Kirklees COUNCIL

ARCADIS Design & Consultancy for natural and built assets

Working on behalf of Kirklees Council

WY+TF A629 HALIFAX ROAD PHASE 5 CARBON IMPACT ASSESSMENT

ARC-WYCA-KC-RP-A629-CIAR-V2.0

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Incorporating

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CONTENTS

FIGURES

TABLES

1 Introduction

1.1 Purpose of the Report

1.1.1 This Carbon Impact Assessment (CIA) has been prepared to assess the associated greenhouse gas (GHG) emissions of the A629 Phase 5 project (hereinafter 'Scheme') that are estimated to be generated during construction and operation. Kirklees Council has strategic environmental priorities, including promoting development that helps to reduce and mitigate climate change, and development which is adapted so that the potential impact from climate change is reduced and to help the transition towards a low carbon economy.

1.1.2 Although there are physical limitations (e.g. type of structural material that could be used) associated with the Scheme, there remains ample opportunity to incorporate sustainability and energy efficiency measures within the Scheme. The CIA provides the framework for determining the carbon emissions from the Scheme, such as 'do something' and 'do-something-good practice' scenarios, as presented in Table 1.

Table 1 Scheme Scenarios

Scenario		Description
'Do-something'	Proposed scheme	The scheme with embedded GHG mitigation measures. The expected policy impacts of the future baseline underpins this scenario.
'Do-something – good practice'	Proposed scheme with additional mitigations	The scheme with embedded mitigation measures and additional mitigations that have not been agreed but could potentially be agreed at later stage.

1.2 Proposed Scheme Description

1.2.1 The A629 Halifax Road corridor between Halifax and Huddersfield has been identified as one of several key projects within the West Yorkshire Plus Transport Fund (WY+TF) programme. This has been prioritised for delivery within the first five years of the WY+TF (by 2021) and has been allocated £120.6m to drive economic growth by addressing transport and accessibility issues.

1.2.2 The Scheme forms part of the wider package of interventions along the A629, which runs between Huddersfield and Halifax. This is being delivered in five phases by Calderdale Council and Kirklees Council; Phases 1 to 4 are being delivered by Calderdale Council. Kirklees Council is responsible for delivering Phase 5, which covers a section of the corridor between Huddersfield town centre and Ainley Top roundabout, located south of Junction 24 of the M62 motorway. WY+TF A629 Phase 5 is progressing through the West Yorkshire Combined Authority (WYCA) approvals processes.

1.2.3 An Outline Business Case for the package of highway improvements along the A629 corridor between Fitzwilliam Street and Ainley Top roundabout was approved by WYCA on 10 May 2018 and it was recommended to progress to Full Business Case (FBC) stage. The results of this study feed into the FBC with a target submission date in summer 2020. The mobilisation and construction works are expected to commence in 2021, with the Scheme opening in 2023.

The WY+TF A629 Halifax Road Phase 5 scheme will deliver improvements at three key junctions between Huddersfield town centre and Ainley Top roundabout, together with provision of new private residential off-road parking as summarised below in

1.2.4 Table 2 and at the Work Package (WP) locations shown in Figure 1.

Table 2 A629 Halifax Road Scheme Elements

Elements	Description
WP1	New North Road / Edgerton Road / Edgerton Grove Road / Blacker Road (Blacker Road Junction) – widening to Blacker Road, Edgerton Road and Edgerton New North Road together with removal of existing parking and construction of new off-road parking.
WP2	Halifax Road / East Street / Birkby Road junction (Cavalry Arms Junction) – widening to Birkby Road.
WP3	Cavalry Arms to Birchencliffe Hill Road - provision of new off-road residential parking on land to the west of Halifax Road.
WP4	Yew Tree Road to Ainley Top (Yew Tree to Ainley Top) – widening to Halifax Road and approach to Ainley Top roundabout.

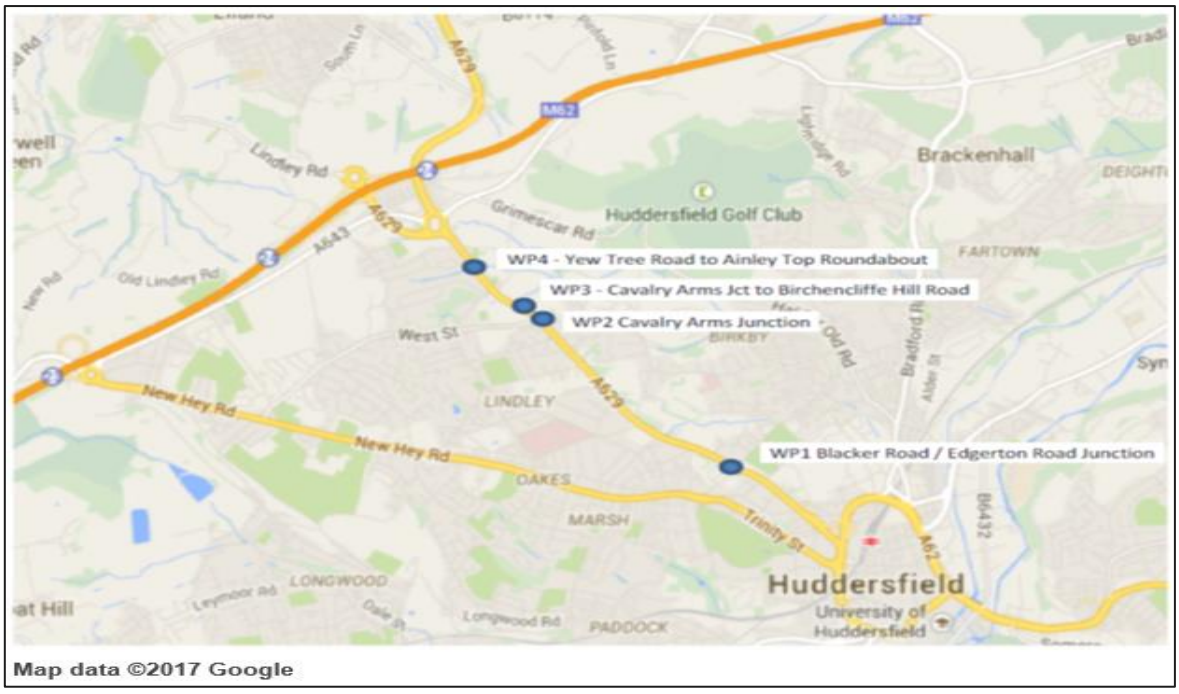

Figure 1 Proposed Improvement Location Plan

2 Legislation and Policy Context

2.1.1 This section provides an overview summary of the national, regional and local policy relating to energy and carbon emission reduction. This is intended as an overview of the key policy and regulatory requirements that need to be considered and, where necessary met, in the development of the Scheme.

