A57 Link Roads
TR010034
6.3 Environmental Statement
Chapter 14 Climate

APFP Regulation 5(2)(a)

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure)

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The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

A57 Link Roads Scheme

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6.3 ENVIRONMENTAL STATEMENT
CHAPTER 14 CLIMATE

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14.1 Introduction

14.1.1 This chapter has been divided into two sub-sections in order to address the climate change requirements outlined in The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (SI No. 572) (hereafter referred to as the 'EIA Regulations'), which state that the assessment should consider both:

- The potential effects of the Scheme on climate, in particular the magnitude of greenhouse gases (GHGs) emissions emitted during both construction and operation
- The vulnerability of the Scheme to climate change, in particular the impacts of extreme weather (caused by climate change) during operation and construction and adaptation to mitigate the effects of these impacts.

Effects of the Scheme on Climate Change

14.1.2 The scope of the effects on climate sections of this chapter details an assessment of the Scheme's effects on climate during construction and operation. It identifies the study area, describes the methodology, presents baseline conditions, identifies potential impacts on climate and presents suggested mitigation measures during construction and operation. The approach taken aligns with the guidance set out in Design Manual for Roads and Bridges (DMRB) LA 114[1] and DMRB LA 105 Air quality[2].

14.1.3 The Scheme has the potential to affect the earth's climate by increasing the emission of greenhouse gases (GHGs) into the atmosphere, which will occur during construction and throughout its operational life. The earth absorbs energy from the sun and re-emits it as thermal infrared radiation. GHGs in the atmosphere absorb this radiation, preventing it from escaping into space. The higher the concentration of GHGs, the more heat energy is retained, and the higher global temperatures become. Due to human activities the concentration of GHGs in the atmosphere has increased dramatically, leading to global warming. This leads to myriad indirect impacts as the climate responds to the increased atmospheric temperature.

14.1.4 The UK has made commitments to tackle the root cause of climate change by reducing GHG emissions, as well as to increase the resilience of development and infrastructure to the changing climate. The Climate Change Act 2008 (as amended in 2019)[3] sets a target to reduce net GHG emissions by at least 100% from 1990 levels by the year 2050.

14.1.5 The effective assessment and management of impacts on climate offers the opportunity to reduce the impact of projects on climate by minimising the magnitude of GHG emissions as far as possible.

[redacted]

14.1.6 This chapter addresses regulation 5(2)(c) and paragraph 5(f) of Schedule 4 of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (SI 2017/572) (herein referred to as the 'EIA Regulations 2017'), which state that the assessment should consider the potential effects of the Scheme on climate, in particular the magnitude of GHGs emitted during both construction and operation.

Vulnerability of the Scheme to Climate Change

14.1.7 The scope of the climate vulnerability assessment sections of this chapter provides an assessment of the exposure and resilience of the Scheme to the effects of climate change during construction and operation and has overlaps with aspects of other chapters in this report, in particular:

- Air Quality chapter (Chapter 5)
- Landscape and visual effects chapter (Chapter 7)
- Geology and soils chapter (Chapter 9)
- Road drainage and water environment chapter (Chapter 13)
- Appendix 4.3 – Assessment of vulnerability to major accidents and disasters.

14.2 Legislative and Policy Framework

Effects of the Scheme on Climate Change

Human activities contribute to the emission of GHGs such as carbon dioxide (CO_2) to the atmosphere, primarily by the combustion of fossil fuels. Greenhouse gases trap heat in the atmosphere, with higher concentrations leading to increased global temperatures. Atmospheric CO_2 concentrations now exceed 400 parts per million for the first time in around 3 million years, and increased emissions have led to global average surface temperatures of 1°C higher than pre-industrial levels. There is a global consensus that emissions must be reduced dramatically. Relevant international, national and local policies are cited below in Table 14.1. The UK's carbon reduction targets and Carbon Budgets are presented in Table 14.2.

Table 14.1: Legislation, regulatory and policy framework for effects on climate

Scale	Legislation/regulation/policy	Summary of requirements
International	Kyoto Protocol (1997)	The first international agreement to mandate greenhouse gas emission reductions. Under the United Nations Framework Convention on Climate Change (UNFCCC) treaty, industrialised nations pledged to cut their annual emissions by 5% on a 1990 baseline by 2012. Although the target was met successfully, it was insufficient to offset the increase in emissions from industrialising countries. Total global emissions continued to grow over the period, by 40% between 1990 and 2009.

		Strengthened negotiations at COP 21 led to the 2015 Paris Agreement, the aim of which is to maintain the increase in global average temperature at 'well below' 2°C and 'pursue efforts' to limit the temperature increase even further to 1.5°C . By April 2016, 190 parties, including the UK, had made voluntary pledges to reduce emissions[4], however the cumulative effect of these would still lead to an estimated 3°C of warming or greater. In 2018, the International Panel on Climate Change (IPCC) published a special report in response to the Paris Agreement, to present the impacts of the targeted 1.5°C temperature rise. The report highlighted that to achieve this, global emissions must decrease by 45% by 2030 (against a 1990 baseline), and that net zero global emissions (where emissions and removals from the atmosphere are balanced) must be achieved by 2050. This is noted to require rapid and far-reaching transitions for every sector on an unprecedented scale.
National	Climate Change Act (2008) as amended in 2019[5]	To support international efforts, the UK Climate Change Act (2008) sets a legal reduction target of 80% against 1990 levels by 2050. It also introduced a series of carbon 'budgets' for five-year periods, to act as stepping-stones to the overall reduction. There are budgets currently set up to 2032. In response to the ambitions of the Paris Agreement, in June 2019 the Climate Change Act was amended to set the overall reduction target by 2050 to at least a 100% reduction in net emissions against 1990 levels, i.e. 'net zero carbon'. The UK has so far outperformed its budgets, but progress is slowing, and the country is not on track to meet its future budgets or the overall reduction target, according to the most Recent Progress to Parliament by the Committee on Climate Change[6] .
	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017[7]	The Regulations require: "A description of the likely significant effects of the project on climate (for example the nature and magnitude of GHG emissions)."
	National Planning Policy Framework (NPPF) 2019[8]	Paragraph 148 outlines its support for transitioning to a low carbon future, by way

[redacted]

		of reducing greenhouse gas emissions and supporting renewable and low carbon energy and associated infrastructure. Building on the NPPF, planning practice guidance published in June 2014 advises on how to identify suitable measures in the planning process to mitigate for and adapt to climate change.
	National Policy Statement for National Networks (NPS NN)[9]	The NPS NN paragraph 5.17 states that 'it is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet the targets of its carbon reduction target plan.' However, the paragraph goes on to say that applicants should provide evidence of the carbon impact of the project and an assessment against the Government's Carbon Budgets. Paragraph 5.18 states that development consent should be refused if it would have a material impact on the Government reaching its reduction targets. Paragraph 5.19 outlines the need for appropriate mitigation measures to be implemented in both design and construction. The effectiveness of such mitigation will be considered by the Secretary of State in order to ensure the carbon footprint is not 'unnecessarily high', with the adequacy of the measures constituting a material factor in the decision-making process.
	Department for Transport: Decarbonising Transport – setting the challenge (2020)[10]	The document presents transport modes and their current GHG emissions, the existing strategies and the policies already in place to deliver against current targets. It covers the projected trajectory of the forecast GHG emissions from transport to Carbon Budget 5 (2028-2032) and beyond based on the firm and funded commitments outlined. The document describes the challenge in meeting Carbon Budgets and net zero by 2050 and split the challenge into six strategic priorities. The document sets out the work approach through which interested parties and communities around the UK will collaborate to take urgent action on climate change, as well as delivering the substantial co-benefits of decarbonisation.
	Road Investment Strategy (RIS) and Strategic Business Plan 2015[11]	The Government's RIS will see £15.2 billion invested in over 100 road schemes between 2015 and 2021 (Department for Transport, 2014b). Of this total, some £300

[redacted]

[10] Decarbonising Transport: Setting the Challenge[redacted]

[redacted]

		million has been allocated to address issues including flooding, carbon emissions, landscape and biodiversity.
	Road Investment Strategy (RIS): for the 2015/16 – 2019/20 Period	The Road Investment Strategy (2015), as amended in 2016, published by the Department for Transport, sets out the strategy for the transformation of the strategic road network (SRN) by 2040 to create a modern SRN that supports a modern Britain. The Strategy also specifies objectives to significantly reduce emissions across the SRN, including emissions reductions from SRN construction activities.
	Road Investment Strategy (RIS2): for the 2020 – 2025 Period[12]	RIS2 includes a vision to contribute to the Government's wider climate change strategy. It notes that the Government has adopted one of the most ambitious plans in the world to decarbonise road transport, committing to end the sale of new conventional petrol and diesel cars and vans by 2040, and taking steps to decarbonise freight. Provision is also being made to encourage alternative forms of transport, such as cycling and bus use. Through RIS 2, the SRN will be modernised to support the Government's ambitions.
	Highways England: Sustainable Development Strategy (2017) and Environment Strategy (2017)	The Sustainable Development Strategy (2017) and Environment Strategy (2017), together, set out National Highways' vision for delivering a sustainable development approach that ensures their work supports society and the wider national interest, as well as supporting to minimise environmental impact and pushing to achieve an improved environment. The environment strategy's vision relates to a strategic road network working more harmoniously with its surroundings to deliver an improved environment. The sustainable development strategy defines sustainable development (SD) in National Highways' licence to operate. The strategy focuses on five 'capitals' associated with SD – financial, human, natural, social and manufactured. The natural capital focuses to carbon management and its vision outlines the UK's legally-binding commitment to achieve an 80 percent reduction in its greenhouse gas emission by 2050 and identifies that the infrastructure sector has a key role to play in contributing to the national

[redacted]

		reduction. The strategy aims to reduce carbon emissions and footprints.
	Highways England: Sustainable Development and Environment Action Plan Roads Period 1 (December 2018)	This action plan is based on HE's SD and Environment strategy documents. It describes key actions that will enable HE to make a significant change in its effectiveness in delivering sustainable development and doing the right thing for the environment.
	Highways England: Strategic business plan 2020-2025 (2020)	The Strategic business plan 2020-2025 sets out HE's response to government's second Road Investment Strategy (RIS2). It presents the careful balancing between maintaining and operating the strategic road network (SRN) safely and providing new capacity where it is needed. It supports government's ambition to achieve net zero UK carbon emissions by 2050. It notes that HE has a shared responsibility to tackle climate change and is dedicated to minimising the greenhouse gases generated from the activities within HE's control including designing the schemes and services to be carbon and energy efficient, reducing carbon footprint through initiatives such as introducing energy-saving measures for maintenance depots and using low-energy lighting and control systems for motorways.
	Construction 2025 (July 2013) HM Government[13]	Construction 2025 (2013) sets out how efficiency improvements will be created in construction covering sustainability and carbon and including a target to reduce emissions by 50%. The emissions reduction target of 50% is not scheme specific, and the efficiency improvements are broad. In terms of the Scheme and emissions reduction, the reduction target should be taken into account when developing Scheme specific mitigation measures, where relevant.
	Infrastructure Carbon Review (2013) HM Treasury[14]	The Infrastructure Carbon Review sets out carbon reduction action required by infrastructure organisations that have formally endorsed the review; this includes National Highways. The Review shows that the infrastructure industry controls 16% of the UK's total carbon emissions, covering construction (A1-5), and operation and maintenance of assets (B1-8). It also highlights that a further 37% of carbon emissions are related to the use of infrastructure assets (B9), over which the industry can have some influence.

[13] [redacted]

Local	5 Year Environment Management Plan for Greater Manchester (2019-2024)[15]	The plan identifies "the threat of climate change – reducing carbon dioxide (CO_2) emissions" as the most significant of environmental challenges. It highlights the need to make fair contribution to global commitments aimed at limiting global temperature rise. The vision statement includes neutral, climate resilient city region with a thriving natural environment and circular, zero-waste economy requirements with the aim for 'mitigating climate change: For our city region to be carbon neutral by 2038 and meet Carbon Budgets that comply with international commitments'. The plan contains priorities around increasing the use of public transport and active travel modes and phasing out fossil-fuelled private vehicles.
	High Peak Local Plan Adopted (April 2016)[16]	The Local Plan identifies 'Addressing the Challenges of Climate Change' as one of the key issues for the council. The Section 4 of the Plan outlines the commitments towards Sustainable Development Principles. The Borough Council will expect that all new development makes a positive contribution towards the sustainability of communities and to protecting, and where possible enhancing, the environment; and mitigating the process of climate change, within the Plan Area. Section 5 of the Plan includes the Climate Change Policy and outlines that the Council will adopt strategies to mitigate and adapt to climate change. In addressing the move to a low carbon future for High Peak, the Council will plan for new development in locations and ways that reduce greenhouse gas emissions and adopt the principles set out in the energy hierarchy.
	High Peak Borough Council's Corporate Plan 2019-2023 [17]	The Corporate Plan sets out the Council's vision - 'Working together to protect and invest in the High Peak with the Council on your side'. It outlines Protecting and improving the environment including responding to the climate emergency as one of the key themes. The key priorities of the plan include reduced carbon emission, reduced levels of environmental crime and a deliverable climate emergency plan.
	Climate Change and Low Emission Strategies' Whole Place	The plan sets out priorities to 2020 and beyond. It includes actions to both address climate change and improve Greater Manchester's air quality.

[redacted]

	Implementation Plan for Greater Manchester (2016-2020)[18]	The objectives extend beyond achieving a challenging 48% carbon reduction target (by 2020) to preparing the city region to adapt to unavoidable climate change, promoting carbon literacy and transitioning Greater Manchester (GM) into a low carbon and low emissions economy with clean air and sustainable lifestyles.
	Derbyshire Environment and Climate Change Framework (2019)[19]	The Environment and Climate Change Framework seeks to reduce greenhouse gas emissions to levels which are consistent with the allocated Carbon Budgets for Derbyshire and to reduce carbon emissions to net zero by 2050. The Framework contains Carbon Budgets and suggested trajectories, outlining an approach to tackle climate change and improve the environment, which can be adopted by all partners across the county. Section 6 sets out the key strategies which partners will develop and implement to achieve collective ambitions to tackle climate change and contribute to an overall reduction in greenhouse gas emissions across Derbyshire as a whole.
	Derbyshire Local Transport Plan 2011-2026 (2011)[20]	The vision of the Derbyshire Local Transport Plan is to achieve a transport system that is both fair and efficient, promotes healthier lifestyles, safer communities, safeguards and enhances the natural environment and provides better access to jobs and services. Tackling climate change and improving quality of life and promoting a healthy natural environment are included into transport goals. The plan identifies the need of a preferred strategy to achieve longer term benefits for climate change.

Table 14.2: UK carbon reduction targets

UK Carbon budget period	UK Carbon budget level
First Carbon Budget (2008 to 2012)	~~3,108~~3,018 -$MtCO_2e$
Second Carbon Budget (2013 to 2017)	2,782 $MtCO_2e$
Third Carbon Budget (2018 to 2022)	2,544 $MtCO_2e$
Fourth Carbon Budget (2023 to 2027)	1,950 $MtCO_2e$

[redacted]

UK Carbon budget period	UK Carbon budget level
Fifth Carbon Budget (2028 to 2032)	1,725 $MtCO_2e$
Sixth Carbon Budget (2033 to 2037)	965 $MtCO_2e$

Table Source: UK Government Carbon Reduction Targets 2008 (Committee on Climate Change, 2017)

14.2.1 The Committee on Climate Change (CCC) has provided a recommended Sixth Carbon Budget[21], which will run from 2033 to 2037, building on its previous Net Zero advice. The recommended budget looks to set a steeper reduction curve moving forward than was set by the previous budgets, to reflect the 2050 target having been increased from an 80% to a 100% reduction. To facilitate this, the CCC recommends the budget be set at 965 $MtCO_2e$. The Government has agreed in April 2021 with the Climate Change Committee's recommendation on setting the budget at 965 MtCO2e for the period 2033 to 2037. The Sixth Carbon Budget has been committed to by government and is expected to become law by June 2021[22].

