M60/M62/M66 Simister Island Interchange

TR010064

ENVIRONMENTAL STATEMENT
CHAPTER 14 CLIMATE

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

M60/M62/M66 Simister Island Interchange

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ENVIRONMENTAL STATEMENT
CHAPTER 14 CLIMATE

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14.1 Introduction

14.1.1 This chapter presents the information required by the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 to be provided in the Environmental Statement for the M60/M62/M66 Simister Island Interchange (the 'Scheme') in respect of climate. This chapter considers both:

- The impact of the Scheme on climate (for example, the nature and magnitude of greenhouse gas (GHG) emissions)
- The vulnerability of the Scheme to climate change

14.1.2 This assessment has been undertaken in accordance with Design Manual for Roads and Bridges (DMRB) LA 114 (Highways England, 2021a). As per DMRB LA 114, the assessment set out in this chapter considers the impact of the Scheme on climate and the effects of climate on the Scheme during both its construction and operation.

14.1.3 This chapter is supported by the following Environmental Statement Figures (TR010064/APP/6.2):

- Figure 14.1: Study Area for Operational Road User Greenhouse Gas Emissions
- Figure 14.2: Construction Areas Used for Land Use Change Greenhouse Gas Emissions Calculations
- Figure 14.3: Operational Areas Used for Land Use Change Greenhouse Gas Emissions Calculations

14.1.4 This chapter is supported by the following Environmental Statement Appendices (TR010064/APP/6.3):

- Appendix 14.1: Estimation of Greenhouse Gas Emissions
- Appendix 14.2: Vulnerability Assessment

Impact of the Scheme on climate

14.1.5 The Scheme has the potential to affect Earth's climate by causing (either directly or indirectly) the emission of GHGs into the atmosphere, both as a result of its construction and throughout its operational life. Earth absorbs energy from the Sun and re-emits this energy as thermal infrared radiation. The GHGs in the atmosphere absorb this radiation, preventing it from escaping into space. The higher the concentration of GHGs in the atmosphere, 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 warming leads to numerous indirect impacts (including hotter, drier summers; warmer, wetter winters; and more frequent and intense extreme weather events) as the climate responds to the increased atmospheric temperature.

14.1.6 As a result, the UK has entered into international obligations including the Paris Agreement (United Nations Framework Convention on Climate Change, 2016), which was ratified by the UK Government in 2016. In order to fulfil these obligations, the UK has established the 'Net Zero target' for 2050 and implemented carbon budgets under the Climate Change Act 2008.

14.1.7 In June 2019 the Government announced its 2050 ‘Net Zero target’, which was a significant step towards carbon reduction and alignment with the Paris Agreement.. This is a legally binding target for the Government to cut carbon emissions to net zero, against the 1990 baseline, by 2050. The Climate Change Act requires five-yearly carbon budgets to be set 12 years in advance so as to meet the 2050 target. Six carbon budgets have been adopted to-date, which are enshrined into law through the implementation of the Climate Orders. These orders serve as legislative mechanisms that enshrine the carbon budgets, ensuring their legal enforceability and accountability. The time periods covering the fourth, fifth and sixth budgets are 2023-2027, 2028-2032 and 2033-2037 respectively. Achieving net zero will require the UK's future GHG emissions to be aligned with these budget targets and any future new or revised carbon budget targets that may be set out by Government to achieve net zero carbon by 2050, i.e. a 100% reduction in the UK’s carbon emissions by 2050 compared with those in 1990.

14.1.8 In accordance with paragraphs 3.18 to 3.20 of DMRB LA 114, estimated GHG emissions associated with the Scheme have been compared to and assessed against relevant UK carbon budgets (see Section 14.10 of this chapter). The only statutory carbon targets are the carbon budget targets and the Net Zero 2050 target that are set at a national level i.e. they are targets for the UK as a whole. The Applicant is not aware of any relevant non-statutory targets. There are no sectoral targets (e.g. for transport), nor any targets set at a sub-national geographic scale. The Net Zero 2050 and the carbon budget targets are themselves cumulative as they are a sum of carbon emissions for a range of sectors. In addition to the absence of sectoral or sub-national scale targets for carbon emissions, it is not possible for the Applicant to produce a baseline at such scales. Accordingly, there is no reasonable basis upon which the Applicant can assess the potential likely significant effect of the Scheme's carbon emissions at anything other than at the national level.