2.2 International and National Policy

Paris Agreement, 2015 (Ref. 1)

2.2.1 Adopted in 2015 and entered into force in November 2016, the Paris Agreement is an international climate agreement aiming to limit global temperature increase this century to less than 2 degrees Celsius above pre-industrial levels. It additionally establishes a goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change.

The Climate Change Act 2008 (Ref. 2)

2.2.2 The Climate Change Act 2008 sets up a framework for the UK to achieve its long-term goals of reducing GHG by 34%, over the 1990 baseline by 2020 and by 80% by 2050 and to ensure steps are taken towards adapting to the impact of climate change. The Act introduces a system of carbon budgeting which constrains the total amount of emissions in a given time period and sets out a procedure for assessing the risks of the impact of climate change for the UK, and a requirement on the Government to develop an adaptation programme.

2.2.3 The Climate Change Act introduced new powers and duties on climate change adaptation and mitigation. For adaptation it established a:

- UK-wide Climate Change Risk Assessment that must take place every five years.
- National Adaptation Programme which must be put in place and reviewed every five years to address the most pressing climate change risks.
- Government power to require 'bodies with functions of a public nature' and 'statutory undertakers' to report on how they have assessed the risks of climate change to their work, and their response.
- Adaptation Sub-Committee of the independent Committee on Climate Change in order to oversee progress on the national programme and advise on the risk assessment.

Regional Policy

Kirklees Local Plan; Strategy and Policies, 2019 (Ref. 3)

2.2.4 This Plan was formally adopted on 27th February 2019, this document covers all policies necessary to achieve the vision and strategic objectives for the administrative area of Kirklees Council up to 2031. Strategic objective 7 specifically states that the council seeks to: *Promote development that helps to reduce and mitigate climate change, and development which is adapted so that the potential impact from climate change is reduced and to help the transition towards a low carbon economy.*

2.2.5 The Local Plan includes a suite of policies that development proposals are considered against and which cover a wide range of issues that seek to ensure development can be resilient to and reduce the causes of climate change. The Plan takes the National Planning Policy Framework (NPPF) into account when addressing climate change and contributes to the delivery of sustainable development.

Guidance

The Green Construction Board PAS 2080:2016 Carbon Management in Infrastructure 2016 (Ref. 4)

2.2.6 Publicly Available Specification (PAS) 2080:2016, sponsored by the Green Construction Board, was the first publicly available specification in the world that specifically addressed managing carbon in infrastructure. The purpose of the PAS 2080 specification is to:

- Provide governance and leadership.
- Quantify GHG emissions.
- Integrate emissions management into infrastructure delivery processes.
- Provide targets, baselines, and monitoring methods.
- Assist with reporting and managing information.
- Spread responsibility across the asset value chain (designers, constructors, suppliers, managers).
- Encourage continuing improvement.

2.2.7 PAS 2080:2016 provides a common framework for all infrastructure sectors and value chain members on how to manage whole life carbon when delivering infrastructure assets and programmes of work. PAS 2080:2016 promotes reduced carbon, reduced cost infrastructure delivery, more collaborative ways of working and a culture of challenge in the infrastructure value chain through which innovation can be fostered.

2.2.8 It includes requirements for all value chain members to show the right leadership and to establish effective governance systems for reducing whole life carbon through the use of a detailed carbon management process. All value chain members can claim conformity to the PAS 2080:2016 by demonstrating that the requirements in the PAS 2080:2016 that are relevant to them have been met.

Clean Growth Strategy 2017 (Amended 2018) (Ref. 5)

2.2.9 Published in October 2017, the Clean Growth Strategy outlines the UK government's proposals to decarbonising all sectors of the UK economy though the 2020s.

The UK Climate Change Risk Assessment (CCRA) 2017 (Ref. 6)

2.2.10 Under the 2008 Climate Change Act, the UK government is required to publish a UK-wide Climate Change Risk Assessment every 5 years. The CCRA sets out the main priorities for adaptation in the UK under 5 key themes (Agriculture and Forestry, Business, Industries and Services, Health and Wellbeing, Natural Environment and Buildings and Infrastructure). The CCRA also reviews the evidence for 56 risks and opportunities of climate change in a UK context. The 6 key priority risks and opportunities identified in the UK Climate Change Risk Assessment 2017 Evidence Report include:

- Flooding and coastal change risks to communities, businesses and infrastructure.
- Risks to health, well-being and productivity from high temperatures.
- Risk of shortages in the public water supply, and for agriculture, energy generation and industry.
- Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity.
- Risks to domestic and international food production and trade.
- New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals.

2.2.11 Detailed analysis was undertaken for 56 risks and opportunities across natural environment and assets, infrastructure, people and the build environment, business and industry, international dimensions and cross-cutting issues. This has been undertaken on the basis of their likelihood, the scale of their potential consequences and the urgency with which action may be needed to address them. For the UK's infrastructure sector, the key risks for the identified relevant to the Scheme are:

- Infrastructure (In) 1: Risks of cascading failures from interdependent infrastructure networks.
- In 2: Risks to infrastructure services from river, surface water and groundwater flooding.
- In 4: Risks of sewer flooding due to heavy rainfall.
- In 5: Risks to bridges and pipelines from high river flows and bank erosion.
- In 6: Risks to transport networks from slope and embankment failure.
- In 8: Risks to subterranean and surface infrastructure from subsidence.
- In 11: Risks to energy, transport and digital infrastructure from high winds and lightning.
- In 13: Risks to transport, digital and energy infrastructure from extreme heat.

The National Adaptation Programme (NAP) and the Third Strategy for Climate Adaptation Reporting: Making the country Resilient to a changing Climate, 2018 (Ref. 7)

2.2.12 The NAP sets out actions for addressing the risks identified in CCRA 2017 and outlines the steps government, businesses and communities will take. The long-term vision set out in the first NAP (2013) still stands: ‘A society which makes timely, far-sighted and well-informed decisions to address the risks and opportunities posed by a changing climate’.