Vulnerability of the Scheme to Climate Change

14.2.2 The legislation and policy framework for the Scheme's vulnerability to climate changes is set out in Table 14-3.

Table 14.3: Legislation, regulatory and policy framework

Scale	Policy Document	Key Implication for the Scheme
National	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017[23]	The Regulations require: "A description of the likely significant effects of the project on climate…. Including the vulnerability of the project to climate change." [24]
	National Policy Statement for National Networks (NPS NN, 2014)	The NPS NN includes a section on climate change adaptation from 4.36 to 4.47. Paragraph 4.40 states that new national networks infrastructure should typically be long-term investments which should remain operational over "many decades in the face of a changing climate". Therefore, applications should "consider the impacts of climate change when planning location, design, build and operation". Paragraph 5.19 outlines the need for appropriate mitigation measures to be implemented in both design and construction. The effectiveness of such mitigation will be considered by the Secretary of State in order to ensure the carbon footprint is not 'unnecessarily high', with the

[redacted]

Scale	Policy Document	Key Implication for the Scheme
		adequacy of the measures constituting a material factor in the decision-making process.
	National Planning Policy Framework (NPPF, 2019) [25]	The NPPF develops a planning system that contributes to radical reductions in greenhouse gas emissions, minimises vulnerability and improves resilience; encourages the reuse of existing resources, including the conversion of existing buildings; and supports renewable and low carbon energy and associated infrastructure. The NPPF states that "New development should be planned for in ways that avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure[26]. Paragraph 149 states that policies should "support appropriate measures to ensure the future resilience of communities and infrastructure to climate change impacts". Building on the NPPF, planning practice guidance published in June 2014, advises on how to identify suitable measures in the planning process to mitigate for and adapt to climate change.
	Climate Change Act 2008[27]	The UK passed legislation that introduced the world's first long term legally binding framework to tackle the risks posed by climate change. The Climate Change Act (2008) created a new approach to managing and responding to climate change in the UK, by: • Setting ambitious, legally binding reduction targets • Taking powers to help meet those targets • Strengthening the institutional framework • Enhancing the UK's ability to adapt to the impacts of climate change • Establishing clear and regular accountability to the UK Parliament and to the developed legislatures. Key provisions of the Act in respect of climate change adaptation include a requirement for Government to report, at least every five years, on the risks to the UK of climate change, and to publish a programme setting out how these will be addressed. This Act also introduces powers for Government to require public bodies and statutory undertakers to carry out their own risk assessment and make plans to address those risks. The Adaptation Sub-Committee of the Committee on Climate Change will provide advice to, and scrutiny of, the Government's adaptation work.
	The Highways Agency Climate	The Climate Change Act (2008) led to modifications in existing standards on the national network. The Highways Agency has committed to assessing the potential risks that

[25] National Planning Policy Framework, 2019,

National Planning Policy Framework, 2019, Planning for climate change, 150 (a)
[27] Climate Change Act 2008

Scale	Policy Document	Key Implication for the Scheme
	Change Adaptation Strategy and Framework (2009) [28]	climatic changes pose to the ongoing management, maintenance, improvement, and operation of the strategic road network. This document sets out how the UK's road network may be vulnerable to climate change and how these vulnerabilities will be factored into the delivery of their business, along with the development of appropriate management and mitigation solutions to remove or reduce the vulnerabilities.
	Highways England Sustainable Development Strategy and Action Plan (2017) [29]	National Highways recognise that changes in climate may result in more frequent and severe weather events. This document sets out their commitment to ensure resilience to climate change is embedded in the activities of their business to reduce whole life costs and increase safety. To do this their ambition is to invest for the long-term – "our road network contains components that have a very long design life, such as bridges and tunnels; they will require timely and cost effective investments to reduce the risk of increased future costs, whilst improving resilience to climate change."
Regional / local	Peak District National Park Authority – Climate change and the peak district[30]	The authority recognises that: • "Increasing temperatures and severe weather events induced by climate change will directly and indirectly result in habitat alterations and increase the vulnerability of animal and plant species." • Climate change may reduce the ability of Peak District National Park habitats to store carbon through the loss of important carbon sinks such as peat, soils and plants. Climate change may reduce the area and sustainability of peat-forming blanket bog systems within the UK and research shows that the Peak District National Park is the third most vulnerable region for this in Great Britain. • Protected areas like the Peak District National Park where wildlife can thrive are vital to sustaining resilient habitats, particularly as they may then repopulate other areas in the future.
	Derbyshire County Council Environment and Climate Change Framework, 2019[31]	The framework sets out: • A county wide energy strategy that will reduce carbon emissions. The report acknowledges that this will increase the resilience of cities and their communities to future changes in energy prices and energy systems, as well as potentially increasing resilience of communities and infrastructure to the impacts of climate change • A local transport plan that improves resilience to climate change impacts

[28] The Highways Agency Climate Change Adaptation Strategy and Framework, 2009, [redacted]

[29] Sustainable development strategy, 2017, [redacted]

Scale	Policy Document	Key Implication for the Scheme
		• A natural capital strategy that assist in making the county more resilient to flooding; ensuring in the future there is depth in the type and number of insects to pollinate our crops and contributing to clean watercourses that support biodiversity: among a wide range of other benefits.
	High Peak Borough Council Corporate Plan, 2019-2023[32]	The council's approved Corporate Plan pledges to work towards a carbon neutral High Peak by 2030 which is in line with their declared climate emergency status. The council is also developing a Develop a Climate Change Strategy and an Action Plan of response to the declared climate emergency.
	Tameside Metropolitan Borough Council - Local Development Framework – Core Strategy	This report identified the importance of: • Support sectors that are vulnerable to climate change as well as developing opportunity sectors • Adapting urban areas to the challenges and opportunities of climate change.

[redacted]

14.3 Assessment methodology

Effects of the Scheme on Climate Change

14.3.1 DMRB LA 114 Effects of the Scheme on Climate Change advises on the level of assessment which should be carried out, based on the expected level of data availability at the project stage.

14.3.2 Based on the available design details related to key items like waste, materials, water and energy, quantitative assessment has been undertaken, which quantifies emissions from these elements to identify the potential for significant effects.

14.3.3 The life cycle stages and GHG sources presented in Table 14.4 are included within the assessment, with reference to the type of assessment which has been carried out.

Table 14.4: Sources and lifecycle stages for project GHG emissions

Main stage of project life cycle	Sub-stage of life cycle	Potential sources of GHG emissions (not exhaustive)	Details of sources scoped in
Construction stage	Product stage; including raw material supply, transport and manufacture.	Embodied GHG emissions associated with the required raw materials.	Materials quantities
	Construction process stage: including transport to/from works site and construction /installation processes.	Activities for organisations conducting construction work	Fuel/electricity consumption. Construction activity type/duration. Transportation of materials from point of purchase to site, mode/distance.
Operation stage (in line with appraisal period)	Use of the infrastructure by the end-user (road user).	Vehicles using highways infrastructure.	Traffic count/speed by vehicle type for highway links.
	Operation and maintenance (including repair, replacement and refurbishment).	Energy consumption for infrastructure operation and activities of organisations conducting routine maintenance.	Fuel/electricity consumption for vehicles, lighting and plant. Waste and arisings quantities, transport mode/distance and disposal fate.
Opportunities for GHG reduction throughout project life cycle (construction, operation and decommissioning)	GHG emissions potential of recovery including reuse and recycling GHG emissions potential of benefits and loads of additional functions associated with the study system.	Avoided GHG emissions through substitution of virgin raw materials with those from recovered sources.	Waste and arisings material quantities and recycling/reuse fate.

Table Source: adapted from DMRB LA 114

14.3.4 DMRB LA 114 also includes reference to GHG emissions and removals associated with short- and long-term land use change. However, it states that 'a proportionate approach shall be applied to calculating and reporting GHG emissions from changes in land use and forestry (i.e. reporting only where there is likely to be a substantial change)'. It is not considered that the Scheme will lead to a substantial change in GHG emissions and removals associated with land use (compared with overall Scheme emissions), and this has therefore been excluded from the assessment.

14.3.5 It is key to note that whilst effects on climate is a wide-ranging topic in terms of potential sources, it differs from many topics assessed in this Environmental Statement in that there is a single receptor, the atmosphere, on which the Scheme could have a direct impact. All units of carbon dioxide equivalent (CO_2e) can be considered to have the same impact regardless of their emission source or location.

14.3.6 Therefore, assessment of the effects of the Scheme on climate is limited to quantification of the magnitude of emissions, from individual sources and in total, and comparison of these to the baseline. Different GHGs have different global warming potentials (GWPs), and to account for this they have been reported throughout this assessment as their CO_2 equivalent (CO_2e) value using their GWPs[33].

14.3.7 Emissions calculations are carried out by multiplying activity data by an emission factor associated with the activity being measured. Activity data is a quantitative measure of an activity that results in emissions during a given period of time, (e.g. kilometres driven, kWh electricity consumed, tonnes waste sent to landfill). An emission factor is a measure of the mass of emissions relative to a unit of activity.

14.3.8 Scheme emissions have been quantified by calculation, using project data from the emerging design and relevant carbon conversion factors.

Quantifying construction emissions

14.3.9 For the construction stage of the Scheme, calculations have been undertaken using National Highways' Carbon Tool[34] (herein after referred to as 'The Carbon Tool'). The Carbon Tool is spreadsheet-based, and provides space to input material and non-material construction information under the following categories:

- Bulk materials
- Earthworks
- Fencing, barriers and road restraint systems
- Drainage
- Road pavements
- Street furniture
- Civil structures and retaining walls

[redacted]

- Fuel, electricity and water use
- Business and employee transport
- Waste.

14.3.10 The Carbon Tool then uses a range of pre-programmed materials data (e.g. mass) and carbon factors to calculate an itemised and overall emissions total. Materials emissions factors are sourced from the Bath Inventory of Carbon and Energy (ICE) database v2 and v3. These factors are in t~~CO2e~~CO_2e/t. All energy and waste factors are taken from Defra 2014 or the Waste Resources Action Programme WRAP. Where an input unit is not required as a mass, such as a number (no.) of products or metres of product, a conversion factor is applied. This is based upon the mass of a product calculated using suppliers' specifications and technical drawings.

14.3.11 When a product contains multiple materials a weighted average carbon factor has been calculated using multiple factors from the ICE inventory. ICE carbon factors used within the Carbon Tool include the embodied carbon within the raw materials but do not account for the carbon associated with the manufacture or processing of the raw materials into a product prior to their purchase by the reporting contractor[35].

14.3.12 The design and construction information for the assessment was obtained from the appointed Principal Designer and Principal Contractor (that is delivering the Scheme on behalf of the Applicant) through Principal Quantities and specific data request spreadsheet prepared based on the requirements of the Carbon Tool. Further detail of data sources, collection methodology, assumptions and calculation input data are described in section 14.5-14.6.

Quantifying operational emissions

14.3.13 Operational emissions are calculated separately from the Carbon Tool, which is focused specifically on construction-phase emissions. Road user carbon emissions have been modelled ~~in~~ using modelling methodologies referenced within DMRB LA 105, which specify the calculation of carbon dioxide (CO_2) from expected traffic usage, along with other pollutant gases that will be emitted. Emissions have been calculated using the National Highways speed band emission rates which use the Defra Emissions Factors Toolkit (v10)[36]. These emission rates were the latest available at the time of the emissions modelling was undertaken and includes assumptions about future fleet mixes. Calculations use traffic data from the Scheme specific traffic model and consider the full road network included in the traffic model over the appraisal period.

14.3.14 There is no project-specific data available for operational energy use, or maintenance and refurbishment during the Scheme's operational life, so emissions cannot be calculated using the above methodology. Instead they have been estimated using published data from other highways schemes of a similar scale to this Scheme, based on the assumption that emissions from the operation and maintenance of similar highways is broadly consistent across the

[35] Emissions Factors tab of the Carbon Tool

[36] Defra Emissions Factors Toolkit (v10.1) released 19 August 2020 and the associated Highways England speed band emission rates which account for the August 2020 DEFRA Emissions Factors Toolkit update.

UK road network. Published data from three other highway schemes[37] (M4CaN new relief road, A14 improvement scheme, A465 embankment works) shows that, proportionally, annual emissions from operational energy use and maintenance works equate to between 0.05% and 0.29% of in-use traffic emissions. 0.29% of road user emissions has been applied as a reasonable worst-case operation and maintenance figure, based on this limited data set.

14.3.15 Operational emissions for the Do-Something scenario are compared with emissions from the baseline Do-Minimum scenario to give a magnitude of impact, for the Opening Year, Design Year and cumulative over the 60-year operational period as defined in the appraisal.

Comparison to UK Carbon Budgets

14.3.16 The UK has in place Carbon Budgets for five-year periods up to 2032. Both the construction (2023) and Opening Year (2025) of the Scheme fall within the fourth budget period (2023 to 2027). The results of emissions calculations will therefore be presented in terms of their percentage contribution to the Fourth Carbon Budget period.

14.3.17 Recommendations for the 6th Carbon budget (for period 2033-2037) were published by the CCC in December 2020 and is due to pass into law in June 2021.

14.3.18 However, the Design Year (2040) falls beyond the sixth budget period, and there is currently no budget with which to compare emissions.

Significance assessment

14.3.19 The construction phase of the Scheme will lead to a negative effect on climate due to the generation of emissions from the extraction, processing and transport of the requisite materials, and on-site construction processes. Similarly, the operational phase of the Scheme will lead to a negative effect on climate due to the consumption of energy, water and materials on site,

14.3.20 There is no policy or technical guidance for determining a level of significance of the effect of a development on climate, and there are no legal limits for emissions from any one development. For this reason, professional judgement has been applied in determining significance, considering the Scheme's potential effects on the UK's ability to meet the emission reduction targets set out in its Carbon Budgets. As stated in DMRB LA 114: 'The assessment of projects on climate shall only report significant effects where increases in GHG emissions will have a material impact on the ability of Government to meet its carbon reduction targets.'

Scoping responses

14.3.21 An overview of the Planning Inspectorate's Scoping Opinion on the proposed scope of the Carbon assessment is provided in Appendix 4.1 (APP-152). Any additional consultation responses or changes to assessment methodology due to the latest DMRB standards or design changes are also detailed in Appendix 4.3 (APP-154). This includes the exclusion of GHG emissions and removals associated with short- and long-term land use change, which was not considered

[37] Welsh Government (2016). M4 Corridor around Newport, Environmental Statement: Volume 3, Appendix 2.4 Carbon Report

at Scoping stage as this pre-dated the requirement in DMRB LA 114. This has been scoped out in line with LA 114's statement that 'a proportionate approach shall be applied to calculating and reporting GHG emissions from changes in land use and forestry (i.e. reporting only where there is likely to be a substantial change)'.

Vulnerability of the Scheme to Climate Change

14.3.22 Where the climate change impact on project receptors is potentially significant, a risk assessment has been undertaken. The method for this assessment is set out in this section. It follows the guidance set out in DMRB LA 114[38] and is informed by best practice climate assessment approaches and literature, as well as professional judgement.

14.3.23 There are four stages to the climate vulnerability assessment method:

- Stage 1 – Identify the receptors
- Stage 2 – Assess the likelihood of impacts on each receptor
- Stage 3 – Assess the consequence of impacts for each receptor
- Stage 4 – Determine the significance of each impact based on a combination of the likelihood of an impact occurring and the consequences of that impact.

Stage 1 – Identification of receptors

14.3.24 Receptors which may be affected by climate change have been identified with consideration of the characteristics of potential future extreme weather events as well as gradual changes to the climate that could occur in the study area over the Scheme's design life. Identification of these is based on an assessment of climate projections from UKCP18 (United Kingdom Climate Projections 2018). These projections have been developed by the Met Office Hadley Centre Climate Programme which is supported by the Department of Business, Energy and Industrial Strategy (BEIS) and the Department for Environment, Food and Rural Affairs (Defra). They provide the most up-to-date assessment of how the climate of the UK may change over the 21st century.