14.1.9 The effective assessment and management of GHG emissions offers the opportunity to reduce the impact of the Scheme on climate by reducing the magnitude of GHG emissions, as far as practicable.

14.1.10 Where it is practical and proportionate to do so (e.g. where industry recognised emission factors are available), this chapter has considered emissions of the seven GHGs that contribute to climate change, namely:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)

- Perfluorocarbons (PFCs)
- Nitrogen trifluoride (NF_3)
- Sulphur hexafluoride (SF_6).

14.1.11 As required by DMRB LA 114, these GHG emissions have been expressed throughout this chapter as emissions of carbon dioxide equivalent (CO_2e).

Vulnerability of the Scheme to climate change

14.1.12 It is important that UK infrastructure schemes are designed to be resilient to projected changes in climate (e.g. higher temperatures, heavier rainfall and more extreme weather events).

14.1.13 As a result, this chapter provides an assessment of the potential vulnerability of the Scheme to current and potential future climatic conditions during both its construction and operation.

14.2 Competent expert evidence

14.2.1 The assessment has been undertaken and reported by a team of competent specialists. The competent expert responsible for the assessment is a Technical Director for climate and air quality who has a Bachelor of Engineering (Honours) in Environmental Engineering and a Master of Science in Geographical Information Science. The competent expert is also a member of the Institution of Environmental Science (MIEnvSci) and a Chartered Environmentalist (CEnv) and has over 20 years' experience in undertaking climate assessments for major infrastructure and linear schemes, including highways, for which the process of Environmental Impact Assessment (EIA) has been required.

14.3 Legislative and policy framework

Legislation

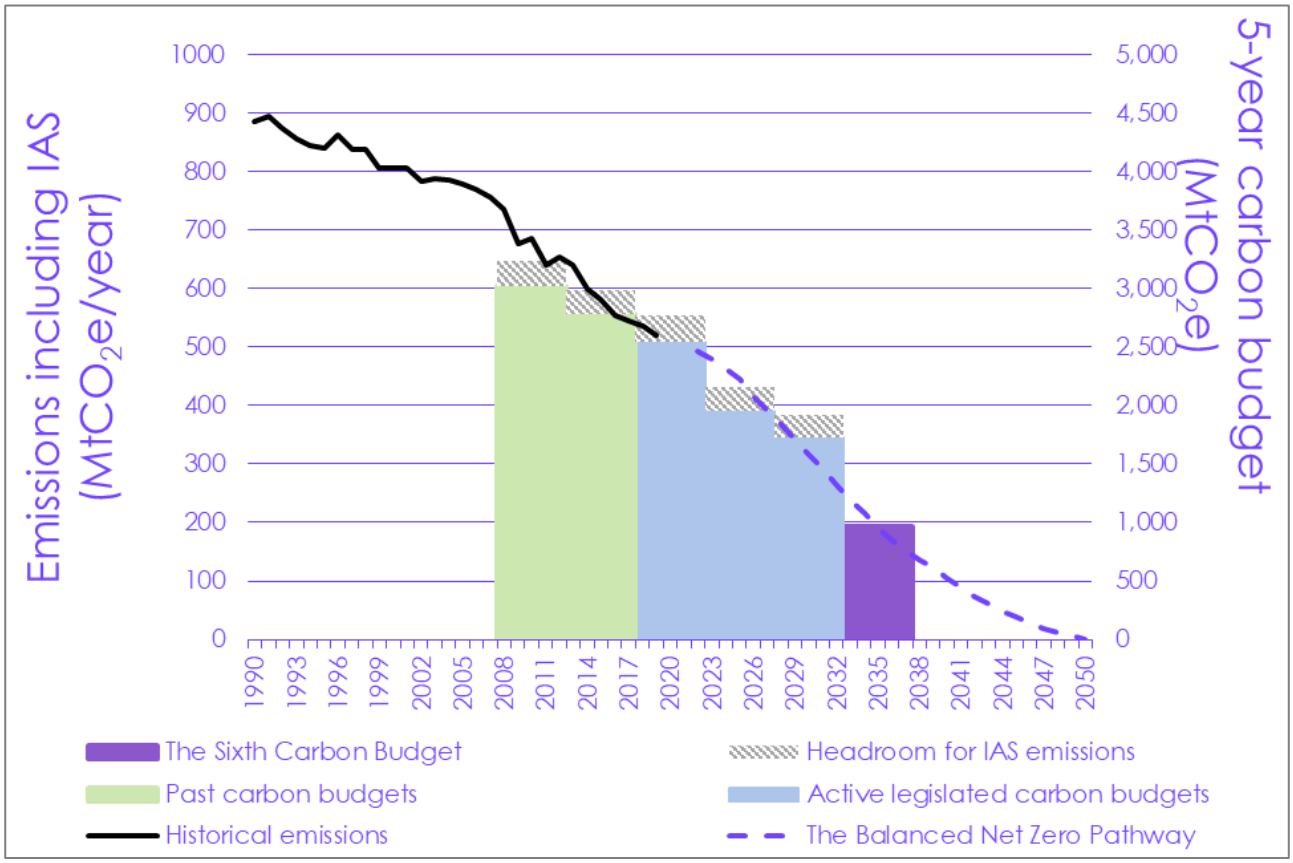
14.3.1 The climate assessment has been undertaken in accordance with the legislation set out in Table 14.1.