2.2.13 The NAP explains a wide range of climate risks which affect our natural environment, our critical infrastructure services, our communities and buildings, local government and businesses. Each chapter aligns with each risk area set out in the CCRA, each chapter sets out the vision, the risks the sector faces from climate change and outlines actions that is being taken to mitigate these risks.

2.2.14 Chapter 3: Infrastructure states the vision as ‘An infrastructure network that is resilient to today’s natural hazards and prepared for the future changing climate’. Key risks to infrastructure are identified as:

- Risks to infrastructure from river, surface/ groundwater flooding and coastal flooding and erosion.
- Interdependency risks to infrastructure asset management.
- Risks to transport networks from embankment and bridge failure.
- Risks to infrastructure from high winds, lightning, storms, and high waves.

The Carbon Plan: Delivering our Low Carbon Future 2011 (Ref. 8)

2.2.15 This superseded previous report published in 2009 (The Low Carbon Transition Plan: National strategy for climate and energy), it presents the Government’s strategy for meeting all four carbon budgets for periods 2008-2012, 2013-2017, 2018-2022 and 2023-2027. This outlines the UK’s plans to achieve decarbonisation within the framework of energy policy to make a transition to a low carbon economy while maintaining energy security, and minimising costs to consumers. This aims in increasing the energy efficiency across all sectors with help of wind and other renewables.

Kirklees Climate Emergency Declaration and the Kirklees Air Quality Strategy and Five-Year Air Quality Action Plan, 2019 (Ref. 9)

2.2.16 A Climate Emergency Declaration was made by Kirklees Council in January 2019. The declaration is a symbolic motion for the council to acknowledge that humanity is in a climate emergency. Following the declaration, the Kirklees Council established a Climate Emergency Working Party (CEWP) to identify actions to reduce emissions in Kirklees, with the aim to become a carbon neutral district by at least 2038.

2.2.17 The purpose of the report is to:

- Present the findings of the Climate Emergency Working Party.
- Set out the proposed response to the Climate Emergency for approval.
- Present the Kirklees Council Five Year Air Quality Action Plan and Strategy for approval.

2.2.18 Kirklees Council has sought advice and independent analysis from the Tyndall Centre (a partnership of UK Universities working together to provide evidence to inform society's transition to a sustainable low-carbon and climate resilient future) in order to set a 'carbon budget' for Kirklees and identify an advisory climate change target.

2.2.19 The resulting report recommends that Kirklees' target is to stay within a cumulative carbon dioxide emissions budget of 11.9 million tonnes CO_2 ($MtCO_2$) for the period 2020 to 2100; with the recommended breakdown below as presented in Table 3.

Table 3 Periodic Carbon Budgets for 2018 for Kirklees

Carbon Budget Period	Recommended Carbon Budget (Mt CO_2)
2018 - 2022	7.9
2023 - 2027	4
2028 - 2032	1.9
2033 - 2037	0.9
2038 - 2042	0.4
2043 - 2047	0.2
2048 - 2100	0.2

3 Construction Carbon and Energy

3.1 Introduction

3.1.1 This section of the CIA focuses solely on the carbon and energy associated with the construction materials and processes (e.g. plant, welfare facilities and equipment). Which will be based on PAS 2080:2016 (Ref. 4), taking into account boundaries and the scope of the scheme, and calculated using industry accepted tools (e.g. Bath Inventory of Carbon and Energy (ICE) Database (Ref. 10) and Rail Carbon Tool (Ref. 11)). This would inform carbon reduction planning and serve as the reference point to quantify emerging carbon reduction initiatives.

3.1.2 A proportionate approach has been taken to the scope of the assessment methodology, consistent with principles associated with GHG emissions set out in PAS 2080:

- Relevance – data and assessment methodology has been selected and presented in Table 8 4.
- Completeness – the GHG emissions assessment has been based on a Life Cycle (LC) approach.
- Consistency – consistent methodology and data sources for GHG emissions have been used to allow comparison of emissions over time.
- Accuracy – the quantification of the GHG emissions have neither been over nor underestimated, as far as can be judged. Also, uncertainties have been reduced as far as reasonably practicable.
- Transparency – the outputs of the GHG emissions assessment have been made available along with data sources and any relevant assumptions.

3.1.3 Key aspects to be assessed for this scheme will be:

- Material Resources: information provided from the design team based on the Bill of Quantities produced for the scheme (key material resources quantities and distances to suppliers) will be used to determine the embodied carbon emissions from key material resources and GHG emissions from their transportation to site;
- Transportation of waste off-site;
- Plant and equipment fuel and energy requirements;
- Water usage;
- Business and employee transport;
- Design Usage and Renewable Energy; and
- Decommissioning Carbon: If information is available from the design team on how the scheme will be decommissioned, it will be reviewed to ensure that it is being designed to avoid assets that are expensive, time consuming and risky to decommission.

3.1.4 There are no accepted criteria for quantifying the GHG emissions for construction activities. Guidance does exist but is largely focussed on discrete products or commercial entities. In the absence of such guidance, the CIA has been undertaken using professional judgement and utilising the ICE Database (Ref. 10).

3.1.5 The ICE database is widely used in the built environment sector to measure the carbon and energy associated with a project, including the Environment Agency (EA) and the Building Research Establishment (BRE) which have produced carbon calculators which primarily reference figures from the Bath University Inventory of Carbon and Energy. The ICE contains carbon factors related to the types of materials commonly used in construction and is designed to provide a robust, reliable means of measuring carbon emissions associated with the construction phase. For this reason, it has been selected to support the embodied carbon quantification associated with the construction of the Scheme.

3.1.6 In line with the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) GHG Protocol guidelines (Ref. 12), the GHG assessment will be reported as tonnes of carbon dioxide equivalent (tCO_2e). CO_2e is a metric measure used to compare the emissions from various GHGs on the basis of their global-warming potential (GWP). CO_2e is calculated by converting amounts of the seven Kyoto Protocol gases to the equivalent among of carbon dioxide with the same GWP:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Sulphur hexafluoride (SF_6);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs); and
- Nitrogen Trifluoride (NF_3).

3.1.7 The collected data comprises estimates of material resources, energy use and commuting journeys. The data has been presented below in order to generate an estimate of the carbon footprint related to the preliminary and final design options of the Scheme. The input data included:

- Material resources quantities;
- Information on the logistics of material resources, staff and construction, demolition and excavation waste; and
- Energy used during construction.