14.3.25 In accordance with DMRB LA 114 the assessment has considered the impacts of climate change on the following receptors:

- Construction process (including workforce, plant, machinery etc.)
- The assets and their operation, maintenance and refurbishment (including pavements, structures, earthworks and drainage and technology assets such as signals and signs)
- End-users (members of the public, commercial operators, nearby residential properties, road user safety and experience).

14.3.26 Where it is not already covered in the relevant topic chapters, consequential loss or damage to environmental receptors as a result of the Scheme's vulnerability to climate change will be discussed in the cumulative effects section of the chapter.

[redacted]

Stage 2 – Assess the likelihood of impacts

14.3.27 In accordance with DMRB LA 114, the likelihood of specific changes to the climate and/or extreme weather events causing impacts are determined using available data (such as the known recurrence interval of extreme weather events) and professional judgement, based on knowledge and experience of other similar schemes. The likelihood categories and associated frequencies are provided in Table 14-5. These are determined after consideration of embedded mitigation.

Table 14-5: Likelihood categories

Likelihood category	Description (probability and frequency of occurrence)
Very high	The event occurs multiple times during the lifetime of the project (60 years) e.g. approximately annually, typically 60 events.
High	The event occurs several times during the lifetime of the project (60 years) e.g. approximately once every five years, typically 12 events.
Medium	The event occurs limited times during the lifetime of the project (60 years) e.g. approximately once every 15 years, typically 4 events.
Low	The event occurs during the lifetime of the project (60 years) e.g. once in 60 years.
Very low	The event can occur once during the lifetime of the project (60 years).

Table Notes: Project lifetime is considered to include construction and operational phases; project lifetime is taken to be 60 years in line with LA 114 and WebTAG.

Table Source: DMRB LA 114 Table 3.39a (October 2019).

Stage 3 – Assess the consequence of impacts

14.3.28 The consequence of climate change impacts on the Scheme receptors are categorised using the criteria in Table 14-6.

Table 14-6: Measure of consequence

Consequence of impact	Example description
Very large adverse	Operation – national level (or greater) disruption to strategic route(s) lasting more than 1 week.
Large adverse	Operation – national level disruption to strategic route(s) lasting more than 1 day but less than 1 week or regional level disruption to strategic route(s) lasting more than 1 week.
Moderate adverse	Operation – regional level disruption to strategic route(s) lasting more than 1 day but less than 1 week.
Minor adverse	Operation – regional level disruption to strategic route(s) lasting less than 1 day.
Negligible	Operation – disruption to an isolated section of a strategic route lasting less than 1 day.

Table Source: DMRB LA 114 Table 3.39b (Oct, 2019).

Stage 4 – Determine significance of impacts

14.3.29 The results of the likelihood and consequence assessments are combined to derive a significance classification as outlined in Table 14-7.

Table 14-7: Significance matrix

Impact consequence	Impact likelihood				
	Very low	Low	Medium	High	Very high
Very large	NS	S	S	S	S
Large	NS	NS	S	S	S
Moderate	NS	NS	S	S	S
Minor	NS	NS	NS	NS	NS
Negligible	NS	NS	NS	NS	NS

Table notes: NS = Not Significant, S = Significant

Impacts can be adverse or beneficial.

Table Source: DMRB LA 114 Table 3.41 (Oct 2019).

14.3.30 The assessment is undertaken with consideration of the Scheme design and mitigation.

14.4 Assumptions and limitations

Effects of the Scheme on Climate Change

14.4.1 The data for the assessment has been provided by the appointed Principal Designer and Principal Contractor and is up-to-date for the Preliminary Design stage. Where assumptions have been made, they have been selected to present the worst-case scenario for that particular item/factor.

14.4.2 This section presents the input data and assumptions which underpin the assessment.

Materials

14.4.3 Temporary and permanent construction materials data has been provided by the appointed Principal Designer and the Principal Contractor, based on the current Scheme design. Where the design is not finalised, assumptions on material types and quantities were made by engineering specialists based on professional judgement on similar data from other highways schemes of a similar scale to this Scheme. The materials and quantities listed in Table 14.4 were included in the assessment; this is the complete list of materials provided by the appointed Principal Designer and Principal Contractor. The carbon factors for materials integral to the Carbon Tool were used.

Table 14.8: Construction materials

Category	Material	Type	Unit	Quantity
Bulk materials	Ready mix concrete	C28/35	m^3	1,789
		General	m^3	12,620
	Fill and aggregate	General fill/aggregate	tonnes	160,992
	Asphalt	General asphalt	tonnes	48,482
	Reinforcement steel	Steel bar and rod	tonnes	1,224
Earthworks	Imported soil	Stabilised soil - Cement, Fly Ash or Ground granulated blast-furnace slag (GGBS)	tonnes	75,098
		General soil/topsoil	tonnes	33,942
Fencing, barriers & road restraint systems	Road restraint system/ safety barrier	Steel Road Restraint Systems (RRS) barrier double sided	metres	264
		Pre-cast concrete step barrier	metres	1,439
	Fence	Timber rail fence (all types, includes posts)	metres	1,446
		Steel/wire/chain fence (includes posts)	metres	10,070
Drainage	Plastic pipework (HDPE)	600 mm diameter	metres	11,500
	Precast concrete inspection chambers	1000 mm diameter, 1.2m-3m depth	no.	193
	Gullies	Precast concrete gully pots	no.	156
	Channel & slot drains	Precast concrete channel (heavy duty)	metres	1,960
	Headwalls	Brick (includes mortar)	no.	24
Road pavements	Kerb	Pre-cast concrete 125x255mm	metres	8,552
Street furniture & electrical equipment	Road lighting and columns	LED light	no.	292
		Aluminium columns 10 m	no.	138
	Marker posts/signs	Aluminium marker sign	no.	28
	Variable Message Signs (VMS)	MS4 Sign	no.	3
		AMI (advanced motorway indicator)	no.	312
Civils structures & retaining walls	Formwork / shuttering	Plywood	m^3	362
	Piling	Pre-cast concrete piles	tonnes	30,288

Transport

14.4.4 Information relating to where materials will be sourced from is not yet available, as this will be determined at a later date by the appointed Principal Designer and Principal Contractor. Based on previous experience by specialists of materials transportation for infrastructure schemes, including highway schemes, it has been assumed that all materials have been transported an approximate worst-case distance of 100 km by HGV. Locally sourced materials are often preferentially used to reduce transportation cost and to minimise transport emissions, and many materials will be sourced from a distance of less than 100 km. However, not all required material is expected to be available locally and will have to be sourced from further afield. Hence, based on professional judgment and consultation with design team to prefer locally sources material as far as possible, 100 km worst case has been considered which draws on the Royal Institution of Chartered Surveyors 'whole life carbon' transport distances of 50 km for locally manufactured materials, but accounts for some scenarios where portions of the necessary materials may have to be transported from further afield. The emission factor used for transportation is based on a heavy goods vehicle having an assumed average load. This factor is integral to the Carbon Tool.

Construction processes

14.4.5 The construction period for the main works has been approximated at 24 months (spring 2023 to spring 2025). Further details are provided in Description of the Scheme chapter, (Chapter 2).

14.4.6 Quantities of diesel used by construction plant for the duration of the construction phase have been estimated at 2,100,000 litres by the appointed Principal Contractor. Water use was estimated by the appointed Principal Contractor to be 148,000 litres for the Scheme. In a similar way, the electricity use for the construction phase has been estimated to be 1,200,000 kWh. The above-mentioned quantities have been estimated based on previous project data with similar scope of work. The carbon factors for diesel, UK grid electricity and mains water integral to the Carbon Tool were used.

14.4.7 Waste is assumed to be transported 50 km, as specific details are not available at this stage of the project. As above, 50 km is based on previous experience and knowledge of similar highway schemes. It is considered likely that waste will be dealt with within 50 km to adhere to the proximity principle. The waste transport has been assumed to be a HGV having an assumed average load based on the definition in the Carbon Tool. The disposal method of ‘recycled’ has been suggested by the appointed Principal Contractor except for mixed metal and oil and liquid fuel waste. Table 14.9 below presents the data used to calculate emissions from waste transport and processing.

Table 14.9: Construction waste

Waste	Disposal method	Quantity (tonnes)
Mixed construction and demolition waste	Recycle	500
General office waste	Recycle	80
Plastic	Recycle	24
Wood/Timber	Recycle	180
Mixed metals	Recycle	120
Paper and cardboard	Recycle	5
Oil and liquid fuel waste	Incineration	0.1

14.4.8 The Carbon Tool needs data input separately for Business travel and Employee commuting categories under Business and Employee Transport tab. The data provided by the appointed Principal Contractor business travel (30,200 km) and employee commuting (1,824,803 km) is based on the estimation taken for a 2 year construction period, with assumption of the spilt between business travel and commuting as 20:80.

14.4.9 Vehicle emission factors take account of Department for Transport fleet projections including conventional vehicles (petrol and diesel) as well as hybrid and electric vehicles. However, it should be noted that these projections do not currently account for government commitments to changes in fleet makeup, for example the phasing out of conventional fuel cars and vans by 2030. This means that the assessment is likely to lead to an overestimation in operational emissions.

Vulnerability of the Scheme to Climate Change

14.4.10 The climate vulnerability assessment will provide a broad, high-level indication of the potential impacts of climate change on the Scheme based on professional judgement.

14.4.11 The climate projections used will be from UKCP18 (United Kingdom Climate Projections 2018). The UKCP18 projections do not provide a single precise prediction of how weather and climate will change years into the future. Instead UKCP18 provides ranges that aim to capture a spread of possible climate responses. This better represents the uncertainty of climate prediction science. It should also be noted that the level of uncertainty of the projections is dependent on the climate variable, for example, there is greater confidence around changes in temperature than there is in wind. In the climate vulnerability assessment this will be considered when assessing the likelihood of impacts.

14.4.12 The climate vulnerability assessment will be based on data from Representative Concentration Pathway (RCP) 8.5. This is a greenhouse gas concentration trajectory under which it is assumed that emissions continue to rise throughout the 21st century. There is considerable uncertainty regarding if, how far and how quickly emissions will be reduced in the future. Using RCP 8.5 represents a conservative position.

14.4.13 Other key caveats and limitations of UKCP18 data are presented on the Meteorological Office website[39].

14.5 Study area

Effects of the Scheme on Climate Change

14.5.1 The study area comprises the emission of GHGs resulting from the Scheme in its construction and operation phases. The study area for construction and operational maintenance is not limited to the geographic extent of the Scheme itself, as many emissions will result from upstream, downstream, and off-site activities such as materials production. It comprises GHG emissions associated with project construction related activities and materials and their associate maintenance, for operational road user GHG emissions, the study area is consistent with the affected road network defined in the traffic model.

14.5.2 The study area has been determined based on DMRB LA 114, the boundaries and scopes of National Highways' Carbon Tool, and PAS 2080:2016 'Carbon Management in Infrastructure', which is the technical standard for measuring and managing GHG emissions from infrastructure.

14.5.3 The activities for which emissions have been quantified in the assessment include the direct and supply chain activities for the Do Something scenario of the Scheme's life cycle, for both the construction and operation stages of the Scheme. The specific elements of the Scheme lifecycle included in the assessment boundary are listed in Table 14.4. The 'assessment boundary' defines the source of emissions considered, including direct or supply chain emissions.

The timescale of the assessment covers:

- Construction, as a single time period,
- Total annual operation for the Opening Year (2025) and
- Total annual operation for the Design Year (2040)

Vulnerability of the Scheme to Climate Change

14.5.4 In accordance with DMRB LA 114 the study area for assessing the Scheme's vulnerability to climate change is based on the Development Consent Order (DCO) boundary, see The Scheme chapter (Chapter 2). The DCO boundary includes compound areas and temporary land take needed during construction.

14.6 Baseline conditions

Effects of the Scheme on Climate Change

14.6.1 Baseline conditions are defined by the:

- Total background emissions from all sources, i.e. all UK emissions, at all scales; and

- Predicted total emissions occurring for both the Opening Year (2025), and the Design Year (2040), assuming the Scheme is not constructed, i.e. the Do Minimum scenarios.

National emissions baseline

14.6.2 Global greenhouse gas emissions, from all sources, currently amount to approximately 50 billion tonnes of CO_2e per year. At the time of writing (April 2021) the UK is the world's eighth largest emitter of CO_2e, with the total background UK emissions for 2018 (the last reported year) being 452 million tonnes of CO_2e [40]. The transport sector was the largest emitting sector of UK greenhouse gas emissions in 2018, contributing 28% of emissions. There has been little overall change (3% reduction) in emissions from the transport sector between 1990 and 2018. Improvements in fuel efficiency are approximately balanced by increasing vehicle numbers. The UK has in place Carbon Budgets for five-year periods up to 203~~7~~2. Both the construction and Opening Year of the Scheme fall within the Fourth Carbon Budget period (2023 to 2027), (see Table 14.10 below). The Carbon Budget for the 2023–2027 budgetary period is 1,950 Mt CO_2e, ~~and~~ the budget for 2028-2032 is 1,725 $MtCO_2e$ and the budget for 2033-2037 is 965 $MtCO_2e$ ~~(see Table 14.10 below)~~. Whilst budgets are not set beyond this, there is a legal requirement for the UK to reduce net emissions by at least 100% by 2050.

14.6.3 The dataset for the fifth UK Carbon Budget central scenario[41] includes forecasts of emissions for different sectors, representing the best estimate of the least cost path to the UK's 2050 target of reducing emissions by 80% of 1990 levels. In this dataset, total domestic transport emissions (excluding domestic aviation and shipping) for the third budget period are 480 $MtCO_2e$.

Scheme emission baseline

14.6.4 Scheme-specific baseline emissions equate to emissions in the opening and design years assuming the Scheme was not constructed (the Do Minimum scenario). There are no construction emissions associated with the Do Minimum scenario; only the 'operation' life cycle modules presented in are included in the baseline, shown below for the opening and design years. Road user carbon emissions have been modelled using traffic model data in accordance with DMRB LA 105, as described in section 14.3.13. Operational and maintenance emissions have been estimated as described in 14.3.14.

Table 14.10: Scheme Do Minimum emissions

Life cycle module	2025 Emissions (tCO_2e)	2040 Emissions (tCO_2e)	Total Emissions over the 60 Year Operational Period (tCO_2e)
Road user carbon	735,352	782,909	46,594,066
Operation and maintenance	2,133	2,270	135,123
Total operation	737,485	785,179	46,729,189

[redacted]

Vulnerability of the Scheme to Climate Change

14.6.5 The baseline for climate change vulnerability is presented in two parts:

- The first section describes the current climatic conditions in the study area; and
- The second presents a range of possible future climate projections.

14.6.6 It should be noted that climate change is not only a challenge for the future. We are already observing changes in the UK climate.

14.6.7 Climate is defined as the typical weather conditions experienced in a place over a period of time, conventionally expressed as average weather over a 30-year period.