Table 14.1 Legislation relevant to the climate assessment

Legislation	Relevance to the scheme	How this legislation is addressed in the assessment
Climate Change Act 2008 Carbon Budget Order 2011, Carbon Budget Order 2016 and Carbon Budget Order 2021	The Climate Change Act 2008 commits the UK to reducing carbon emissions to net zero by 2050. 'Net zero' means that the UK carbon account for the year 2050 is at least 100% lower than the net UK emissions of GHGs for the 1990 baseline. The Climate Change Act 2008 also requires the Secretary of State to set legally binding carbon budgets over five-year periods and to ensure that net UK carbon emissions do not exceed these budgets. The UK Government carbon budgets which have been set to-date and that are relevant to the Scheme are as follows: • The fourth carbon budget: 2023 – 2027 defined within The Carbon Budget Order 2011 – 1,950MtCO_2e, equivalent to a 50% reduction in annual emissions from a 1990 baseline • The fifth carbon budget: 2028 – 2032 defined within The *Carbon Budget Order 2016* – 1,725MtCO_2e, equivalent to a 57% reduction in annual emissions from a 1990 baseline • The sixth carbon budget: 2033 – 2037 defined within The Carbon Budget Order 2021 – 965MtCO_2e, equivalent to a 78% reduction in annual emissions from a 1990 baseline. It is also the first budget which is in line with the 2050 net zero carbon target. These carbon budgets are summarised in Plate 14.1.	In accordance with paragraphs 3.11 to 3.20 of DMRB LA 114, changes in GHG emissions associated with the construction and operation of the Scheme have been estimated and compared to relevant UK carbon budgets in order to assess their significance (see Section 14.10 of this chapter). The Climate Change Act 2008 does not impose a legal duty to set carbon budgets at a smaller scale than those set out nationally. There are no legal duties that require particular geographical areas within the UK to achieve particular reductions in GHG emissions by particular dates. There are no legal duties to identify and set any sectoral targets for GHG reductions related to transport, or any other sector. There is no requirement in the Climate Change Act 2008, or in Government policy, for GHG emissions for all road transport to become net zero.

14.3.2 On 12 December 2020, the UK communicated its new Nationally Determined Contribution under the Paris Agreement to the United Nations Framework Convention on Climate Change. The Nationally Determined Contribution commits the UK to reducing economy-wide GHG emissions by at least 68% by 2030, compared to 1990 levels (UK Government, 2020).

