programme, they require early consideration so that any benefits are not lost. In addition, they can easily sit as an item outside of the main contract allowing more flexibility.

In contrast, activities such as paving, whilst making a significant contribution to emissions occur later in the contract programme and are more complicated commercially meaning that progress on these items is very much reliant on the early engagement of the supply chain. On contracts such as this, such early engagement is not common. Therefore, one of the focusses of our learning will be how this can be addressed in the future.

3.2 Limitations to the baseline

One item noted in the OBC which has been considered further by the Live Labs team are those items which are not covered by carbon calculation tools. For this scheme, these key items comprise the carbon contained within the vegetation and soils on site.

3.2.1 Progress

Knowing that the carbon stocks of both the vegetation and soil will be affected by the scheme construction through vegetation removal and earthworks activities, we have estimated the carbon stocks in these items as set out in Table 3:

External Carbon Stocks	
Source	**Carbon (tCO2e)**
Vegetation	490

Soil	2464

Table 3. Carbon stocks in vegetation and soil.

Having calculated these, we have developed strategies around them which will seek to understand what happens to that carbon both through traditional activities and as a result of our proposed interventions.

3.2.2 Challenges and learning

Availability of reliable and relevant data has been one of the main challenges for this aspect resulting in high level calculations. On the vegetation front, gathering information on site specifics such as number of trees, age and species has not been possible, so calculations are based on assumptions of number per area, general type and average age.

For the planting at the end of the project we aim to be more specific, having better knowledge of what is being planted with the aim of creating a carbon profile across the life of the project for the vegetation.

The development of a soil carbon study specific to the site will enable us not only to better understand the impact of our activities, but also to appreciate the quality of the existing data.

3.3 Carbon data

In assessing the merit or otherwise of an innovation, one of the key items is the carbon data issued by the suppliers, whether that be EPDs or other documents. Our aim with the calculation and capture process has been to use the best data available, with generic factors only used where necessary. As part of the assessment process any data provided is rigorously scrutinised and queries raised as necessary with the suppliers. In some instances queries are satisfactorily addressed and we can complete the assessment, but in other instances querying of the data can result in long delays, increased confusion or complete disengagement by the supplier. Items identified that are generating queries are listed below:

- Where a product has a commonly used equivalent, the figures used to generate a benchmark for that equivalent is not always from recognised sources such as ICE or UK Conversion Factors for Company Reporting. This can lead to vastly exaggerated claims of the carbon saving.

- Suppliers are not aware of how their carbon data has been produced, resulting in queries having to be relayed to others; this results in significant delays or no response.

This experience has resulted in a change of strategy in requesting carbon data. In future, when requesting carbon data we propose to advise what basis our baseline for an item is calculated and request a supplier's carbon data relative to that baseline. It is hoped that this will allow for a like-for-like comparison.

4 Conclusion

4.1 Main takeaways

By developing a carbon baseline over multiple years and throughout the development of the design of the project, we have had the opportunity to consistently refine our modelling approach. This has allowed us to identify areas of the scheme that were previously not included in the working baseline, to better understand carbon hotspots, and to update any changing carbon factors or quantities. The work that had already been undertaken by DCC, the UoE and

Milestone on different carbon tools also provided us with the ideal platform to pursue a bespoke scenario-based tool for the A382 Project. The select innovations and design changes that have already been processed through it demonstrate the tool's ability to express carbon savings.

Despite these successes, significant challenges remain in gathering industry carbon data and understanding the impact of activities whose carbon is not usually assessed, such as vegetation clearance and movement of soils. However, it is clear to us that only by tackling these challenges head on can we begin to encourage the discussions and industry-wide change that is needed to decarbonise local highway networks.

4.2 Going forward

The principal task for us ahead of work commencing on site is to complete our final project carbon baseline. This will occur following the completion of Milestone's estimating exercise and a final bill of quantities. Using the latest and most accurate industry figures, we can then update the quantities and carbon factors currently in the C-Est Baseline 2 model and add the elements that are yet to be included, such as streetlighting and signing. This will give us our final pre-start baseline – Baseline 3.

Innovations will continue to be reviewed and assessed both through the Decision Board governance process and by calculating the carbon impact of different innovation-based scenarios through the A382 Carbon Calculator. The potential savings of pursuing different innovations can be compared against Baseline 3. Whilst we are on site, we will be capturing live carbon data through the Devon Carbon Capture Tool. We are confident that such an approach – comparing live captured data against a thorough baseline that has developed over many years – provides us with the optimum strategy for the most accurate and precise carbon data. This data will continue to inform our decision-making throughout the remainder of the Live Labs 2 programme, assisting us to achieve our carbon aims.

5 Appendix

5.1 Appendix A – Baseline 2 Headline Data

Bill Element	Module A Estimated Carbon (tCO2e)	Percentage of Total (%)	Subcategory					
			Materials		Equipment & Fuel		Labour	
			Total tCO2e	% of Bill Element Emissions	Total tCO2e	% of Bill Element Emissions	Total tCO2e	% of Bill Element Emissions
General Prelim	2560.33	24.91%	52.43	2.05%	2498.28	97.58%	9.61	0.38%
Pavements	2143.65	20.86%	2015.47	94.02%	124.61	5.81%	3.58	0.17%
Earthworks	2059.58	20.04%	989.51	48.04%	1033.61	50.19%	36.46	1.77%
Drainage	873.82	8.50%	424.39	48.57%	431.21	49.35%	18.22	2.08%
Kerbs & Footways	648.55	6.31%	581.64	89.68%	60.39	9.31%	6.52	1.00%
Structural Concrete	549.13	5.34%	293.75	53.49%	251.99	45.89%	3.39	0.62%
Traffic Management	444.07	4.32%	0.00	0.00%	405.26	91.26%	38.81	8.74%
Brickwork & Blockwork	359.50	3.50%	302.71	84.20%	50.40	14.02%	6.39	1.78%
Staff	216.17	2.10%	0.00	0.00%	0.00	0.00%	216.17	100.00%
Forches Cross Footbridge (separate item)	208.44	2.03%	114.00	54.69%	86.44	41.47%	8.00	3.84%
Site Clearance	98.43	0.96%	12.49	12.69%	83.01	84.34%	2.92	2.96%
Vehicle Restraint Systems	55.18	0.54%	55.18	100.00%	0.00	0.00%	0.00	0.00%
Ducting & Electrical	48.25	0.47%	20.42	42.33%	26.69	55.31%	1.14	2.36%
Fencing	13.47	0.13%	9.80	72.72%	1.92	14.23%	1.61	11.92%
Total:	**10279**		4872		5054		353	