Current climate

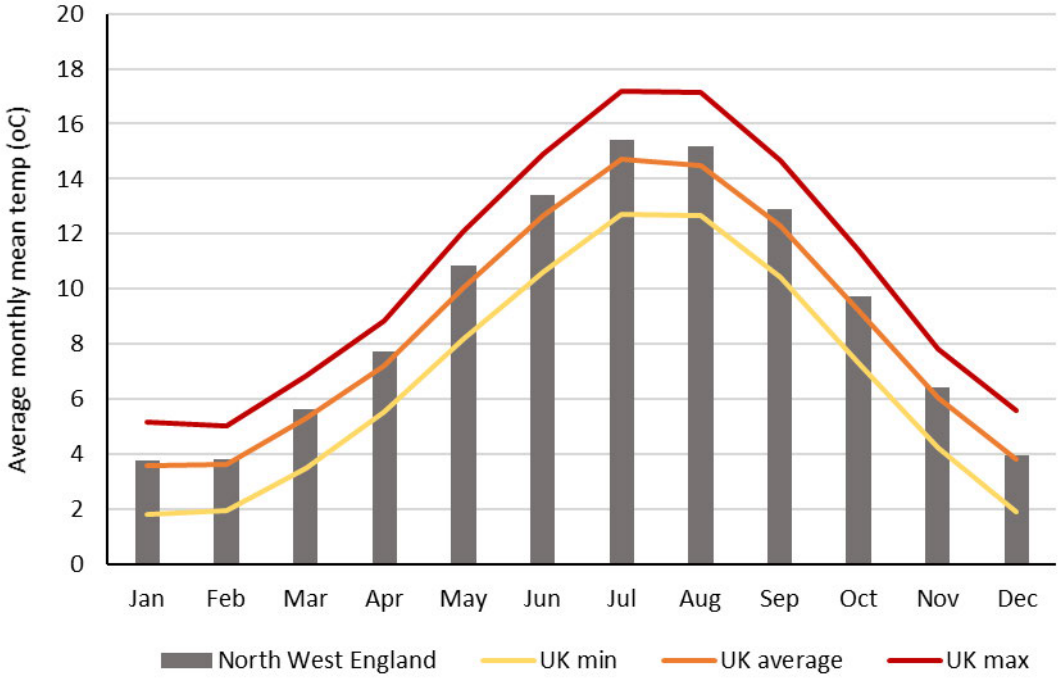
14.6.8 To inform adaptation decisions this section presents data from the Meteorological Office (hereafter referred to as the Met Office) to summarise the current climate in North West England. The Met Office's standard average data tables are used, they show the latest set of 30-year averages covering the period 1981-2010[42]. Context to this is provided by including comparison to the equivalent national dataset (UK minimum, average and maximum). In summary this section finds that annual temperatures and precipitation in the region are comparable to the UK average.

Temperature

14.6.9 Observations for the UK show that for the most recent decade (2010-2019) temperatures were on average 0.3 °C warmer than the 1981-2010 average and 0.9 °C warmer than 1961-1990. All of the top ten warmest years have occurred since 2002.

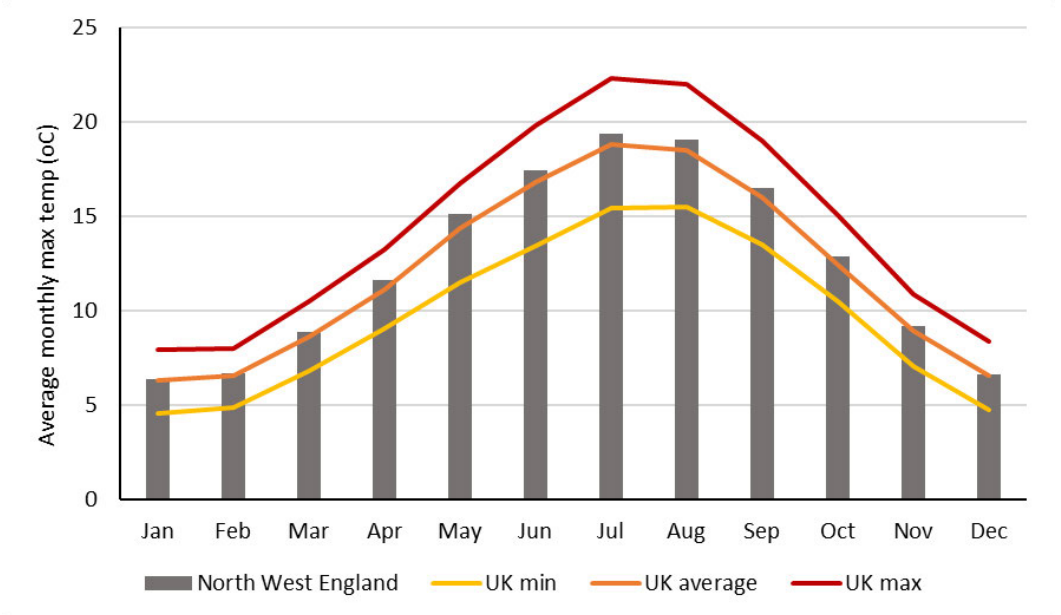
14.6.10 The North West England Basin's climate is one of mild winters and mild summers. As shown in Insert 14-1 and Insert 14-2, monthly average and mean maximum temperatures are average for the UK. Across the timeseries, 1981-2010, peak summer (July) average maximum temperatures of 19.34 °C in the North West are comparable to the maximum UK average of 22.26 °C. Note that mean maximum temperatures are calculated as the monthly average of daily maximums – as such some individual days are likely to have recorded hotter temperatures than those stated.

[redacted]



Source data: Met Office's standard average data tables

Insert 14-1: Long-term average monthly mean temperature (1981-2010)



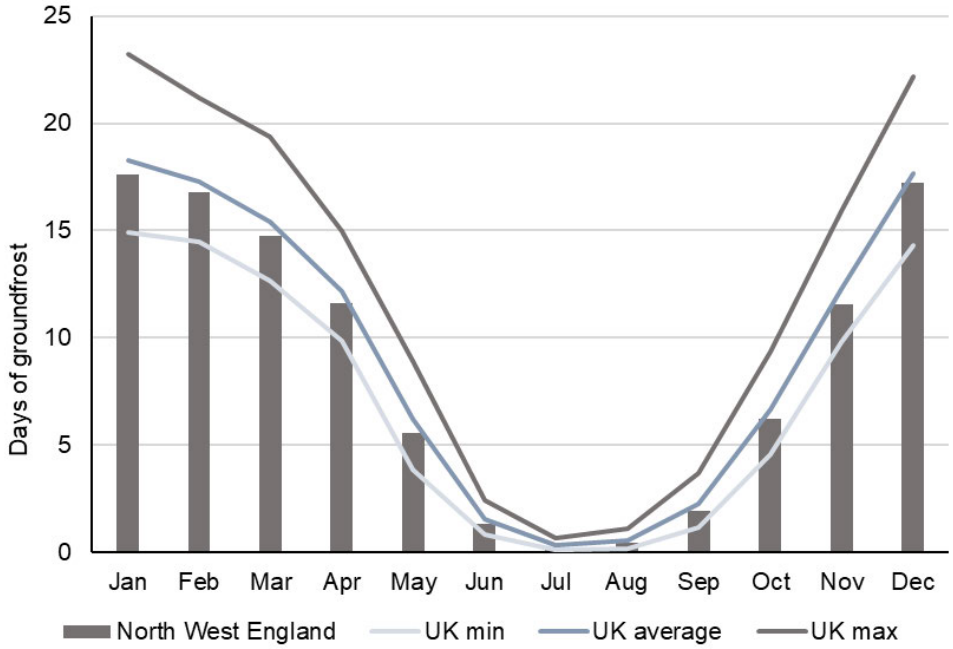
Source data: Met Office's standard average data tables

Insert 14-2: Long-term average monthly maximum temperature (1981-2010)

14.6.11 The closest long running climate station to the Scheme is located at Sheffield[43]. Since 1883, the highest monthly mean daily maximum temperature (t-max) it has recorded is 25.6 °C in July 2006. Conversely the lowest mean daily minimum temperature (t-min) it has recorded is -4.2 °C in February 1895. February 1963 recorded the stations maximum monthly number of days with air frost, 28 days.

[redacted]

14.6.12 As shown in Insert 14-3, the long-term average days with ground frost (1981-2010) in the North West England Basin are close to the UK average.



Source data: Met Office's standard average data tables

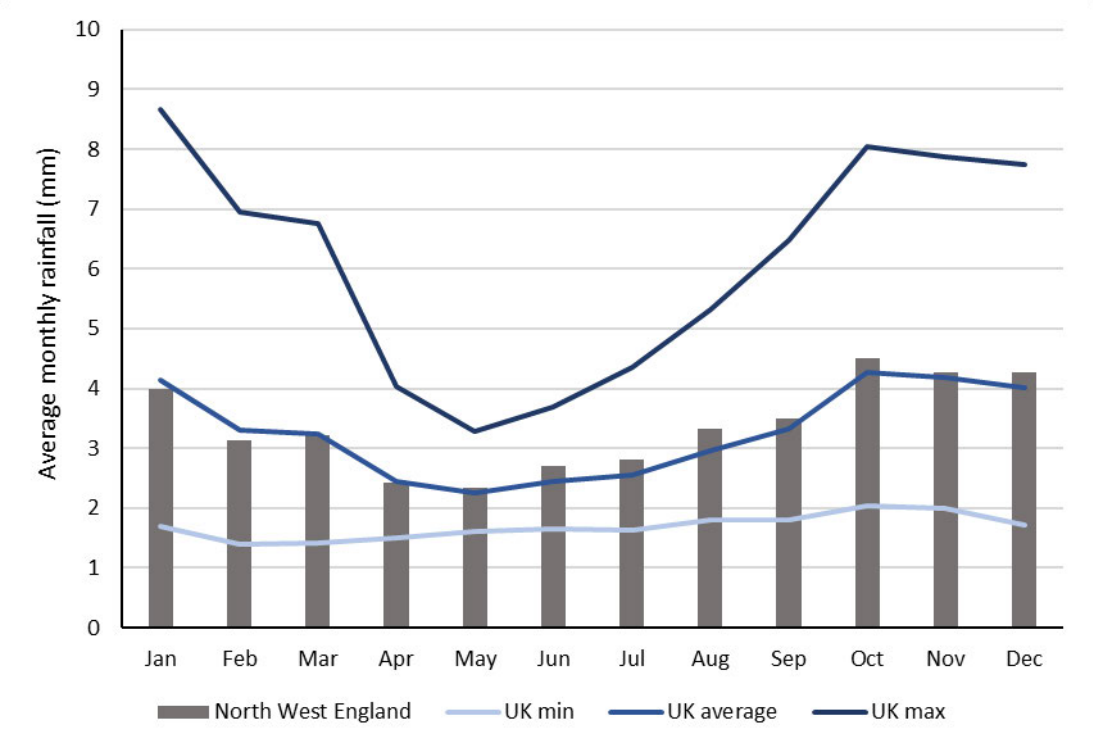
Insert 14-3: Long-term average monthly days of ground frost (1981-2010)

Precipitation

14.6.13 Observations across the UK show a high level of variability in precipitation from year to year, with a slight overall increase in both UK winter and summer precipitation in recent decades.

14.6.14 The exposure of NW England to westerly maritime air masses and the presence of extensive areas of high ground mean that the region has some of the wettest places in the UK. The higher parts of the Lake District are particularly wet, with an average of over 3200 mm of rain each year. In contrast, the reputedly wet city of Manchester averages only 830 mm and the more sheltered areas of Cheshire and the Eden valley in Cumbria are even drier with less than 800 mm per year. These areas benefit from the 'rain shadow' effect of the high ground of North Wales and the Lake District respectively.

14.6.15 As shown in Insert 14-4, the overall long-term average monthly rainfall (1981-2010) in the North West England Basin is close to the UK average.



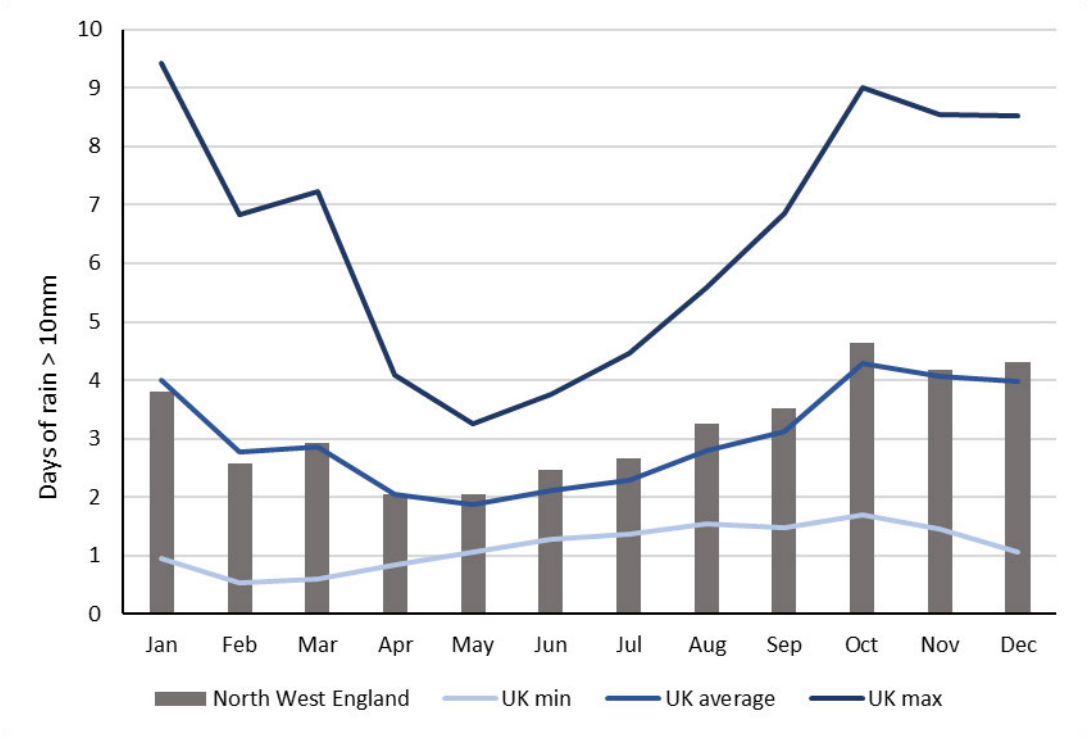
Source data: Met Office's standard average data tables

Insert 14-4: Long-term average monthly rainfall (1981-2010)

14.6.16

14.6.17 The closest long running climate station to the Scheme is in Sheffield. Since 1883, the highest total monthly rainfall recorded at the station is 285.6 mm in June 2007.

14.6.18 Insert 14-5 shows the long-term average number of days that had rainfall over 10 mm. The North West England River Basin experiences an average number of heavy rainfall days when compared to the rest of the UK.



Source data: Met Office's standard average data tables

Insert 14-5: Long-term average monthly days rain >10 mm (1981-2010)

14.6.19 With regards to storminess, there are still no compelling trends over the last five decades, as determined by maximum gust speeds from the UK wind network[44].

Projected climate

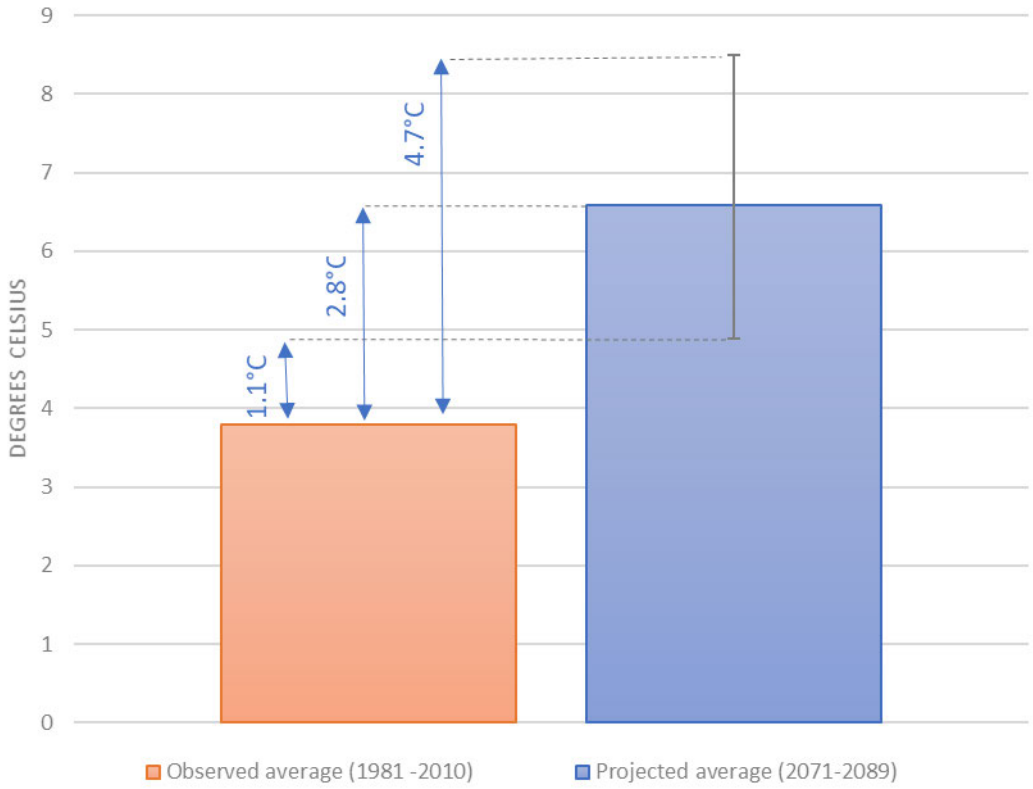
14.6.20 This section presents the output of climate change models that cover the study area. Future projections are presented for the UKCP18 North West England River Basin, within which the Scheme is located. The data is presented as averages for the 2080s based on climate projections running from 2071 to 2089. For temperature and precipitation seasonal averages are provided for summer and winter, which represent the most extreme changes in response to climate change. The projections are probabilistic, those plotted are for the central estimate (i.e. 50th percentile) and use the emissions scenario RCP8.5. This is the most extreme emissions scenario representing a future where greenhouse gas emissions continue to rise, and the nations of the world choose not to switch to a low carbon future. This aligns with DMRB LA 114, which specifies use of a high emissions scenario and is considered appropriate as it provides a precautionary view of possible future climate responses.