Plate 14.1 UK carbon budgets set to achieve net zero carbon by 2050 (Committee on Climate Change, 2020)



Policy

National Policy Statement for National Networks

14.3.3 The National Policy Statement for National Networks (NPS NN) (Department for Transport (DfT), 2014) sets out the Government's policies relating to the development of Nationally Significant Infrastructure Projects (NSIPs) on the national road and rail networks in England. The Secretary of State uses the NPS NN as the primary basis for making decisions on Development Consent Order (DCO) applications.

14.3.4 The NPS NN was, however, written in 2014, before the Government's legal commitment to achieving net zero by 2050, the new Sixth Carbon Budget (see Table 14.1) and the publication of the Transport Decarbonisation Plan (TDP) (DfT, 2021). While the NPS NN continues to remain in force, the DfT has committed to review it in the light of these developments, and update forecasts on which it is based to reflect more recent, post-pandemic conditions, once they are known.

14.3.5 Table 14.2 summarises the policy requirements from the NPS NN relating to the applicant's assessment and mitigation requirements for climate and how these requirements have been addressed in the assessment. See also the NPS NN Accordance Tables (TR010064/APP/7.2) for an assessment of the Scheme's compliance with the NPS NN.

Table 14.2 NPS NN requirements for climate

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
4.40	'*New national networks infrastructure will be typically long-term investments which will need to remain operational over many decades, in the face of a changing climate. Consequently, applicants must consider the impacts of climate change when planning location, design, build and operation. Any accompanying environment statement should set out how the proposal will take account of the projected impacts of climate change.'*	In accordance with paragraphs 3.26 to 3.45 of DMRB LA 114, possible future changes in climate over a 60-year appraisal period, and potential impacts on the Scheme associated with these climatic changes, have been considered. Measures to mitigate these potential impacts, which are embedded within the design of the Scheme, are identified within this aspect chapter and residual risks are assessed (see Sections 14.7 to 14.10 of this chapter).
4.41	'*Where transport infrastructure has safety-critical elements and the design life of the asset is 60 years or greater, the applications should apply the UK Climate Projections 2009 (UKCP09) high emissions scenario (high impact, low likelihood) against the 2080 projections at the 50% probability level*.'	In accordance with paragraph 3.28 of DMRB LA 114, the latest available projections (i.e. UK Climate Projections 2018 (UKCP18)) have been used for the high emissions (i.e. Receptor Concentration Pathway (RCP) 8.5) scenario against the 2080 projections at the 50% probability level. UKCP18 supersede UKCP09 and are considered to provide a better estimate of future climate conditions.
4.42	'*The applicant should take into account the potential impacts of climate change using the latest UK Climate Projections available at the time and ensure any environment statement that is prepared identifies appropriate mitigation or adaptation measures. This should cover the estimated lifetime of the new infrastructure. Should a new set of UK Climate Projections become available after the preparation of any environment statement, the Examining Authority should consider whether they need to request additional information from the applicant.'*	The UKCP18 projections are the latest available and have been used to understand possible changes in climate over the lifetime of the Scheme (i.e. up to the 2080s), as per paragraphs 3.31 and 3.32 of DMRB LA 114. Based on these possible changes in climate, mitigation measures embedded within the design of the Scheme have been identified and presented within this assessment (see Section 14.9 of this chapter).