3.2 Embodied Carbon from Material Resources

Material resources include primary raw materials, such as steel, and manufactured construction products which include recycled and secondary aggregates. Many material resources originate off-site, purchased as construction products, and some arise onsite such as excavated soils.

The way in which material resources are used throughout the construction process is known as the Material Resource Flow. A simplified flow diagram representing the flow of material resources and the management of waste is shown in Figure 2 overleaf.

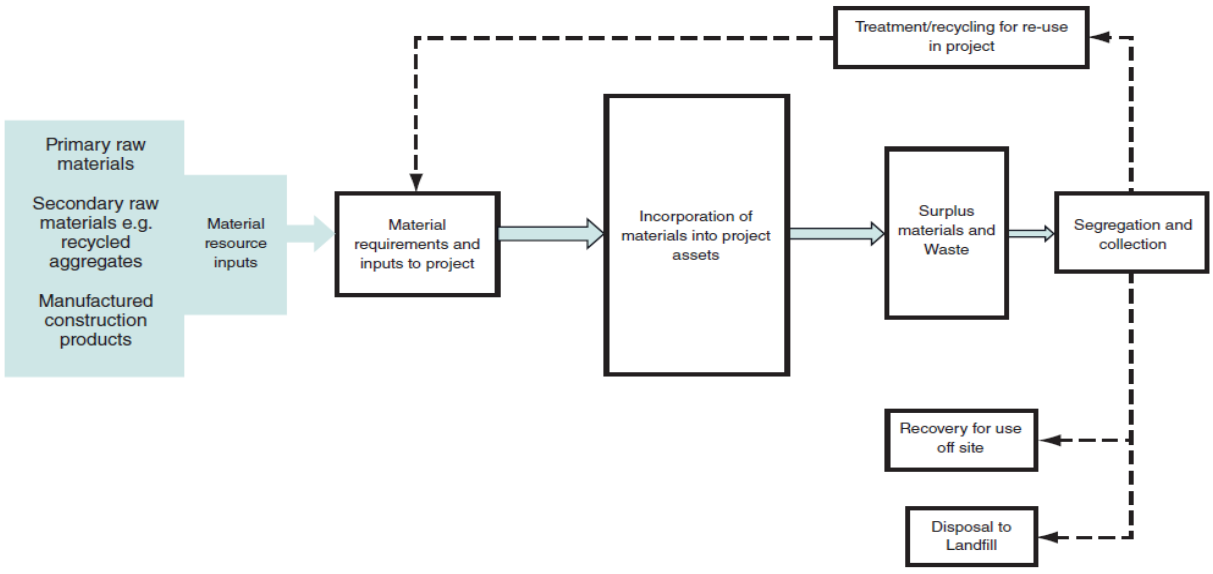

Figure 2 Diagram Representing the Flow of Material Resources and The Management of Waste

3.2.1 This CIA covers the requirements for construction related material resources and their transportation. It does not include the material resources required to produce the construction products used. It has been possible to quantify the use of typical key material resources required for the Scheme in absolute terms, for example, volumes of concrete and steel.

3.2.2 For the purposes of this CIA, the embodied carbon emissions of material resources are the total carbon dioxide equivalent emissions released prior to it leaving the suppliers' site of where each individual material resource would be sourced from. 'Carbon' is used as shorthand to refer to the basket of six GHGs recognised by the Kyoto Protocol (Ref. 13). GHGs are converted to CO_2e based on their global warming potential per unit as compared to one unit of CO_2. It does not include the CO_2

emissions associated with transport from the factory gate to site, construction activities, maintenance or decommissioning. The boundary condition used for this CIA is known as 'cradle-to-gate'.

3.2.3 Material resources required for the Scheme largely consist of binder. Although the reuse of material resources within the Scheme would be maximised, additional materials such as concrete, aggregates and other raw materials would still be needed for the construction works.

3.2.4 Several Bills of Quantities (BoQs) have been produced for the scheme, which itemises all expected works to allow for the scheme to define the quality and quantity of works required to be carried out by the main contractor to complete the scheme. Using the BoQs, an estimate of material resources could be derived and have been used to calculate embodied carbon (presented in Table 4). Key material resources have been categorised according to the types and subtypes specified in the ICE Database. Where in-depth information was not available, assumptions were made regarding the materials in order to obtain a carbon emission factor. Table 4 Estimated material resources quantities and the associated embodied carbon values.

Table 4 Estimated Material Resources Quantities And The Associated Embodied Carbon Values

Material Type	Estimated quantities (tonnes)	Carbon emission factor (tonnes CO_2e/ tonne)	Estimated carbon emissions (tonnes CO_2e)
Aggregates	855.53	0.007470	6.39
Asphalt	2,376.22	0.058364	138.69
Binder	2,647.72	0.553899	1,466.57
Concrete	2,163.79	0.064783	140.18
Fill Material	3.21	0.004384	0.01
Liquids	10.97	0.200194	2.20
Plant Material	35.24	0.492826	17.37
Plastic	110.93	3.230000	358.29
Soil Material	266.32	0.492826	131.25
Steel	0.95	3.020000	2.86
Stone	619.61	0.079000	48.95
Timber	1.92	0.492826	0.95
Vitrified Clay	1.43	0.550000	0.79
Total	**9,093.83**		**2,314.48**

3.3 Logistics

Material Resources

3.3.1 The requirements for the transport of material resources to the site have been estimated (by material type) in order to calculate the estimated carbon emissions associated with the transport of each material. It is intended that the required key material resources for the construction of the Scheme would be imported by road. At the current stage of the scheme the source of all material resources is not known as no supply agreements are in place. It has therefore been assumed that where feasible, materials would be sourced from relatively local suppliers within a maximum distance of 50 km per trip (one way) of the Application Site. The total transport carbon emissions per tonne/km for each key material resource for transport by road have been input into the CIA, following the Defra Guidance (Ref. 14).

3.3.2 For the purpose of this report, it has been assumed that material resources will be transported by road, with materials transported by 44 tonnes Heavy Goods Vehicles (HGVs) with a 10% void allowance for the purpose of this assessment. Table 5 shows key material resources quantities and associated carbon emissions associated to the transportation by road for the construction of the scheme.