14.6.21 In summary this section finds that, on average, the North West England River Basin, is likely to experience hotter and drier summers, and warmer, wetter winters. This is a widely agreed finding and is common for most of the UK with the exception of some areas of North West Scotland. Alongside these changes in the average conditions, it is possible, but less certain, that climate change will also increase the frequency and severity of extreme weather events; such as: heavy rainfall, storms and heatwaves.

[redacted] Last accessed: December 2020.

Temperature projections – warmer winters

14.6.22 Insert 14-6 shows that under RCP 8.5 average winter temperatures in the North West England River Basin are expected to increase from 3.8ºC (observed average 1981-2010) to 6.6 ºC (projected average 2071-2089), an increase of 2.8ºC (based on the central estimate, i.e. 50th percentile). The uncertainty around this estimate of change ranges from ~1.1ºC to ~4.7ºC (represented by the 10th and 90th percentiles respectively).



Insert 14-6: Projected average mean winter temperatures (2071-2089)

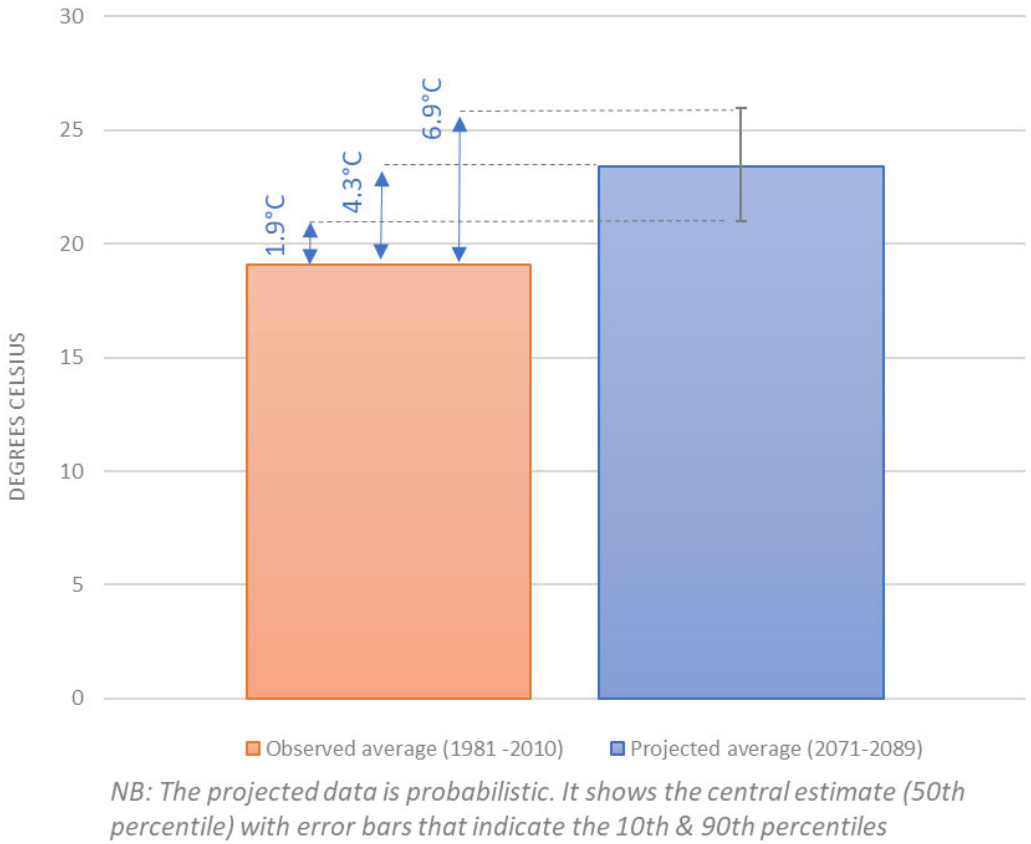
14.6.23 In the UK, the heaviest snowfalls tend to occur when the air temperature is between zero and 2°C[45]. The projected increase in winter temperatures are therefore expected to reduce mean snowfall, number of snow days and heavy snow events[46]. While there is less certainty in the magnitude of these changes, there is confidence in the negative direction of the change. This is supported by the fact that the most recent decade (2010-2019), had 16% fewer days of air and ground frost per year than the 1961-1990 average, and 6% / 10% fewer, respectively, compared to 1981-2010[47].

[redacted] Last accessed: December 2020.

Temperature projections – hotter summers

14.6.24 In the recent past (1981-2000) the probability of seeing a summer as hot as 2018 in the UK was low (<10%). This probability has already increased due to climate change and is now estimated to be between 10-25%. With future warming, hot summers by mid-century could become even more common (with probabilities of the order of 50% depending on the emissions scenario followed)[48].

14.6.25 In the North West England River Basin, projected mean daily maximum summer temperatures have been obtained from the UKCP18 probabilistic projections for 2071-89. Since these are an average of daily maximum values it should be noted that some days in this period are likely to be hotter than the values indicated below. Insert 14-7 shows that under RCP8.5 average maximum summer temperatures in the North West England River Basin are expected to increase from 19.1 ºC (observed average 1981-2010) to 23.4 ºC (projected average 2071-2089), an increase of 4.3 ºC (based on the central estimate, i.e. 50th percentile). The uncertainty around this estimate of change ranges from ~1.9ºC to ~6.9ºC (represented by the 10th and 90th percentiles respectively).

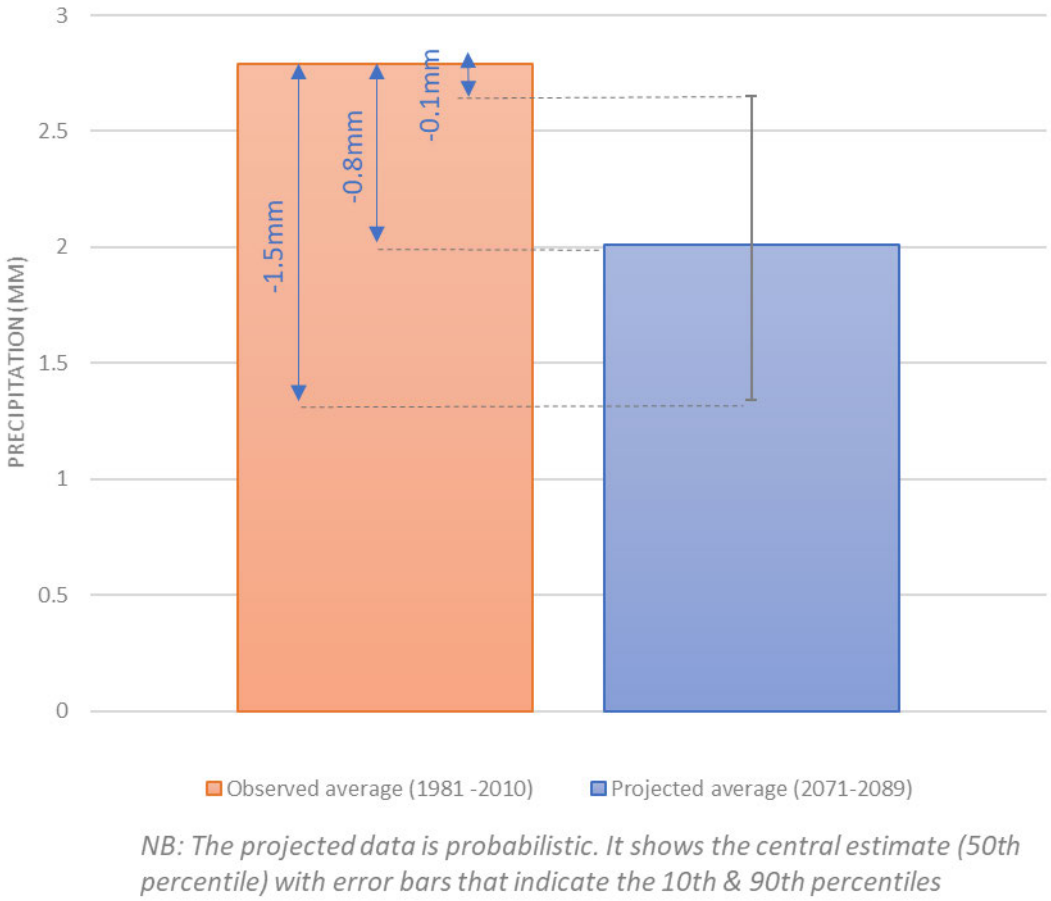


Insert 14-7: Projected average maximum summer temperature (2071-2089)

[redacted] Last accessed: December 2020.

Precipitation projections – drier summers

14.6.26 In UKCP18, the probabilistic projections provide local low, central and high changes across the UK, corresponding to 10%, 50% and 90% probability levels. Projected precipitation levels for RCP8.5 have been averaged across the North West England River Basin, to give a range of projected average rainfall change between the 10% and 90% probability levels. As shown in Insert 14-8 by 2071-2089 this range amounts to -52% to -5% for summer rainfall, where negative values indicate reduced precipitation. The central estimate of change (i.e. 50th percentile) in mean summer precipitation for the same period is -18.5%. These projections suggest that future average rainfall trends are uncertain, but it is highly likely that summer rainfall will decrease.



NB: The projected data is probabilistic. It shows the central estimate (50th percentile) with error bars that indicate the 10th & 90th percentiles

Insert 14-8: Projected average summer precipitation (2071-2089)

Precipitation projections – Heavier rainfall and wetter winters

14.6.27 Insert 14-9 shows that UKCP18 climate projections forecast that by 2071- 2089, under RCP8.5 central estimate (i.e. 50th percentile), winter mean precipitation will increase by 0.5mm. The variability in projections indicate that winter rainfall trends are uncertain, but it is more likely than not that winter rainfall will increase.

14.6.28 There is further support for increase winter precipitation when the latest 2.2km resolution “convection-permitting” model (CPM) from the Met Office is considered. This high-resolution model gives a significantly better representation of rainfall and forecasts a 27% increase in average winter precipitation compared

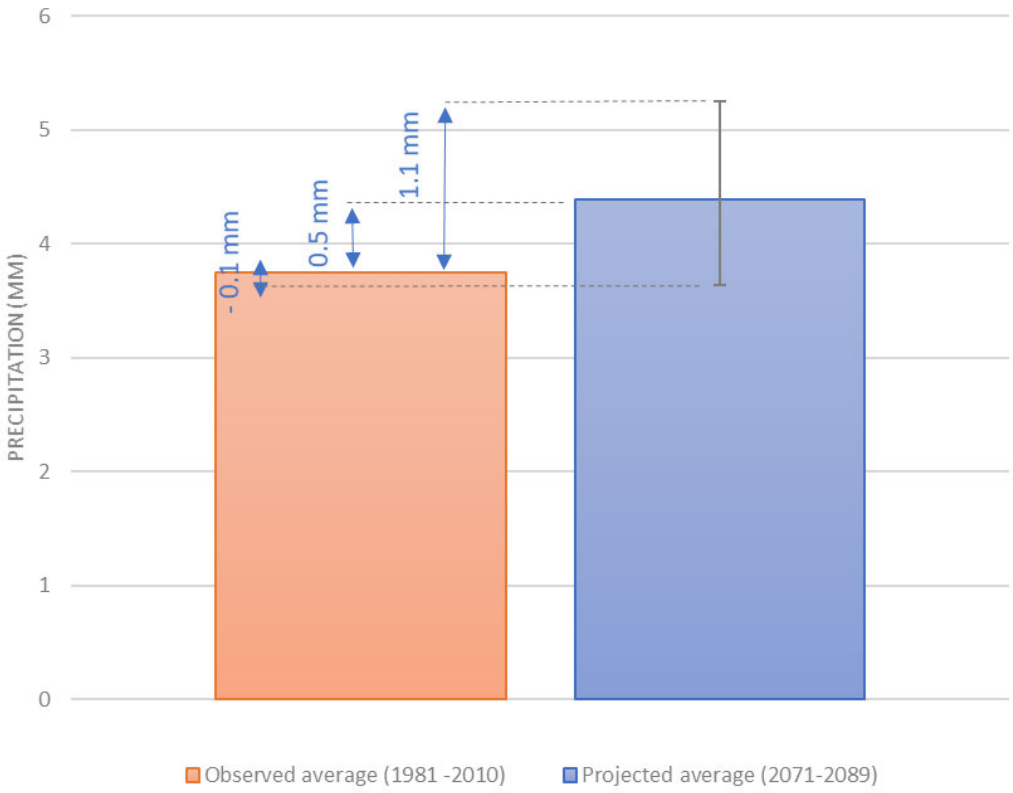
to the 16% increase projected using the UKCP18 regional climate model (RCM)[49].

14.6.29 It should also be noted that year to year levels are expected to continue to vary widely. This is demonstrated in the recent historical record in which the winters of 2013-14 and 2015-16 stand out as having particularly high amounts of rainfall, each with over 150% of the 1981-2010 average UK winter rainfall. More recently, whilst both December 2019 and January 2020 received typical rainfall, February 2020 saw 350% of the 1981-2010 average UK winter rainfall in the North West[50] making the winter of 2019-2020 the 5th wettest on record[51].

14.6.30 Across the UK, the number of rainfall days exceeding 10 mm has increased by 10% when comparing the period 2010-2019 to 1961-1990. Other extreme rainfall indices exhibit large inter-annual variability but are broadly consistent with increased rainfall over the UK, particularly during the last decade which has recorded more heavy rain events than any earlier decades.

14.6.31 During 2019, northern England experienced its ninth wettest year in a series from 1962. The three highest rain-gauge records in this year were all in the Lake District in the North West England River Basin where 5,217 mm were recorded at Styhead[52].

[redacted]



Insert 14-9: Projected average winter precipitation (2071-2089)

Extreme weather projections

14.6.32 The Met Office identifies either different types of extreme weather[53]. This section focuses on those related to storms. Future projections of storms are uncertain; global projections using the members of the Met Office Hadley Centre model over the UK suggest an increase in near surface wind speeds during winter over the second half of the 21st century, with a projected increase in winter storm frequency. However, the overall increase to wind speed is small when compared to the interannual variability[54] and other global climate models suggest that changes are influenced by natural variability as opposed to climate change[55].

14.7 Potential impacts

Effects of the Scheme on Climate Change

14.7.1 The construction stage of the Scheme would have an adverse effect on climate, as it would give rise to emissions. These emissions would arise from the production of materials to be used in construction, their transportation to site, and

[redacted]

onsite through construction activities (for example from emissions from diesel-fuelled construction plant).

14.7.2 The operational stage of the Scheme would give rise to emissions from road users and operational energy use (for example, streetlights). Impacts may be positive or negative depending on whether this presents an~~d~~ increase or decrease against the Do Minimum. The results of the assessment are presented in section 14.11.

Vulnerability of the Scheme to Climate Change

Construction

Construction processes

14.7.3 The climate of the study area has already changed from its natural state, as a result of climate change. However, the Scheme's construction is not expected to be so far in the future that the climate will notably change further prior to construction. Climate change is therefore not expected to impact construction.