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
4.43	'*The applicant should demonstrate that there are no critical features of the design of new national networks infrastructure which may be seriously affected by more radical changes to the climate beyond that projected in the latest set of UK climate projections. Any potential critical features should be assessed taking account of the latest credible scientific evidence on, for example, sea level rise (e.g. by referring to additional maximum credible scenarios such as from the Intergovernmental Panel on Climate Change or Environment Agency) and on the basis that necessary action can be taken to ensure the operation of the infrastructure over its estimated lifetime through potential further mitigation or adaptation.'*	DMRB LA 114 states that climate assessments should use the H++ climate scenarios to test the sensitivity of vulnerable safety-critical features, to ensure that such features would not be affected by more radical changes to the climate beyond that projected in the latest set of UK Climate Projections. The H++ scenarios cover heat waves, cold snaps, low and high rainfall, droughts, floods and windstorms. However, of these climate related events, the greatest risks to safety critical features (e.g. structures) are considered likely to be those associated with flooding. The H++ scenarios were developed using a set of climate change projections which have since been superseded (i.e. UKCP09); however, the Met Office does not propose to update these scenarios using UKCP18. Following the publication of updated guidance on climate change allowances, the H++ scenarios are no longer used to inform peak river flow allowances on highway schemes. As discussed in Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1), however, consideration has been given to potential changes to the risk of flooding should more radical changes in climate occur. It is, however, considered unlikely that such changes would substantially increase the risk of flooding to the Scheme. As the Scheme is located in Flood Zone 1 (i.e. at less than 0.1% chance of flooding in any year), hydraulic modelling has not been undertaken, nor an assessment of a H++ scenario.

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
4.44	'*Any adaptation measures should be based on the latest set of UK Climate Projections, the Government's national Climate Change Risk Assessment and consultation with statutory consultation bodies. Any adaptation measures must themselves also be assessed as part of any environmental impact assessment and included in the environment statement, which should set out how and where such measures are proposed to be secured.'*	The UKCP18 projections are the latest available and have been used to understand possible changes in climate over the lifetime of the Scheme (i.e. up to the 2080s) within this chapter. The Independent Assessment of UK Climate Risk (Climate Change Committee, 2021a), which provides advice to the Government to inform the UK's third Climate Change Risk Assessment (CCRA3), has also been reviewed as part of this assessment (see Section 14.7 of this chapter). As noted in Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1), climate change uplifts based on the latest published Environment Agency guidance (May 2022) have informed the design of the Scheme. Based on the above, mitigation measures embedded within the design of the Scheme have been identified and presented within this chapter, along with essential mitigation measures, which are presented within the Register of Environmental Actions and Commitments (REAC), which is contained within the First Iteration Environmental Management Plan (EMP) (TR010064/APP/6.5) (see Section 14.9 of this chapter for further details).

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
5.17	*'Carbon impacts will be considered as part of the appraisal of scheme options (in the business case), prior to the submission of an application for DCO. Where the development is subject to EIA, any Environmental Statement will need to describe an assessment of any likely significant climate factors in accordance with the requirements in the EIA Directive. 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. However, for road projects applicants should provide evidence of the carbon impact of the project and an assessment against the Government's carbon budgets.'*	In accordance with paragraphs 3.11 to 3.20 of DMRB LA 114, changes in GHG emissions associated with the construction and operation of the Scheme have been estimated and compared to relevant UK carbon budgets in order to assess their significance (see Section 14.10 of this chapter).
5.19	*'Evidence of appropriate mitigation measures (incorporating engineering plans on configuration and layout, and use of materials) in both design and construction should be presented. The Secretary of State will consider the effectiveness of such mitigation measures in order to ensure that, in relation to design and construction, the carbon footprint is not unnecessarily high. The Secretary of State's view of the adequacy of the mitigation measures relating to design and construction will be a material factor in the decision making process.'*	Mitigation measures have been identified (see Section 14.9 of this chapter) which would reduce GHG emissions associated with the Scheme, both in terms of its design and its construction. These measures are considered likely to substantially reduce the carbon footprint of the Scheme.

Draft National Policy Statement for National Networks

14.3.6 The Government has published a draft of the NPS NN in March 2023 (DfT, 2023). The consultation closed in June 2023 and the draft NPS NN has not yet been designated. However, it is potentially capable of being an important and relevant consideration in the decision-making process. The Environmental Statement continues to reference the 2014 NPS NN though, as it remains the relevant Government policy. Notwithstanding that position, Table 14.3 summarises the policy requirements from the draft NPS NN relating to good design, climate change adaptation, the applicant's assessment and mitigation requirements for climate and how these have been addressed in the assessment. See also the NPS NN Accordance Tables (TR010064/APP/7.3) for an assessment of the Scheme's compliance with the draft NPS NN.