Table 5 Estimated Carbon Emissions From Transport Of Material Resources

Material Resource	Estimated Quantities (tonnes)	Distance (km)	Number of trips (one way)	Carbon Emission Factor		Estimated Carbon Emissions (tonnes CO_2e)
				100% Load level kg CO_2e / tkm	0% Load level kg CO_2e / vkm	
Aggregates	855.53	50	34	0.07723	0.64923	1.23
Asphalt	2,376.22	50	95	0.07723	0.64923	3.45
Binders	2,647.72	50	106	0.07723	0.64923	3.85
Concrete	2,163.79	50	86	0.07723	0.64923	3.12
Fill Material	3.21	50	1	0.07723	0.64923	0.04
Liquids	10.97	50	1	0.07723	0.64923	0.04
Plant Material	35.24	50	2	0.07723	0.64923	0.07
Plastic	110.93	50	5	0.07723	0.64923	0.18
Soil Material	266.32	50	11	0.07723	0.64923	0.40
Steel	0.95	50	1	0.07723	0.64923	0.04
Stone	619.61	50	25	0.07723	0.64923	0.91
Timber	1.92	50	1	0.07723	0.64923	0.04
Vitrified Clay	1.43	50	1	0.07723	0.64923	0.04
Total	**5,501.98**		**369**			**13.40**

3.3.3 The total estimated carbon emissions have been calculated using BEIS emission factors (Ref. 15). The estimated carbon emissions from the transport of material resources are approximately 13.40 tCO_2e.

Waste

3.3.4 Waste quantities arising from site clearance (excavation and demolition works) have been included in the assessment; however at this stage, no Waste Contractor has yet been appointed – therefore waste quantities from construction have been calculated by using Waste & Resources Action Programme (WRAP) wastage rates (Ref. 16) in order to estimate GHG emissions from the transport of waste.

3.3.5 Table 6 and Table 7 shows estimated waste arising from the scheme's site clearance and construction activities presented by material stream respectively. For the purposes of this assessment, the collective term of site clearance has been used to represent waste arising from demolition, excavation, site clearance and pavement milling.

3.3.6 The scheme has committed that where possible items will be carefully set aside for re-used off-site, therefore some waste have been omitted from the scope of waste movements.

Table 6 Estimated Waste Arising From Site Clearance Activities

Waste Type	Estimated Waste Volume (m^3)	Estimated Waste Quantity (tonnes)
Bituminous mixtures (non-hazardous e.g. asphalt) (17 03 02)	158.53	0.00
Concrete (17 01 01)	20,219.48	0.00
Inert (17 01 07)	49,052.31	0.00
Mixed construction and/or demolition waste (17 09 04)	0.50	0.00
Plastic (excluding packaging waste) (17 02 03)	3.70	0.00
Soil and stones (17 05 04)	12,124.98	0.00
Timber (17 02 01)	5,209.57	0.00
Total	**86,769.06**	**0.00**

Table 7 Estimated Waste Arising From Construction Activities

Waste Type	Estimated Waste Volume (m^3)	Estimated Waste Quantity (tonnes)
Binders (17 01 01)	19.11	40.95
Bituminous mixtures (non-hazardous e.g. asphalt) (17 03 02)	30.57	229.12
Concrete (17 01 01)	81.26	0.00
Inert (17 01 07)	487.16	11.04
Liquids (16 10 02)	7.92	0.00
Metals (17 04 07)	0.00	0.01
Mixed construction and/or demolition waste (17 09 04)	1.90	0.00
Plastic (excluding packaging waste) (17 02 03)	2.67	0.00
Soil and stones (17 05 04)	93.10	0.00
Tiles and Ceramics (17 01 03)	0.02	0.00
Timber (17 02 01)	0.77	0.00
Total	724.49	281.12

3.3.7 Table 8 shows the carbon emissions arising from the expected HGV movements of waste presented by waste stream, it has been assumed that all waste would leave the construction site by road as non-hazardous construction waste.

Table 8 Estimated Carbon Emissions From Transport Of Waste

Waste Stream	Estimated Quantities (Tonnes)	Destination	Distance (km)	Number of trips (one way)	Carbon Emission Factor		Estimated Carbon Emissions (tonnes CO_2e)
					100% Load level kg CO_2e / tkm	0% Load level kg CO_2e / vkm	
Bituminous mixtures (non-hazardous e.g. asphalt) (17 03 02)	158.53	Onsite Storage	0	31	0	0	0.00
Concrete (17 01 01)	20,219.48		0	803	0	0	0.00
Inert (17 01 07)	49,052.31		0	6,237	0	0	0.00
Mixed construction and/or demolition waste (17 09 04)	0.50		0	1	0	0	0.00
Plastic (excluding packaging waste) (17 02 03)	3.70		0	1	0	0	0.00
Soil and stones (17 05 04)	12,124.98		0	1,540	0	0	0.00
Timber (17 02 01)	5,209.57		0	199	0	0	0.00
Binders (17 01 01)	19.11	Waste Management Facility	50	7	0.0772	0.6492	0.25
Bituminous mixtures (non-hazardous e.g. asphalt) (17 03 02)	30.57		50	25	0.0772	0.6492	0.91
Concrete (17 01 01)	81.26		50	4	0.0772	0.6492	0.15

Waste Stream	Estimated Quantities (Tonnes)	Destination	Distance (km)	Number of trips (one way)	Carbon Emission Factor		Estimated Carbon Emissions (tonnes CO_2e)
					100% Load level kg CO_2e / tkm	0% Load level kg CO_2e / vkm	
Inert (17 01 07)	487.16	Waste Management Facility	50	63	0.0772	0.6492	2.29
Liquids (16 10 02)	7.92		50	1	0.0772	0.6492	0.04
Metals (17 04 07)	0.00		50	1	0.0772	0.6492	0.04
Mixed construction and/or demolition waste (17 09 04)	1.90		50	1	0.0772	0.6492	0.04
Plastic (excluding packaging waste) (17 02 03)	2.67		50	1	0.0772	0.6492	0.04
Soil and stones (17 05 04)	93.10		50	12	0.0772	0.6492	0.44
Tiles and Ceramics (17 01 03)	0.02		50	1	0.0772	0.6492	0.04
Timber (17 02 01)	0.77		50	1	0.0772	0.6492	0.04
Total	**87,493.55**			**8,929**			**4.25**

3.3.8 The estimated total carbon emissions from the transport of waste been calculated using BEIS (Ref. 15) emission factors are estimated to be 4.25 tCO_2e.