14.7.4 If construction coincides with extreme weather event(s) such as drought or storms there may potentially be construction impacts. These are not assessed in this chapter as they would be managed through the First Iteration Environmental Management Plan (APP-183) and are addressed as required by the other topics within this report, for example potential construction related surface water flood risks related to extreme weather are addressed within the Schemes Flood Risk Assessment (FRA) (APP-056).

Operation

14.7.5 Potential operational impacts on assets (including their operation, maintenance and refurbishment) are listed below under the heading of the receptor they could affect.

- Road surfaces and pavements:
  - Warmer winters could reduce winter maintenance and associated traffic disruption (less road salting and freeze thaw damage).
  - Hotter summers could damage materials (rutting, shrinkage and expansion) increasing maintenance requirements and associated traffic disruption.
  - Heavier rain and wetter winters could increase pothole formation (by weakening the soil beneath the carriageway) increasing maintenance requirements and associated traffic disruption.
- Structures (including embankments, earthworks and bridges):
  - Hotter summers could reduce the asset lives of structures (over expansion and buckling) increasing maintenance requirements and associated traffic disruption.
  - Drier summers could cause soil instability (intensify and extend soil moisture deficits and impact groundwater levels and earth pressures) increasing maintenance requirements and associated traffic disruption.

- Drainage infrastructure:
  - Drier summers in combination with hotter temperatures could dry out soils and subsequently increase erosion. This may cause sedimentation within the Scheme's drainage infrastructure that reduces its drainage capacity and so increases the risk of flooding causing traffic disruption. Additional maintenance work to prevent flooding may also cause traffic disruption.
  - Heavier rain and wetter winters could increase the risk of pluvial or surface flooding. Flooding and additional associated maintenance requirements could both cause traffic disruption.
  - Warmer winters could reduce freeze thaw erosion which can damage underground assets. Reducing maintenance requirements and associated traffic disruption.
- Road technology and street furniture:
  - The frequency of extreme weather impacts on electrical equipment may increase, for example lightning strikes become more regular and extreme, and hot temperatures become more common causing thermal over loading of circuits. Repair and maintenance may cause traffic disruption.
  - High winds in more regular storms could overload small structures and signage and damage roadside planting and furniture. Repair and maintenance may cause traffic disruption.
- Landscaping:
  - Drier summers could damage the Scheme's landscaping. More regular maintenance may cause traffic disruption.

14.7.6 Potential operational impacts on end-users are listed below, the potential receptor for all of these would be driver experience:

- Warmer winters could improve winter driver safety (less ice) and so reduce traffic disruption caused by accidents.
- Hotter summers could increase the number of vehicle breakdowns and so increase traffic disruption and the number of associated accidents.
- Hotter summers could increase accident rates and so increase traffic disruption.
- Heavier rain and wetter winters could reduce driver safety and so increase traffic disruption associated with accidents.
- Storms and high winds could reduce driver safety and so increase traffic disruption associated with accidents.

14.7.7 Potential operational impacts on environmental receptors that are related to, or could be intensified by, climate change are assessed as cumulative effects. These are summarised in section 14.10.

14.8 Design, mitigation and enhancement measures

Effects of the Scheme on Climate Change

14.8.1 DMRB LA 114 states that: 'Projects shall seek to minimise carbon emissions in all cases to contribute to the UK's target for net reduction in carbon emissions'. This requirement applies whether or not the Scheme is anticipated to generate a significant effect on climate.

14.8.2 Emissions are mitigated by applying the carbon reduction hierarchy set out in DMRB LA 114: Avoid / Prevent, Reduce, Remediate. Items at the top of the hierarchy have a greater potential to reduce emissions and are prioritised.

- Avoid / prevent:
  - Maximise potential for re-using and / or refurbishing existing assets to reduce the extent of new construction required
  - Explore alternative lower carbon options to deliver the project objectives (i.e. shorter route options with smaller construction footprints).
- Reduce:
  - Apply low carbon solutions (including technologies, materials and products) to minimise resource consumption during the construction, operation, user's use of the project, and at end-of-life
  - It is recommended that as far as possible, materials are locally procured to minimise transportation emissions
  - Construct efficiently, using techniques (e.g. during construction and operation) that reduce resource consumption over the life cycle of the project
- Remediate:
  - After addressing avoid/prevent and reduce measures projects will identify, assess and integrate measures to further reduce carbon through on or off-site offsetting or sequestration.

14.8.3 To fully embed this hierarchy in the project team's ways of working, the Principal Contractor has committed to adhering to the principles of the PAS 2080 – Carbon Management in Infrastructure Verification[56]. PAS 2080 is a global standard for managing infrastructure carbon and looks at reducing carbon across the whole value chain through more intelligent design, construction and use. It also ensures that carbon is consistently and transparently quantified at key points during the process, to inform decision-making.

Embedded mitigation

14.8.4 Embedded mitigation measures are those which are incorporated into the design to avoid or prevent GHG emissions. DMRB LA 114 notes that 'minimising GHG emissions through design is a core principle of the Government's Infrastructure Carbon Review and the Specification on infrastructure carbon management PAS

[redacted]

2080:2016 2016'. Mitigation measures which have been embedded into the design are shown in Table 14-11.

Table 14.11: Embedded mitigation measures

Life cycle module	Mitigation measures	LA 114 Carbon reduction hierarchy action
Construction (product stage)	Modification of the design through the Preliminary Design process has resulted in the removal of new infrastructure, for example the spur and roundabout, and reducing the size of the River Etherow Bridge. This has reduced the volume of materials required.	Avoid/prevent
	The Scheme is committed to reuse over 99% of the excavated soil onsite, particularly near the underpass where there is large amount of cutting. This would reduce the quantity of materials required to be managed or disposed of off-site. A full Materials Management Plan (MMP) would be prepared to meet the CL:AIRE Definition of Waste: Code of Practice (DoWCoP), to enable maximum use of on-site materials.	Reduce
	The appointed Principal Contractor is committed to off-site manufacturing of components and use of modular construction and other modern methods of construction. These are likely to minimise the generation of waste. Circular economy considerations would be included in the Detained Design stage through specifications to use the target amount of recycled material, e.g. 30% recycled content target in construction of the scheme. Opportunities for potential re-use and recycling of all material assets and waste will be promoted and material use will be managed in order to maximise the re-use within the scheme.	Reduce
Construction (construction process stage)	Modification of the design through the Preliminary Design process has resulted in the removal of new infrastructure, for example the spur and roundabout, and reducing the size of the River Etherow Bridge. This has reduced the transport of materials to site, and also the extent of on-site construction/installation processes required.	Avoid / prevent
	Redesign of the Mottram Underpass during the Preliminary Design stage has made this element easier and quicker to construct, reducing emissions associated with construction plant and site equipment.	Avoid/prevent
	Standard and easy-to-source materials have been specified for the Scheme, to increase the likelihood that they can be procured locally and reduce transport emissions. The Scheme has benefitted from early contractor engagement,	Reduce

Life cycle module	Mitigation measures	LA 114 Carbon reduction hierarchy action
	which has allowed materials procurement to be a factor in the Scheme design.	
	The Scheme is committed to reuse over 99% of the excavated soil onsite, particularly near the underpass where there is large amount of cutting. This would reduce the transportation of materials to site. A full Materials Management Plan (MMP) would be implemented to meet the CL:AIRE Definition of Waste: Code of Practice (DoWCoP), to enable maximum use of on-site materials.	Reduce
	Various traffic management measures are laid out in detail within the Traffic Management Plan (APP-186) which would result in smoother flow of traffic, reducing traffic congestion and GHG emissions.	Reduce
	Waste treatment/disposal would be carried out in accordance with the mitigation measures outlined in the Material Assets and Waste chapter (Chapter 10). The Principal Contractor has committed to recycle or recover 95% of wastes that leave site, diverting them from landfill, as outlined in the Material Assets and Waste chapter (Chapter 10). Impacts from material asset use and waste generation will be managed during construction through the implementation of the First Iteration Environmental Management Plan (EMP) (APP-183).	Reduce
Operation	The addition of signals and land widening within the circulatory carriageway will reduce congestion. This allows vehicle engines to operate more efficiently and reduces emissions.	Avoid/prevent
	The sizes of planted areas within the DCO boundary have been increased, which will lead to increased removal and sequestration of GHGs from the atmosphere. However, it is not considered that this element will have a significant impact on overall Scheme emissions and has not been quantified in this assessment.	Remediate
	LED lighting has been incorporated into the design. This is more energy efficient than conventional HID lamps and reduces GHG emissions from electricity generation. They also require little maintenance.	Reduce
	During design development the extent of proposed lighting has been reduced following consultation with the relevant local authorities. This would, reduce emissions from electricity generation.	Avoid/prevent

Life cycle module	Mitigation measures	LA 114 Carbon reduction hierarchy action
	Footpath connections are included in the design to promote walking following Scheme opening.	Avoid/prevent

Essential mitigation and enhancement measures

14.8.5 Essential mitigation measures are those which have not been embedded into the design of the Scheme but will be secured and implemented during construction to further reduce emissions.

14.8.6 Enhancement measures are not factored into the environmental assessment, the early identification of these measures allows for associated benefits to be highlighted. These measures have not been included in the assessment in section 14.10 but would provide a further reduction in emissions against those reported in this chapter. Essential mitigation measures and enhancements are shown in Table 14.12.

Table 14.12: Essential mitigation and enhancement measures

Life cycle module	Mitigation measures	LA 114 Carbon reduction hierarchy action
Construction (product stage)	Essential measure: The Scheme is committed to selecting materials for pavements that require less compaction, to reduce emissions from construction plant.	Reduce
	Enhancement measure: The appointed Principal Contractor setting a stretch target of 40-50% recycled content target for the region, through working with the supply chain and designing the road surface to best suit recycled content. These actions will support responsible material procurement. Opportunities include discussions with the supply chain to use reusable packaging and take back unused materials.	Reduce
	Enhancement measure: The EMP and REAC includes a commitment for local procurement options to be investigated as the preferred strategy for the Scheme. This commitment aims being investigated, to reduce the emissions associated with transport of materials and labour.	Reduce
Construction (construction process stage)	Essential mitigation measure: During construction, plant emissions should be managed through specified plant operator efficiency requirements. These requirements would be set at pre-construction stage and would be implemented via the Environmental Management Plan (EMP) (APP-183), which should specify plant operator efficiency requirements. These Appropriate specifications	Reduce

Life cycle module	Mitigation measures	LA 114 Carbon reduction hierarchy action
	would be included in the Register of Environmental Actions and Commitments (REAC) (APP-184).	
	Essential mitigation measure: Where feasible, electric and hybrid vehicles and construction plant will to be used. This would be considered via the PAS2080 analysis of the Scheme.	Reduce
	Enhancement measure: Electricity used on the site will be from renewable sources where viable. This would be considered via the PAS2080 analysis of the Scheme.	Reduce

Vulnerability of the Scheme to Climate Change

14.8.7 To understand the resilience of the Scheme design to climate change, information has been gathered from the design team and the environmental team about the mitigation measures already built into the design (i.e. embedded mitigation).

14.8.8 The assessment of climate vulnerability impacts is undertaken after consideration of the Scheme design and mitigation. Embedded mitigation and additional mitigation are identified in Table 14-5 after section 14.9.14.

14.9 Assessment of effects

Effects of the Scheme on Climate Change

14.9.1 This assessment presents the emissions calculated for the Do Something scenario, a comparison against the Do Minimum baseline, and assessment against UK Government Carbon Budgets.

Do Something scenario emissions

Construction

14.9.2 Construction phase emissions are broken down in Table 14.13. The Carbon Tool used to calculate the emissions is provided in Appendix 14.1 (APP-179). The construction of the Scheme will lead to the release of an additional 38,970 tCO_2e compared with the Do Minimum scenario.

14.9.3 The largest magnitude of emissions (58.5%) is likely to arise from material production and processing, with a further 21.8% from the transport of emissions to site. On-site construction processes will contribute approximately 19.6% of total construction phase emissions.

Table 14.13: Construction phase emissions[57]

Category	Item	Materials		Transport	
		Emissions (tCO_2e)	Percentage of Construction Total	Emissions (tCO_2e)	Percentage of Construction Total
Bulk Materials	Ready mix concrete	3,756	9.64	757	1.94
	Fill and aggregate	837	2.15	3,524	9.04
	Asphalt	3,685	9.46	1,061	2.72
	Reinforcement steel	1,714	4.40	27	0.07
Earthworks	Imported soil	5,396	13.85	2,387	6.13
Fencing, barriers & road restraint systems	Road restraint system/ safety barrier	344	0.88	36	0.09
	Fence	128	0.33	1	0.003
Drainage	Plastic pipework (HDPE)	594	1.52	5	0.01
	Precast concrete inspection chambers	68	0.17	7	0.02
	Gullies	42	0.11	2	0.004
	Channel & slot drains	53	0.14	6	0.02
Road pavements	Kerb	113	0.29	7	0.02
Street furniture & electrical equipment	Road lighting and columns	212	0.54	1	0.0013
	Marker posts/signs	3	0.01	0.01	0.00002
	Variable Message Signs (VMS)	187	0.48	1	0.002
Civil structures & walls	Formwork / Shuttering	215	0.55	4	0.01
	Piling	5,452	13.99	663	1.70
Total material		22,796	58.50	-	-
Total transport		-	-	8,490	21.79
Fuel, energy & water		7,273	18.66	20	0.05

[57] Note that due to rounding, totals may not add to 100%.

Category	Item	Materials		Transport	
		Emissions (tCO_2e)	Percentage of Construction Total	Emissions (tCO_2e)	Percentage of Construction Total
Business and employee transport		371	0.95	-	-
Waste		9	0.02	10	0.03
Total construction processes		7,654	19.64	30	0.08
Total Materials, Transport and Construction (tCO_2e) ~~phase total~~		38,970			

Operation

14.9.4 Operational phase emissions for the opening and design years are shown in Table 14.14. Road user carbon emissions have been calculated using emission modelling methodologies referenced within DMRB LA 105, as described in section 14.3.13. Operational and maintenance emissions have been estimated as described in 14.3.14.

Table 14.14: Operational phase emissions for 2025 and 2040

Life Cycle Module	Emissions (tCO_2e)		
	2025	2040	60-Year Operational Period
Road user carbon	740,660	789,782	46,993,932
Maintenance and operation	2,148	2,290	136,282
Total operation	742,808	792,072	47,130,214

Comparing Do Minimum and Do Something scenarios

14.9.5 As emissions from construction do not occur in the Do Minimum scenario, it can be considered that the construction stage of the Scheme would have the effect of releasing an additional 38,970 tCO_2e into the atmosphere in the Do Something scenario.

14.9.6 The calculated operational stage emissions for the 2025 and 2040 Do Minimum and Do Something scenarios are compared below in Table 14.15.

Table 14.15: Do Something and Do Minimum operational emissions comparison

Life Cycle Module	Emissions (tCO_2e)								
	2025 Do Minimum	2025 Do Something	Difference	2040 Do Minimum	2040 Do Something	Difference	Total over 60-year operation* (Do-Minimum)	Total over 60-year operation* (Do-Something)	Difference
Total Operational Emissions	737,485	~~740,660~~ 742,808	5,323	785,179	792,072	6,893	46,729,188	47,130,214	401,026

14.9.7 Whilst road improvement schemes can sometimes lead to reduced greenhouse gas emissions in operation due to easing of congestion, in both the opening and design years the Scheme will lead to an increase in operational emissions, of 5,323 tCO_2e and 6,893 tCO_2e respectively compared to the Do Minimum scenario, due to increased vehicle kilometres generated by the Scheme.