Table 14.3 Draft NPS NN requirements for climate

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
4.24	*'Applicants should include design as an integral consideration from the outset of a proposal. Applying good design to national network projects should not be limited to general aesthetics. High quality and inclusive design goes far beyond aesthetic considerations. It demonstrates an understanding of context, local needs, history and culture, enhances local landscape character and is adaptable to future needs and technologies. The National Infrastructure Design Principles describes good design as:* • *a key aspect of sustainable development. It includes opportunities to enable decarbonisation, incorporates flexibility, and builds resilience against climate change. The functionality of projects, including fitness for purpose, resilience and sustainability, is equally important.'*	Measures which have been embedded within the design of the Scheme to reduce GHG emissions and improve the vulnerability of the Scheme to future changes in climate are described in Section 14.9 of this chapter.

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
4.35	*'In preparing measures to support climate change adaptation applicants should consider whether nature-based solutions could provide a basis for such adaptation. In addition to avoiding further greenhouse gas emissions when compared with some more traditional adaptation approaches, nature-based solutions can also result in biodiversity benefits as well as increasing absorption of carbon dioxide from the atmosphere (see also paragraphs 5.170 to 5.194 on the role of green infrastructure).'*	The Scheme design has considered a variety of options for the mitigation of potential surface water drainage and flood risk impacts, including nature based solutions. Where practicable, sustainable drainage systems (SuDS), flow conveyance and attenuation features (e.g. attenuation ponds, swales, filter drains, etc.) have been used to reduce the impact of surface water runoff being discharged on the natural environment, thereby reducing flood risk and improving water quality. These measures, in particular SuDS, typically include areas of planting and therefore also have the potential to improve biodiversity and absorb small amounts of CO_2 from the atmosphere. Further information is included in Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1) and Appendix 13.7: Drainage Strategy Report of the Environmental Statement Appendices (TR010064/APP/6.3).
4.36	*'New national networks infrastructure will typically be a long-term investment and will need to remain operational over many decades, in the face of a changing climate. Consequently, applicants must consider the direct (e.g. flooding of road or rail infrastructure) and indirect (e.g. flooding of other parts of the road or rail network) impacts of climate change when planning the location, design, build, operation and maintenance. The Secretary of State will need information on how the proposal will take account of the projected impacts of climate change and remain resilient.'*	The Scheme design has been developed taking into account the potential implications of climate change such as resilience of the Scheme to flooding and high temperatures. The EIA process has considered the effects of possible future changes in climate over a 60-year appraisal period. The potential impacts of these climatic changes on the Scheme have been assessed in Section 14.10 of this chapter. The drainage design has been developed taking into account future potential increases in flooding, while the impacts have been considered in Appendix 13.6: Flood Risk Assessment (FRA) Report of the Environmental Statement Appendices (TR010064/APP/6.3). The Environment Agency's guidance on climate change allowances has been used (Environment Agency, 2022).

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
4.37	*'The Secretary of State should be satisfied that applications for new national networks infrastructure have taken into account the potential direct and indirect impacts of climate change. This should include using the latest UK Climate Projections and associated research and expert guidance (such as the Environment Agency's Climate Change Allowances for Flood Risk Assessments applicable at the time the environmental assessment was prepared as part of their Development Consent Order application, to ensure they have identified mitigation or adaptation measures. This should cover the estimated lifetime of the new infrastructure, with a high level of climate resilience built-in from the outset. The applicant should also be able to demonstrate how proposals can be adapted over their predicted lifetimes to remain resilient to a credible maximum climate change scenario. Should a revised set of UK Climate Projections or associated research be applicable after the preparation of the environmental assessment, the Examining Authority should consider whether they need to request further information from the applicant.'*	The UKCP18 projections are the latest available and have been used to understand possible changes in climate over the lifetime of the Scheme (i.e., up to the 2080s), in accordance with paragraphs 3.31 and 3.32 of DMRB LA 114. Based on these potential changes in climate, mitigation measures embedded within the design of the Scheme have been identified and presented within Section 14.9 of this chapter. With regards to flood risk, Government guidance on climate change consideration for fluvial and surface water flows has been followed. The details of the methodology and assessment together with mitigation and adaptation measures are included in Appendix 13.6: FRA Report of the Environmental Statement Appendices (TR010064/APP/6.3).