3.4 Staff Commuting

3.4.1 As the precise number of workers expected onsite is unknown at this stage, the industry benchmark from EA Carbon Calculator (Ref. 17) has been used, which is based on 400km/week/person travel and in a diesel car / small van. In the EA Carbon Calculator, the scheme qualifies as Large (construction cost £5 to £10 million, between 16 & 25 people permanently on site), giving total estimated emissions of 37.56 tCO_2e.

3.5 Energy

3.5.1 Onsite plant and equipment that would likely be utilised during the construction phase may include scrapers, dozers, 360° excavators, backhoe loaders, dumpers, dump trucks, rollers and compressors.

3.5.2 Floodlight and security lighting associated with temporary car parking areas for workers, secure compounds and any perimeter fencing/hoarding and lighting required for operational purposes associated with construction when working during the late afternoon in the winter period (including light from headlamps of vehicles). Concrete crushers / sorters / riddlers would be needed to crush the remaining concrete pads and sort / grade materials from demolition and excavation. Other heavy equipment may also be required during the construction of buildings including lifting plant, cranes and forklift trucks.

3.5.3 As the precise details of the nature and quantity of plant and machinery are unknown at this stage the industry benchmark for onsite energy use based on construction cost, published by Construction Industry Training Board (CITB) (Ref. 18), assumes all energy would be drawn directly from the main electricity grid.

3.5.4 The carbon emissions from the energy use have been estimated to be around 1,992 tCO_2. A carbon factor was applied to convert this to CO_2e in line with emissions of other elements. Based on the relative molecular mass of carbon dioxide relative to carbon, a conversion factor of 44/12 (approximately 3.67 tCO_2 per tCO_2e) was applied (Ref. 19); this equates to an estimated 543 tCO_2e.

3.6 Water

3.6.1 Water will also be required during construction and would have associated carbon emissions due to the indirect impact of using mains water, or the direct impact of the road transport of water. The construction compound would be located within close proximity to water utilities and potable water needs would be met through a mains water connection. Therefore, it is assumed that no water would be transported by road or abstracted.

3.6.2 As the volume of water that may be required for the Scheme is currently unknown, the industry benchmark for fresh water, published by CITB (Ref. 18) has been used to make an estimate of the GHG emissions arising from the use of water onsite. It has been estimated that approximately 98,917 m^3 of water would be utilised, which represents an equivalent of 34.03 tCO_2e.

3.7 Construction GHG Emissions Summary

3.7.1 Across the entire Scheme, the estimates shown in Table 9 indicates that the GHG emissions from the embodied carbon of construction materials would make up the largest proportion of the construction stage carbon footprint, with energy as the second largest contributor and all other elements make up a relatively small proportion of the total.

Table 9 Estimated Carbon Emissions Summary Table

Element	Estimated GHG Emissions	
	Carbon Emissions (tonnes CO_2e)	% of Total
Materials	2,314.48	79%
Materials transportation	13.40	0.5%
Waste transportation	4.25	0.14%
Workers	37.56	1.3%
Energy	542.86	18%
Water	34.03	1%
Total	**2,946.58**	**100%**

4 Operation Carbon

4.1 Introduction

4.1.1 This section of the CIA focuses on the carbon associated with road users, which will be based on the Transport Appraisal and the Ecosystem Services Assessment.

4.1.2 It is considered that not all aspects of the scheme would have significant effects on climate; based on professional judgement, the emissions of operation processes (such as maintenance) have been considered however it is unlikely produce a significant amount of carbon emissions.

4.2 Road Usage

4.2.1 Operation carbon impacts from road users has been appraised using the Department for Transport (DfT) Transport Appraisal Guidance (TAG) Units A1 and A2.

4.2.2 The appraisal based on the TAG guidance, and associated parameters are largely determined by the parameters used in the scheme's forecast traffic model as follows:

- Current Year – 2020
- Scheme Opening Year – 2023
- Design Year – 2031
- Final Forecast Year – 2038
- Horizon Year – 2082 (60 years from scheme opening year)

5 Ecosystem Services

5.1.1 To quantify the ecosystem services of trees for each area included in the Scheme, data were sourced from Arboricultural Impact Assessments for an Ecosystem Services Assessment, undertaken by Treeconomics (Version 4 - Dated: August, 2020) for the Scheme.

5.1.2 The i-Tree Design tool calculated the ecosystem services for trees removed and proposed to be planted (retained trees were not included as part of this study). The i-Tree Design tool allows for estimation of the benefits provided by individual or small groups of trees. This study considers the following ecosystem services: carbon sequestration, air pollution removal and avoided runoff; for the purpose of this CIA, only the value for carbon has been reported.

5.1.3 Distinction has also been made in this study between trees on land under Local Authority control upon completion of the scheme (Scenario 1) and these combined with those on private land (Scenario 2). For trees to be removed, there is no difference between Scenario 1 and Scenario 2. For trees to be planted, a distinction has been made between Scenario 1 and Scenario 2. The monetary and carbon values in Table 10 is as reported for both Scenario 1 and Scenario 2 for 30 years, 60 years and 100 years.

Table 10 Estimated Monetary And Carbon Values For 30 Years, 60 Years And 100 Years Of Tree Removal And Planting Under Scenario 1 And 2

Years	Trees to be removed (both Scenarios)	Trees to be planted (Scenario 1)	Trees to be planted (Scenario 2)
	$kgCO_2e$	$kgCO_2e$	$kgCO_2e$
30 Years	341,097	2,787,977	2,910,842
60 Years	733,894	6,874,654	7,163,361
100 Years	1,533,861	15,940,594	16,526,707

5.1.4 While it is within reason to account for trees as presented in Scenario 2 in the Ecosystem Services Assessment, tree planting on land not under the control of the Local Authority cannot be guaranteed; therefore Scenario 1 has been used on a worst-case basis for this assessment.

5.1.5 As with construction GHG emission reporting (in line with the WBCSD and WRI GHG Protocol guidelines), carbon emissions (from trees to be removed) and carbon storage (from trees to be planted) have been reported in carbon dioxide equivalent with the net difference presented in Table 11.