Comparison to UK Carbon Budgets

14.9.8 The Scheme is likely to contribute ~~116,332~~116,341 tCO_2e to the UK's Carbon Budgets across the period 2023-37, compared with the Do-Minimum scenario. The (net) contribution of the Scheme to the Fourth Carbon Budget period would be ~~55,253~~ 55,256 tCO_2e (equivalent to 0.0028% of that budget), including construction and operational phase emissions. The contribution of the scheme to the Fifth Carbon Budget would be 29,235 ~~29,231~~ tCO_2e (equivalent to 0.0017% of that budget), from operational emissions. The contribution of the Scheme to the Sixth Carbon Budget would be 31,850 ~~31,848~~ tCO_2e (equivalent to 0.0033% of that budget). The Scheme is unlikely to cause significant effects on climate, or significantly affect the UK's ability to meet its emissions reduction targets. It is considered that this magnitude of emissions from the Scheme will not materially impact the Government's ability to meet the budget, and therefore will not have a significant effect on climate.

14.9.9 This is in line with the position set out in the National Policy Statement for National Networks (NPS NN), which acknowledges that the emissions from the construction and operation of a road scheme are likely to be negligible compared to total UK emissions, and are unlikely to materially affect the UK Government's ability to meet its carbon reduction targets. The NPS NN specifically states that 'it is very unlikely that the effect of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets'.

14.9.10 The Carbon Budget associated with the Design Year has not been set and a quantitative assessment of significance for this period therefore cannot be carried out. However, Design Year emissions are of a similar order of magnitude to Opening Year emissions and, in the absence of any information on what the Carbon Budget for the period might be, it is expected that their contribution would be similarly small.

Table 14.16: Project GHG emissions against relevant budgets

Project stage	Estimated total carbon over Carbon Budget (tCO_2e)	Net CO_2 project GHG emissions (tCO_2e)	Relevant Carbon Budget		
			2023-27	2028-32	2033-37
Construction	38,970	38,970	38,970	-	-
Operation	9,912,678 ~~9,912,676~~	77,371 ~~77,362~~	16,286 ~~16,283~~	29,235 ~~29,231~~	31,850 ~~31,848~~
Total	9,951,648 ~~9,951,646~~	116,341 ~~116,332~~	55,256 ~~55,253~~	29,235 ~~29,231~~	31,850 ~~31,848~~

Residual effects

14.9.11 Mitigation measures to reduce carbon emissions form an inherent part of the project's design and construction practices. Therefore, the assessment of emissions in this ES already takes into consideration the mitigation described in the assessment above.

~~14.9.11~~14.9.12 The residual (net) effect of the Scheme, due to construction, would be 38,970 tCO_2e. Over 60 years of operation, the net effect of the scheme would be 399,867 tCO_2e arising from road user emissions, and 1,160 tCO_2e other operational emissions, leading to a total net effect, including construction of 439,997 tCO_2e net emissions over the whole life cycle of the Scheme.

~~14.9.12~~14.9.13 With respect to the Government's ability to meet its legislated Carbon Budgets, t~~T~~he overall (net) residual effect of the scheme in the Fourth Carbon Budget period is a 0.0028% contribution to the budget. The overall net effect on the Fifth Carbon Budget will be 0.0017% of the budget. The overall net effect on the Sixth Carbon Budget will be 0.0033% of the budget. This will not generate a significant impact on the UK's ability to meet its budget.

~~14.9.13~~14.9.14 It is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets. In this context, it is considered unlikely that this Scheme will in isolation conclude significant effects on climate.

Vulnerability of the Scheme to Climate Change

~~14.9.14~~14.9.15 The likelihood of each potential impact, with embedded mitigation in place, has been assessed along with the consequence of that impact if it occurred. These assessments along with the resulting significance of each impact are presented in two tables, one for each of the two types of receptor (see the methodology section 14.3 for details):

- The assets and their operation, maintenance and refurbishment (Table 14-17); and

End-users (Table 14-18).

Table 14-17: Potential operational impacts on asset receptors (including their operation, maintenance and refurbishment)

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Road surfaces and pavements						
Warmer winters	The projected increase in winter temperatures and decrease in snowfall suggests a reduction in frequency of winter road maintenance (salting). Additionally, since freeze thaw erosion can damage underground assets, milder temperatures projected in the future may reduce the need for maintenance work that would otherwise disturb road surfaces and pavements.	NA as impact is beneficial	NA as impact is beneficial	**Medium** – Following the DMRB LA 114 standards and in line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that winter mean temperatures will increase over the Scheme's lifetime (in winter, under RCP 8.5, mean temperature is likely to increase by approximately 2.8ºC [central estimate]). However, projected changes to snowfall and the number of nights below freezing are less certain so the likelihood of this impact is found to be Medium.	**Minor beneficial** - During the Scheme's operation, road and pavement maintenance, upgrade works, and associated road traffic delays could reduce (minor beneficial). The reduced requirement for the operation of slow-moving salting vehicles would also avoid potential minor traffic disruption.	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Hotter summers	Hotter summers could damage materials, for example: • Ageing bituminous binders (deformation and rutting of road surfaces) • Softening, deforming and damaging bitumen in asphalt • Over expansion and buckling of concrete roads • Failure of expansion joints • Wider temperature variations causing shrinkage and expansion that leads to cracking.	Best practice construction techniques and appropriate material quality standards will be followed to ensure the design lives specified can be met. For example, roads and pavements will use sufficiently hard binders in the asphalt. Polymer modified bitumen will be used in the pavement surface course and a resistance to permanent deformation will be specified as a requirement. Furthermore, heavy-duty macadam will be used in the binder and base course below which has an increased rut resistance. The drainage design will ensure the bound material is constructed on a sound foundation that should perform at it's optimum over the design life.	None	**Medium** - Following National Highways guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that summer mean temperatures will increase over the Scheme's lifetime (by 2071-89 summer mean daily maximum temperatures could be up to +4.3ºC warmer [central estimate under emissions scenario RCP8.5]). With embedded mitigation in place the likelihood of impact is Medium. There is still likely to be some damage to assets during the lifespan of the Scheme.	**Minor adverse** - Emergency repairs and more regular maintenance interventions may be required, in response to changes in deterioration rates. These would create associated traffic delays (minor adverse). Under extreme temperature, certain maintenance activities may be required to be undertaken at night, to keep work to schedule, thus incurring higher programme costs (e.g. labour and illumination) but causing less traffic disruption (negligible).	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Heavier rain and wetter winters	Heavier rain and wetter winters will weaken the soil beneath the carriageway. Loads from traffic may then stress the surface past its breaking point.	The design will ensure continuity of drainage in the pavement and road layers. This will reduce the risk of water getting trapped in the foundation layers which could lead to an increase in moisture content and thus a decrease in performance i.e. lack of sufficient support to the overlaying bound material. The design specifies a Thin Surface Course System (TSCS) with a minimum water sensitivity category of 70 (indirect tensile strength ratio) and a minimum binder content of 5.0% reflecting the revised requirements of MCHW 942 updated in May 2018. Where reflective cracking is considered a high risk, the design may include a geosynthetic (i.e. geogrid) which will stop surface water penetrating the bound layers through the reflective cracks. To further improve the Scheme's longevity the detailed design will investigate the use of warm mix asphalt, which has a reduced binder ageing during production as it is not heated to the same high temperatures as the conventional hot mix asphalt. The design team considered including a maintained drainage network to remove sub-surface	None	**Low** - Following National Highways guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that winter rainfall will increase over the Scheme's lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. The effect on pothole formation may be offset by the summers being drier and the winters being warmer (less freeze thaw erosion and less frost heaving, which are both significant contributors to pothole formation). It is therefore uncertain what the net impact of climate change will be. With the	**Minor adverse** - There may, in the future, be an increase in the number and severity of potholes in the study area. Potholes can damage tires, wheels, and vehicle suspension. In extreme circumstances they can also cause road accidents, particularly where there are higher speed limits. To avoid this there would need to be an increase in maintenance and repair works. All of the above could create traffic disruption (minor adverse).	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
		moisture but considered it would not be appropriate due to the local high groundwater levels.		embedded mitigation the likelihood of impact is low.		
Structures (including embankments, earthworks, bridges)						
Hotter summers	Hotter summers could reduce the asset lives of structures, for example causing: • Over expansion and buckling (e.g. of culverts or kerbs); or • Failure of expansion joints.	The design will ensure structures can adapt to expected future variations in temperature. The Eurocodes[58] used for the two bridges in the Scheme stipulate design to a temperature range of -18°C to 34°C which is adjusted to take account of altitude, material type and depth of surfacing thickness, etc.	Structures will be monitored throughout the life of the Scheme.	**Medium** - Following National Highways Guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that summer mean temperatures will increase over the Scheme's lifetime (by 2071-89 summer mean daily maximum temperatures could be up to +4.3ºC warmer [central estimate under emissions scenario RCP8.5]). With embedded mitigation in place the likelihood of impact is Medium. There is still likely to be some damage to assets during the lifespan of the Scheme.	**Minor adverse** - Emergency repairs and more regular maintenance interventions may be required, in response to changes in deterioration rates. These would create associated traffic delays (minor adverse). Under extreme temperature, certain maintenance activities may be required to be undertaken at night, to keep work to schedule, thus incurring higher programme costs (e.g. labour and	Not significant

[58] The Eurocodes are European standards specifying how structural design should be conducted within the European Union. These were developed by the European Committee for Standardisation upon the request of the European Commission.

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
					illumination) but causing less traffic disruption (negligible).	
Drier summers	Climate change could adversely affect soil stability impacting structures. This could affect physical assets (e.g. foundations) as well as semi natural features (e.g. embankments) and natural structures (e.g. trees). Impact pathways include: • The expected reduction in summer average rainfall is likely to intensify and extend soil moisture deficits and impact groundwater levels. This could impact soil stability, for example causing subsidence or increasing earth pressures • Wetter winters could cause soil instability as heave causes the upward	Risk will be managed by best practice design and construction. The geotechnical design will be in accordance with BS EN 1997-1:2004 Eurocode 7 Geotechnical Design Part 1 General rules. So, for example, cuttings and embankment works will be designed based on slope-stability analysis using site specific soil parameters. Additionally, to avoid waterlogging around embankments appropriate drainage will be included, for example so that runoff is collected and stored before being released gradually to infiltrate after a storm has passed, see DMRB, CG501 - Design of highway drainage systems. The geotechnical construction will be in line with DMRB Standards (DMRB CD 622 Managing Geotechnical Risk) so risks will be controlled, for example, by: • Providing appropriate soil compaction • Completing stability assessments as part of design. Including analysis and modelling to predict maximum and	Vulnerable assets in the study area will be regularly inspected to assess movements.	**Low** - Following National Highways guidance and in line with UKCP18 projections and the precautionary principle it is considered that there is medium certainty that summers will get drier over the Scheme's lifetime. The central estimate of change in mean summer precipitation by 2071-89 is -18.5% under RCP 8.5. However, the uncertainty around this estimate ranges from approximately -52% to -5% (represented by the 10th and 90th percentile respectively). With embedded mitigation in place the likelihood of impact is reduced to Low.	**Minor adverse** - Drier summers could damage assets and increase maintenance and upgrade works causing associated traffic disruption (minor adverse).	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
	movement of the ground; usually associated with the expansion of clay soils which swell when wet • Wetter winters and heavier rain could cause weakening or washout of structural soils • Wetter winters may increase regularity of soil saturation and increase risk of embankment collapse, i.e. landslip.	permittable magnitude of movement • Undertaking appropriate ground investigations • Collecting appropriate groundwater flow data • Where foundations extend below the existing groundwater table or could extend below the future groundwater level, they are designed in accordance with industry standards • Monitoring during the construction works to measure movements, with agreed trigger level and action plan. In addition to the above, existing vulnerable assets in the study area will be regularly inspected to assess movements. This will be supported by reference to the full arboricultural survey that has been completed for the site and identifies large and/or unstable trees.				
Drainage infrastructure						
Drier summers	Drier summers combined with the projected increase in summer temperatures could lead to increased erosion as soils and their substrates dry out.	Embankments will be compacted and planted; topsoil retention systems may be used if necessary. There will be three attenuation ponds, two of which will have sediment forebays with specific arrangements to remove sediment before the water reaches the	None	**Low** - Following National Highways Guidance and in line with UKCP18 projections and the precautionary principle it is considered that there is medium certainty that	**Minor adverse** - Mobilisation of debris could lead to increased sedimentation within the Scheme's drainage	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
		watercourse outfall. Sizing and treatment configuration have been confirmed by a sediment transport assessment. In addition to the above the Landscape and Visual Effects chapter (Chapter 7) of this ES has proposed the following embedded mitigation: • Retain existing trees and vegetation wherever possible • Replace areas of trees and grass lost to facilitate the works wherever practicable.		summers will get drier over the Scheme's lifetime. The central estimate of change in mean summer precipitation by 2071-89 is -18.5% under emissions scenario RCP8.5. However, the uncertainty around this estimate ranges from -52% to -5% (represented by the 10th and 90th percentile respectively). With embedded mitigation in place the likelihood of impact is reduced to Low.	infrastructure adversely affecting its capacity. This could increase maintenance requirements and risk of flooding which could both cause traffic disruption (minor adverse).	
Heavier rain and wetter winters	The projected climate trend of increasing frequency and intensity of heavy rainfall events is likely to increase the risk of pluvial or surface flooding as surface run-off inundates small catchments and the urban landscape. Prolonged periods of excessive precipitation (e.g. wetter winters) saturates soil,	The drainage system will be designed in line with current standards set out in DMRB CG 501[59]. This provides guidance for surface drainage for trunk roads including motorways. The design will include raising the riding surface, using an appropriate camber and providing appropriate maintenance. With regard to pluvial flood risk on the road surface, the surface water drainage system is designed to control runoff rates up to 1 in 100-year return period. Although there	None	**Low** - Following National Highways guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that rainfall will get heavier over the Scheme's lifetime. Emission scenario RCP 8.5 suggests that a central estimate of mean winter	**Minor adverse** - New assets could be damaged, for example by scour around structures, which would then require maintenance. Both flooding and additional maintenance/repair could cause road closures and associated traffic	Not significant

[redacted]

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
	increasing the risk of fluvial or river flooding. Above average precipitation for long periods can also lead to a raised water table, which can result in groundwater flooding in areas where the geological characteristics are favourable.	are various design storm-periods for different aspects of highway construction, ultimately the absolute rainfall thresholds are highly dependent on the local topography, adjacent land-use, gradient and location within the wider catchment. The DMRB standards highlight the importance of this local information to assess absolute rainfall thresholds. This information is provided in the Schemes Flood Risk Assessment (FRA) (APP-056), which also includes consideration and allowance for climate change. The FRA sets out the allowance that has been used for the surface water drainage design with adjustment factors in line with the latest information in the Planning Practice Guidance, EA and LLFA requirements. A 40% climate change allowance has been used for the preliminary drainage design, as outlined in the Drainage Design Strategy Report (APP-188). A climate change allowance has also been applied to fluvial flows for the design of the flood compensation areas (to determine their volume) and to determine the distance needed between the soffit of structures and the design flood water level of the rivers being crossed. In consultation with the EA, the “upper end” allowance of +70% to peak flows has been used when		precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. With embedded mitigation in place the likelihood of impact is Low.	delays (minor adverse).	