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
4.38	*'The Secretary of State should be satisfied that there are no features of the design of new national networks infrastructure critical to its safety or operation which may be seriously affected by more radical changes to the climate. Beyond that projected in the latest set of UK climate projections and taking account of the latest credible scientific evidence on, for example, sea level rise. The Secretary of State should also be satisfied that necessary action can be taken to ensure the operation of the infrastructure over its estimated lifetime.'*	DMRB LA 114 states that climate assessments should use the H++ climate scenarios to test the sensitivity of vulnerable safety-critical features, to ensure that such features would not be affected by more radical changes to the climate beyond that projected in the latest set of UK Climate Projections. The H++ scenarios cover heat waves, cold snaps, low and high rainfall, droughts, floods and windstorms. However, of these climate related events, the greatest risks to safety critical features (e.g. structures) are considered likely to be those associated with flooding. The H++ scenarios were developed using a set of climate change projections which have since been superseded (i.e. UKCP09); however, the Met Office does not propose to update these scenarios using UKCP18. Following the publication of updated guidance on climate change allowances, the H++ scenarios are no longer used to inform peak river flow allowances on highway schemes. As discussed in Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1), however, consideration has been given to potential changes to the risk of flooding should more radical changes in climate occur. It is, however, considered unlikely that such changes would substantially increase the risk of flooding to the scheme. As the scheme is located in Flood Zone 1 (i.e. at less than 0.1% chance of flooding in any year), hydraulic modelling has not been undertaken, nor an assessment of a H++ scenario.

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
4.39	*'Any adaptation measures should be based on the latest set of UK Climate Projections, the government's latest UK Climate Change Risk Assessment, when available and in consultation with the Environment Agency's Climate Change Allowances for Flood Risk Assessments. Any adaptation measures must themselves also be assessed as part of any environmental assessment, which should set out how and where such measures are proposed to be secured.'*	The UKCP18 projections are the latest available and have been used to understand possible changes in climate over the lifetime of the Scheme (i.e. up to the 2080s), in accordance with paragraphs 3.31 and 3.32 of DMRB LA 114 Climate. Based on these probable changes in climate, mitigation measures embedded within the design of the Scheme have been identified and presented within Section 14.9 of this chapter. With regards to flood risk, Government guidance on climate change consideration for fluvial and surface water flows has been followed. The details of the methodology and assessment are included in Appendix 13.6: FRA Report of the Environmental Statement Appendices (TR010064/APP/6.3). As stated in Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1), no adaptation measures have been identified.
5.29	*'A whole life carbon assessment should be used to measure greenhouse gas emissions at every stage of the proposed development to ensure that emissions are minimised as far as possible as we transition to net zero. This includes the construction, maintenance, operation and use of the asset across its entire lifecycle. This is critical at early stages of project planning, for example, the conception stage, because the ability to reduce whole life carbon emissions is increasingly more limited as the project passes through detailed design and enters construction.'*	In accordance with paragraphs 3.11 to 3.20 of DMRB LA 114, changes in GHG emissions associated with the construction, maintenance and operation of the Scheme have been estimated and compared to relevant UK carbon budgets to assess their significance (see Section 14.10 of this chapter). Whilst a whole life carbon assessment was undertaken at the current stage (as reported within this chapter), whole life carbon assessments were not undertaken at earlier stages of the Scheme, as there was no requirement to do so under the NPS NN.