Table 11 Estimated GHG Emissions And Storage Of The Scheme

Years	Trees to be removed ($kgCO_2e$)	Trees to be planted ($kgCO_2e$)	Net Difference ($tonnesCO_2e$)
30 Years	341,097	2,787,977	-2,447
60 Years	733,894	6,874,654	-6,141
100 Years	1,533,861	15,940,594	-14,407

5.1.6 The estimated total GHG emissions across the projected years is expected to have a carbon positive effect on the climate.

5.2 Operation GHG Emission Summary

5.2.1 Overall GHG emissions during the operation of the scheme has been estimated using information available from Economic Appraisal and the Ecosystem Services Assessment. The estimated total GHG emissions across the projected years is expected to have a carbon positive effect on the climate.

6 Mitigation Measures and Enhancements

6.1 Committed Mitigation Measures

Materials and Logistics

6.1.1 The Design team has given consideration to the potential impacts that CD&E waste arisings may have on the environment and where possible minimise waste and where not possible, to have in place systems which maximise the beneficial use and recycling of materials. This will reduce the construction material resources and therefore the transport of these material resources to site and the waste off-site.

6.1.2 Key opportunities for carbon reduction have been identified by the Design Team, as presented below:

- Onsite reuse of suitable materials (e.g. stone copings)
- Prevent the disposal of WEEE products (e.g. CCTV camera);
- Relocation of street furniture (e.g. bench);
- Storage of items that could be reused in the future (e.g. steel gates); and
- Use of precast products where possible (e.g. precast concrete kerbs)

6.1.3 It is not possible to quantify the carbon emissions associated with some of these opportunities due to a lack to information at this stage of the project.

Energy Saving and Efficiency

6.1.4 Opportunities for carbon reduction from energy usage during the construction phase are feasible, the opportunity that represents the largest saving has been identified as the use of electric vehicles by the supervisors from local depot to the Sites. The adoption of electric vehicles would have additional benefits such as savings in costs (fuel and running costs) and reduction in air pollution.

6.2 Best Practice Enhancement Measures

6.2.1 There may also be scope for enhancement measures for the Scheme in additional to embedded mitigation. Measures identified in this section would provide further beneficial effects to the Scheme.

6.2.2 The Contractor would be encouraged to register with the Considerate Constructors Scheme. This is a national initiative, set up by the construction industry. Sites that register with the Scheme sign up and are monitored against a Code of Considerate Practice (CoCP), designed to encourage best practice beyond statutory requirements.

6.2.3 A Construction Environmental Management Plan (CEMP) could be used to set out the responsibilities with regards to compliance with legislation and to implement any mitigation measures. The use of a CEMP is to outline the Contractor's approach to environmental management throughout the construction phases with the primary aim of reducing any adverse impacts from construction on local sensitive receptors. The CEMP would detail management measures and form a framework for the Scheme. If utilized, the CEMP should be considered a living document with reviews being undertaken at set intervals and new information added as appropriate.

Materials and Logistics

6.2.4 Proposals for additional mitigation would follow the mitigation hierarchy of avoid, reduce, remedy and compensate for adverse effects identified. It is the duty of the Contractor ensure the Scheme is delivered to the agreed quality, budget and timeframe. Opportunities for carbon reduction could be mandated though contractual obligations with the Contractor to guarantee the implementation, and could include:

- Specify the use of recycled construction material in the structure (e.g. Asphalt paving);
- Ensure the construction programme is optimised to achieve lower carbon emission from logistics;
- Adopt compost bins to reduce the amount of material sent to landfill (for vegetation from site clearance, kitchen and canteen waste from the workers);
- Plan site layout of construction compound carefully to prevent the risk of material resources damage; and
- Source materials and dispose of waste locally where possible.

6.2.5 Other key opportunities to minimise carbon are presented below:

- Harvesting rainwater harvesting for wash down areas to reduce water demand;
- Provide recycling bins for workers during construction to encourage recycling of biodegradable canteen and kitchen waste;
- Conduct project meetings by video or teleconference where possible throughout the Scheme works to reduce the carbon emissions from commuting;
- Commitment to purchase renewable energy (e.g. from suppliers such as Bulb or Zebra); and
- Connect to mains utilities to reduce construction traffic (i.e. lorries to empty cesspit and bring clean water etc).

Energy Saving and Efficiency

6.2.6 As best practice, the Contractor could address working methods that reduce energy consumption during the construction of the Scheme and would aim to continually improve energy efficiency on the work site. Opportunities could include:

- Minimise both power consumption and the peak power required on all the works associated with the Scheme. This strategy would incorporate two methods – first, phasing of the works and demands to minimise the overall peak energy demand, and secondly a requirement to investigate and adopt methodology, equipment and operational practices throughout the site, including site office and other facilities, that would minimise power consumption and make the whole construction process more energy efficient; and
- Optimise the construction sequence and planned in 3D BIM to identify areas for LEAN implementation; the use of computer-based design software would be used over manual drafting to reduce the use of paper.

6.2.7 The measures outlined below and have been selected for savings in energy consumption and consequently carbon emissions; particular attention should therefore be paid to those measures associated with high energy consuming activities.

6.2.9 Table 12 presents potential energy saving measures based on good practice, including measures from the Considerate Constructors Scheme (Ref. 20). Furthermore, the Carbon Trust's recommendations within their Action Plan to Reduce Carbon Emissions (2010) (Ref. 21) are included.

Table 12 Potential Energy And Carbon Saving Measures During Construction

Measure	Feasibility	CO_2 Saving	Notes
Power down of equipment/plant during periods of non-utilisation	High	Medium	Where not detrimental to the running or lifecycle of plant, switch off all engines/power during periods of non-utilisation.
Appropriate servicing	High	Low	Ensure all vehicles and machinery is serviced at recommended intervals to guarantee optimum engine efficiencies and reduce waste energy.
Energy efficient plant	High	Medium	Fuel-efficient plant, machinery and vehicles used wherever possible.
Optimised vehicle utilisation	Medium	Low	Ensuring all vehicles and plant are fully loaded before starting a cycle or trip to ensure minimum run-time and efficient use of capacity.
Energy Targets	Medium	Low	SMART targets for consumption during construction, workforce will be educated regarding the information displayed. Targets to be made visible to workforce at all times.
Energy metering/monitoring	High	Low	Monitoring of all non-plant related energy consumption. Consumption profile will enable more strategic thinking towards reduced energy demands. (i.e. solar panels)
Energy efficient lighting	High	Medium	Low-energy equivalents (e.g. LED) would be employed in the site compound and for the signalling.
Appropriate generators	High	Medium	Deploy correctly sized generators for electrical provision onsite, where applicable. An accurate approach is to identify the processes and associated electrical equipment in use at each stage of the Scheme, and then apply a 'diversity' factor to each item to allow for its intermittent and partial power usage. This will give a profile of the power requirement which will have a reduced peak.
Efficient site accommodation	High	Low	Eco Cabins will be utilised, comparatively an eco-cabin would have increase wall, door, floor and roof insulation, as well as efficient lighting and heating mechanism to further reduce energy consumption. Eco Cabins would reduce energy consumption by an estimated energy saving of approximately 69% when compared with a standard site cabin.
Compounds	High	Low	The construction compounds would be optimised. Detailed site layout plan of the compound has been produced and the compounds would be close enough to construction site; this will reduce the distance travelled by materials and prevent the risk of material resources damage.