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
		investigating the designs resilience to climate change and the "higher central" (35%) allowance used to determine design levels. Since the programme of design, climate change allowances set out in the NPPF have been updated to include the H++ (95%) allowance. As such, a further sensitivity run of 95% increase in flows has been applied to examine the vulnerability of this type of development (Essential infrastructure) to future flood risk. Further information is presented in the Scheme's FRA (APP-056)				
Warmer winters	Warmer winters reduce freeze thaw erosion which can damage underground assets.	NA as impact is beneficial	NA as impact is beneficial	**Medium** - Following National Highways guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that winter mean temperatures will increase over the Scheme's lifetime (in winter, under the RCP8.5 emissions scenario, mean temperature is likely to increase by approximately 2.8ºC [central estimate]). However, projected	**Minor beneficial** - During the Scheme's operation maintenance and repair works and associated traffic disruption could reduce.	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
				changes to snowfall and the number of nights below freezing are less certain so the likelihood of this impact is found to be Medium.		
Road technology and street furniture (including signs and signals)						
Changes to extreme weather	Extreme weather impacts on electrical equipment: • More regular and intense storms in the future could increase the regularity of lightning strikes on infrastructure which could damage electrical equipment • Extreme hot temperatures increase thermal loadings on electrical and control equipment reducing their life.	At the detailed design stage, electrical calculations will be carried out for the lighting and a risk assessment detailed in section 443 of BS7671:2018[60] will be undertaken to determine if protection against transient overvoltage (lighting strike) is required. In advance of this, based on professional judgement and consideration of the location of the lighting power supplies/feeder pillars, it is expected at this stage that transient overvoltage protection will be included in the final design.	Key electrical components will be regularly checked, and replacement cycles may be shortened if deterioration rates increase.	**Very low** – Climate projections show there is low certainty of how climate change will alter extreme weather in the future. With embedded mitigation in place the likelihood of impact is very Low.	**Minor adverse** – Failure of the Scheme's lighting could cause traffic delays (minor adverse). To avoid this more regular maintenance may be required. This may itself cause traffic disruption (minor adverse).	Not significant
Changes to	High winds in more regular and intense	• The landscape design would adhere to the Specification for		**Very low** – Climate projections show there	**Minor adverse** – Partial road	Not significant

[redacted]

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
extreme weather	storms could overload small structures and damage roadside planting and furniture, for example traffic signs.	Highways Works set out in Series 3000 (Landscape and Ecology) of the Manual of Contract Documents for Highway Works[61]. The design will also adhere to DMRB LD 117 which sets out that shrubs must not be planted within 4.5 m of the carriageway and large trees not within 9 m of • The Applicant's own Adaptation Assessment[62] found that the effect of wind on bridges is minimal as it is not the dominant load. Fatigue actions due to wind gusting shall be determined in accordance with BS EN 1991-1-4, DMRB CD 365 and DMRB CD 354.		is low certainty of how climate change will alter extreme weather in the future. With embedded mitigation in place the likelihood of impact is Very Low.	closures for unplanned minor repairs could cause traffic disruption (minor adverse). To avoid this more regular maintenance may be required for example shorter intervention/ strengthening intervals.	
Landscaping						

[61] Manual of Contract Documents for Highway Works (MCHW), 2019, [redacted]
[62] Highways England Climate Adaptation Risk Assessment, 2016, [redacted]

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Hotter and drier summers	Hotter and drier summers will increase soil moisture deficits in the future which could negatively impact the Scheme's landscaping. The landscaping has aesthetic benefits but also prevents excessive aeolian soil erosion and protects structures from surface water runoff scour.	The proposed landscape design will futureproof the Scheme in terms of climate change as well as in terms of pests/diseases by adhering to best practice. This will include diversifying planting species as much as possible, including drought tolerant species, whilst still having regard to the local character, and generally planting only native species. It will also adhere to best ecological practice. The planting species mixes were selected following consideration of the following: • Dark Peak NCA (National Character Area) 51 Landscape Type Woodland and Hedgerow Species Mix • National Vegetation Classification (NVC) Classes • Scheme Ecology Phase 1 Habitat Surveys • Scheme Arboricultural Assessment • Forest Research Publication: Tree species suitability in a future climate in North West England.	None	**Medium** - Following National Highways Guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that summer mean temperatures will increase over the Scheme's lifetime (by 2071-89 summer mean daily maximum temperatures could be up to +4.3ºC warmer [central estimate under emissions scenario RCP8.5]). With embedded mitigation in place the likelihood of impact is Medium. There is still likely to be some damage to assets during the lifespan of the Scheme.	**Negligible** – Additional maintenance would cause minimal traffic disruption as it is unlikely to require lane closures.	Not significant

Table 14-18: Potential operational impacts on end user receptors

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Driver experience						
Warmer winters	Warmer winters will improve winter driver safety by reducing driving risks for road users as roads will be less icy and snowfall will reduce visibility less often.	NA as impact is beneficial.	NA as impact is beneficial.	**High** - Following National Highways guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that winter temperatures will increase over the Scheme's lifetime (in winter, under emissions scenario RCP8.5, mean temperature is likely to increase by approximately 2.8ºC [central estimate]). The likelihood of impact is therefore High.	**Minor beneficial** - Reduction in road traffic accidents and associated traffic disruption. Although it is noted that this beneficial impact would be equally present both with and without the Scheme.	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Hotter summers	Climate change will increase average summer temperatures. Vehicle breakdowns are more common during warm weather because the heat puts stress on critical components.	None	None	**Medium** - Following National Highways Guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that summer mean temperatures will increase over the Scheme's lifetime (by 2071-89 summer mean daily maximum temperatures could be up to +4.3ºC warmer [central estimate under emissions scenario RCP8.5]). With embedded mitigation in place the likelihood of impact is Medium.	**Minor adverse** - Breakdowns can have the following adverse effects: • Cause drivers to lose control of their vehicle - e.g. in the event of a tyre blowout or brake failure (both can be associated with warmer weather) • Increase the likelihood of vehicle fires and associated risks for road users • Be dangerous for drivers stranded in a live traffic lane • Cause secondary accidents involving other road users. All the above can cause minor adverse traffic disruption consequences (due to obstruction of traffic or as traffic slows to pass).	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Hotter drier weather	Climate change will increase average summer temperatures. During warm weather, accident rates typically increase. This is attributable to more solar glare, more people being out (particularly in the evening), more pedestrians and bikes on the road and an increase in fine particulates on the road surface which reduces skid resistance. Additionally, other contaminants, such as oil and tyre rubber can build up in drier weather acting as lubricants further reducing skid resistance.	The long-term landscape design does not include large areas of exposed soil that could become mobile in hot dry weather (blowing onto the road and reducing skid resistance). It is noted that risks associated with driving cannot be fully removed by changes to the Scheme design. This reflects the fact that the cause of most traffic accidents is composite and often includes driver error.	Regular maintenance assessments of the road will follow the National Highways skid policy which takes into account climate change[63].	**Medium** - Following National Highways guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is high certainty that summer mean temperatures will increase over the Scheme's lifetime (by 2071-89 summer mean daily maximum temperatures could be up to +4.3ºC warmer [central estimate under emissions scenario RCP8.5]). With embedded mitigation in place the likelihood of impact is Medium.	**Minor adverse** – More dangerous driving conditions in the future could increase road traffic accidents and associated traffic disruption (minor adverse).	Not significant

[63] Skidding resistance requirements, 2019, [redacted]

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Heavier rain and wetter winters	In the future heavier rain resulting from climate change will create dangerous driving conditions more often as spray reduces visibility, stopping distances increase and standing water creates an aquaplaning risk.	To inform the design of the Scheme, the FRA (APP-056) has been completed along with a Drainage Design Strategy Report (APP-188) and the Road Drainage and the Water Environment chapter (Chapter 8). This describes how the Scheme has ensured drainage will be sufficient for future rainfall. It is noted that risks associated with driving cannot be fully removed by changes to the Scheme design. This reflects the fact that the cause of most traffic accidents is composite and often includes driver error.	None	**Low** - Following National Highways guidance and in line with the UKCP18 projections and the precautionary principle it is considered that there is medium certainty that rainfall will get heavier over the Scheme's lifetime. Emissions scenario RCP8.5 suggests that a central estimate of mean winter precipitation change is an increase of 0.5 mm by 2071-89. Changes to extreme rainfall are less clear. With embedded mitigation in place the likelihood of this impact is reduced to Low.	**Minor adverse** - Accident rates could increase creating more traffic disruption (minor adverse).	Not significant

Climate trend	Potential impact	Embedded mitigation	Additional mitigation	Likelihood	Consequence	Significance
Changes to extreme weather	More frequent storms and high wind events could affect road user safety. High-sided vehicles can become unstable in gusts of wind over 45 mph. Windblown debris, including loads detached from vehicles and third-party structures blowing onto the network, as well as fallen trees could also be a hazard to vehicles traveling at speed.	The road alignment is not at a high elevation or topographically exposed, e.g. along a ridge. Significant traffic disruption related to wind exposure is therefore not expected. The landscape design will adhere to the Specification for Highways Works set out in Series 3000 (Landscape and Ecology) of the Manual of Contract Documents for Highway Works[64]. The design will also adhere to DMRB LD 117 which sets out that shrubs must not be planted within 4.5 m of the carriageway and large trees not within 9 m of it.	None	**Very low** – Climate projections show there is very low certainty of how climate change will alter extreme weather in the future.	**Minor adverse** - road traffic accidents and associated traffic disruption (minor adverse).	Not significant

[64] Manual of Contract Documents for Highway Works (MCHW), 2019[redacted]

14.10 Cumulative and in combination effects

Effects of the Scheme on Climate Change

14.10.1 Climate change is itself a cumulative effect in that it is the effect of GHG emissions worldwide, over time, on a single receptor. This assessment puts the Scheme in a wider context by comparing against the UK's Carbon Budgets.

Vulnerability of the Scheme to Climate Change

14.10.2 This section considers potential in-combination cumulative climate impacts affecting environmental receptors that are not covered elsewhere in this report, i.e. by the relevant topic chapters. It includes consideration of existing potential impacts on environmental receptors that could be intensified by climate change as well as environmental impacts that could potentially emerge in the future.

Intensification of air quality impacts

14.10.3 In the future air quality impacts caused, in part, by vehicle emissions enabled by the Scheme will be intensified as hotter summers brought on by climate change will increase the formation of ground-level ozone, which is a dangerous air pollutant. A detailed assessment of air quality impacts is provided in the Air Quality chapter (Chapter 5). It is noted that air quality modelling undertaken to date does not account for expected climate changes that will intensify air quality impacts in the future. However, these impacts will likely be offset by the predicted future fleet wide shift toward electric and hybrid vehicles.

Reduced road salting providing benefit for water environment

14.10.4 Warmer winters in the future will reduce the requirement for road salting. This may have benefits for the water environment in the study area with regard to water quality as road salt can be transported in surface water runoff and, in large quantities, can be harmful to aquatic life.

Lower river levels intensifying impacts from surface water runoff discharges

14.10.5 Most of the Scheme's surface water runoff is discharged to watercourses. Hotter and drier summers may lower water levels in these watercourses. In the future water quality impacts related to surface water drainage discharges, for example downstream of outfalls, could increase as the capability of these watercourses to dilute discharges reduces. The design includes Sustainable Drainage Systems (SuDS) which will maintain and manage the water quality and flow of discharges within appropriate thresholds prior to discharge. These have been designed with consideration of the impacts of climate change and so the Scheme's surface water discharges do not rely upon dilution to avoid environmental impacts.

More polluted surface water runoff impacting water environment

14.10.6 Climate change is projected to make summers drier, with occasional heavier convectional rainfall. Water quality in the watercourses, that surface water runoff from the Scheme is discharged into, may therefore in the future become more vulnerable to impacts from first flush events. This is when long periods of dry weather enable contaminants to build up on road surfaces. This then mobilise in surface water runoff following a heavy rainfall event and enters aquatic systems

via surface water runoff and drainage infrastructure en-masse. Pollutants in this runoff can be harmful to aquatic life.

14.10.7 Water quality impacts on the water environment are avoided by inclusion of adequate treatment within the Scheme's SuDS drainage infrastructure. This treatment is sized with regard to flood flows with a climate change allowance. The SuDS intercept any polluted run-off and treat it prior to discharge to a watercourse. The water treatment processes provided by the SuDS primarily comprises filtration and biological treatment within storage areas. The configuration of the SuDS and other treatment infrastructure is designed to manage the types of pollutant typically expected in road runoff.

14.11 NPS NN compliance

Effects of the Scheme on Climate Change

14.11.1 The NPS NN acknowledges that the emissions from the construction and operation of a road scheme are likely to be negligible compared to total UK emissions, and are unlikely to materially impact the UK Government's ability to meet its carbon reduction targets. However, the NPS NN requires evidence of the emissions impact of a scheme, an assessment of the emissions against the Government's Carbon Budgets, and evidence of mitigation measures. The assessment presented in this chapter provides the required evidence and assessment against targets. Embedded mitigation measures which the Scheme has employed include modification of the design to reduce the scale and complexity of construction, specification of materials which are likely to be able to be sourced locally and design of the Scheme to reduce congestion and allow vehicle engines to operate more efficiently in operation.

14.11.2 It is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets. In this context, it is considered unlikely that this Scheme will in isolation conclude significant effects on climate.

Vulnerability of the Scheme to Climate Change

14.11.3 The NPS NN (Department for Transport, 2014) includes a section on climate change adaptation from 4.36 to 4.47. Paragraph 4.40 of the NPS NN sets out that "new national networks infrastructure should be typically long-term investments which should remain operational over 'many decades in the face of a changing climate". As per the NPS NN requirement this chapter therefore considers how projected climate changes in the project area (section 14.7) could alter the design and operation of the Scheme (section 14.10).

14.12 Monitoring

Effects of the Scheme on Climate Change

14.12.1 It is not possible to directly monitor GHG emissions. However, the Carbon Tool will be populated on a quarterly / monthly return basis through the construction process and during maintenance activities through the life of the Scheme, as part of National Highways's existing reporting processes. The objective of this activity is to allow tracking of actual construction and maintenance emissions, which can

be compared against those forecast in this assessment. The scope and parameters of the reporting are as set out in the construction phase element of this assessment, to include material use and transport, transport of workers, and onsite construction processes. The Carbon Tool will be updated and shared by BBA with National Highways during construction, and by the Area Management Team during maintenance works in the operation phase. This would be included as a specific requirement in First iteration EMP (APP-183) and the REAC (APP-184).

14.12.2 In addition, a comprehensive carbon management plan is being developed for the Scheme, which would be implemented from the Detailed Design stage and through construction. This would follow a data collection and analysis methodology which adheres to the requirements of the PAS 2080 – Carbon Management in Infrastructure Verification technical standard (see Section 14.8.3). This would assess carbon use for the whole lifecycle of the project and promote embodied carbon management and commit to achieving carbon reductions.

Vulnerability of the Scheme to Climate Change

14.12.3 The additional mitigation identified in Section 14.10 includes monitoring of the Scheme's major assets resilience to climate throughout their life so that adaptive management actions can be implemented as required. This will be completed as part of regular asset inspections and during maintenance activities.

14.13 Summary

Effects of the Scheme on Climate Change

14.13.1 The Scheme would likely contribute a total of 439,997 tCO_2e emissions over the life of the Scheme, consisting of 38,970 tCO_2e in the construction phase and 401,026 tCO_2e in the operational phase, over 60 years of its operational life, of which 399,867 tCO_2e would result from additional road user emissions.

~~14.13.1~~14.13.2 The Scheme is likely to contribute 116,341 ~~116,332~~tCO_2e to the UK's Carbon Budgets across the period 2023-37, compared with the Do-Minimum scenario. The (net) contribution of the scheme to the Fourth Carbon Budget period would be 55,256 ~~55,253~~ tCO2e (equivalent to 0.0028% of that budget), including construction and operational phase emissions. The contribution of the scheme to the Fifth Carbon Budget would be 29,235 ~~29,231~~ tCO2e (equivalent to 0.0017% of that budget), from operational emissions. The contribution of the scheme to the Sixth Carbon Budget would be 31,850 ~~31,848~~ tCO2e (equivalent to 0.0033% of that budget). It is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets. In this context, it is considered unlikely that this Scheme will in isolation conclude significant effects on climate. However, mitigation measures have been embedded into the Scheme design (Section 14.9) to reduce emissions as far as possible.

Vulnerability of the Scheme to Climate Change

~~14.13.2~~14.13.3 This chapter has presented the Scheme's climate change vulnerability assessment. The assessment considered the potential impacts of extreme weather and possible future climatic conditions on the Scheme during both its construction and operation and has been undertaken in compliance with DMRB LA 114.

~~14.13.3~~14.13.4 Climate projections from UKCP18 have been examined. They confirm that the study area's climate is expected to change in the future. The assessment finds that the Scheme could be vulnerable to operational impacts linked to these changes in the climate. Mitigation measures that either avoids these impacts, minimises them or reduces their consequences are presented. After consideration of this mitigation none of the potential climate vulnerability effects are found to be significant.

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