Measure	Feasibility	CO_2 Saving	Notes
Raise awareness of carbon reduction and encourage behavioural change among the wider team	High	Medium	For example, the Project Team would challenge the supply chain to reduce carbon and incorporate technologies which allows the residues / materials to be recycled, environmental campaign to minimise waste arisings onsite.
Minimising the use of diesel- or petrol-powered generators and instead using mains electricity or battery powered equipment	Low	Medium	Diesel generator will have to be used for plant and equipment, with the associated noise, emissions and cost unless electrical power is available in a timely manner. Where possible, mains electricity supply would be utilised in order to reduce fuel reliance.
Non-concussive taps and toilets	High	Low	Push action 'non concussive' taps could be used to minimise water and energy usage through wastage.
Harvesting rainwater	Medium	Low	Installing a rainwater harvesting system through guttering would reduce the need to bring water onsite, therefore saving emissions associated with the transportation.

7 Assessment Summary

7.1.1 This CIA has been developed to assess the various aspects of the Scheme, with the intention of capturing and incorporating energy and carbon emission minimising measures and to identify areas where carbon emissions could be reduced throughout the Scheme and infrastructure lifecycle.

7.2 Construction

7.2.1 Energy consumption and overall CO_2e emissions during the construction have been estimated using the ICE Database and guidance from Defra and BEIS. This CIA has also presented the carbon emissions from the transportation of the material resources and waste, from water extraction and from the energy consumption from plant and equipment, this has been collated and presented in Table 13.

Table 13 Estimated Carbon Emissions From Construction Works Summary Table

Element	Estimated GHG Emissions	
	Carbon Emissions (tonnes CO_2e)	% of Total
Materials	2,314.48	79%
Materials transportation	13.40	0%
Waste transportation	4.25	0.14%
Staff Travel	37.56	1.3%
Energy	542.86	18%
Water	34.03	1%
Total	**2,946.58**	**100%**

7.2.2 From Table 13, it is clear that the largest portion of the construction carbon emission would rise from the embodied carbon from materials. This assessment has indicated that the Scheme would result in emissions of approximately 2,946.58 tonnesCO_2e from the construction phase.

7.2.3 Overall GHG emissions during the operation of the scheme has been estimated using information available from Economic Appraisal and the Ecosystem Services Assessment. The estimated total GHG emissions across the projected years is expected to have a carbon positive effect on the climate.

7.2.4 The total GHG emissions that would be generated during construction and operation have been presented in context of the government carbon budgets in Table 14. The anticipated mobilisation and construction would commence in 2021 with the Scheme set for opening in 2023. This period falls partially within 3rd and 4th Carbon budgets (2018 – 2022 and 2023 – 2027 respectively) (Ref. 21); and the GHG emissions is estimated to account for 0.00008% and 0.00005% of the respectively.

Table 14 Estimated Carbon Emissions From The Scheme Compared Against UK Carbon Budgets

Carbon Budget	Carbon Budget Level (tonnes CO_2e)	Estimated GHG Emissions	% of Carbon Budget
3rd Carbon budget (2018 -2022)	2,544,000,000	1,964.39	0.00008
4th Carbon budget (2023 – 2027)	1,950,000,000	982.19	0.00005

7.3 Operational

7.3.1 CO_2e emissions during the operation of the scheme have been estimated using information available from the Transport Appraisal and the Ecosystem Services Assessment. The estimated total GHG emissions across the projected years is expected to have a carbon negative effect on the climate by 39,574 tonnes. A detailed breakdown can be found in the greenhouse gas workbooks . It should be noted that the design year (2038) is beyond the limit of the modelling tools (2030) and therefore the values represent a worst case as they are taking into account the increase of vehicle numbers over time but not the improvements in emissions standards over the same time.

7.4 Ecosystems Services

7.4.1 The i-Tree Design tool was used to calculate the ecosystem services for trees removed and proposed to be planted (retained trees were not included as part of this study). The i-Tree Design tool allows for estimation of the benefits provided by individual or small groups of trees.

7.4.2 Over the 60 year period, Ecosystems Services are forecasted to have a carbon positive (benefit) effect on the climate by 6,141 tonnes.

7.5 Carbon Summary Table

Carbon Impact Source	Tonnes CO_2e
Construction	2,947
Operational	39,574
Ecosystem Services	-6,141
Net Carbon Emissions	***36,380***

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Ref. 2	The Climate Change Act 2008
Ref. 3	Kirklees Local Plan; Strategy and Policies, 2019
Ref. 4	The Green Construction Board PAS 2080:2016 Carbon Management in Infrastructure 2016 Available at: http://shop.bsigroup.com/upload/shop/download/pas/pas2050.pdf
Ref. 5	Clean Growth Strategy 2017 (Amended 2018)
Ref. 6	The UK Climate Change Risk Assessment (CCRA) 2017
Ref. 7	The National Adaptation Programme (NAP) and the Third Strategy for Climate Adaptation Reporting: Making the country Resilient to a changing Climate, 2018
Ref. 8	The Carbon Plan: Delivering our Low Carbon Future 2011
Ref. 9	Kirklees Climate Emergency Declaration and the Kirklees Air Quality Strategy and Five-Year Air Quality Action Plan, 2019
Ref. 10	Bath Inventory of Carbon and Energy Database (v3.0) https://circularecology.com/embodied-carbon-footprint-database.html
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Ref. 20	Considerate Constructors Scheme, 2016. Site Registration Monitors' Checklist
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