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
5.30	*'All proposals for national network infrastructure projects should include a whole life carbon assessment at critical stages in the project lifecycle, for example the submission of a major business case. This should be conducted according to the guidance, standards and methodologies set out in Transport Appraisal Guidance Unit A3. Also refer to the Environmental Assessment at paragraphs 4.10 to 4.11 for more information about cumulative assessment.'*	A whole life carbon assessment has been undertaken, in accordance with Transport Analysis Guidance (TAG) Unit A3 (Dft, 2023b), which has been used to inform the business case for the Scheme.
5.31	*'Having regard to current knowledge, a carbon management plan should be produced as part of the Development Consent Order submission and include:* • *an explanation of the steps that have been taken to drive down the climate change impacts at each of those stages* • *how operational emissions and, where applicable, emissions from maintenance activities, have been reduced as much as possible through the application of best available technology for that type of technology (recognising that in the case of road projects while the developer can estimate the likely emissions from road traffic, it is not solely responsible for controlling them)* • *whether and how any residual carbon emissions will be (voluntarily) offset or removed using a recognised framework*	An Outline Carbon Management Plan, which is included in Appendix O of the First Iteration EMP (TR010064/APP/6.5), has been produced for the current Scheme stage (i.e. the preliminary design stage), which is focussed on reducing embodied carbon emissions (e.g. emissions associated with the production of raw materials). The Outline Carbon Management Plan will be developed into the Carbon Management Plan, under the Second Iteration EMP, which is secured through Requirement 4 of the draft DCO (TR010064/APP/3.1).

Paragraph reference	Applicant's assessment / mitigation requirement	How this requirement is addressed in the assessment
	• *where there are residual emissions, the level of emissions and the impact of those on national and international efforts to limit climate change, both alone and where relevant in combination with other developments at a regional or national level, or sector level, if statutory sectoral targets are developed and come into force.'*	
5.32	*'Applicants should look for opportunities within the design of the proposed development to embed nature-based or technological solutions to mitigate, capture or offset the emissions of construction.'*	Both embedded and essential mitigation measures are detailed in Section 14.9 of this chapter.
5.33	*'Steps taken to minimise, capture and offset emissions in design and construction, should be set out in a Greenhouse Gas Reduction Strategy, secured under the Development Consent Order. This Strategy could include, for example, mitigation through woodland creation on or adjacent to the site and registered with the Woodland Carbon Code, contributing significantly to offsetting residual emissions. Applicants may wish to refer to the Institute of Environmental Management and Assessment Greenhouse Gas Management Hierarchy guidance when drafting their Greenhouse Gas Reduction Strategy.'*	Appendix O: Outline Carbon Management Plan of the First Iteration EMP (TR010064/APP/6.5) describes the steps that will be taken to minimise GHG emissions during construction. Relevant embedded (design) and essential mitigation measures are also described in Section 14.9 of this chapter. Areas of woodland would be created within the Order Limits, which (as shown in Table 14.23 of this chapter) is estimated to result in slight increase in carbon sequestration (i.e. a net reduction in GHG emissions) during the operation of the Scheme. However, there are currently no plans to register this woodland with the Woodland Carbon Code.

Other relevant policy

14.3.7 In addition to the NPS NN, other relevant policy has been considered as part of the climate assessment. Table 14.4 sets out other policy relevant to this aspect and how the assessment has considered/addressed these policies.

Table 14.4 Other national, regional and local policy relevant to climate

Plan / policy document	Key requirements and objectives	How this has been considered/addressed in the assessment
National		
National Planning Policy Framework (NPPF) (Department for Levelling Up, Housing and Communities (DLUHC), last updated 2023). The NPPF sets out the Government's planning policies for England and how these should be applied.	Paragraph 154 of the NPPF states that *'New development should be planned for in ways that:* *a) 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; and* *b) can help to reduce greenhouse gas emissions, such as through its location, orientation and design.'*	This chapter identifies possible changes in climate (Section 14.7 of this chapter), the potential impacts associated with these changes (Section 14.8 of this chapter) and the measures embedded within the design of the Scheme to mitigate these impacts (Section 14.9 of this chapter). Section 14.10 of this chapter provides an assessment of the residual risk of each impact based on the assumed likelihood and consequence of each potential impact occurring. As identified in Section 14.9 of this chapter, a number of mitigation measures have been or would be implemented in order to reduce GHG emissions associated with the Scheme.
National Planning Practice Guidance (NPPG): Climate (DLUHC and Ministry of Housing, Communities and Local Government (MHCLG), 2019).	This guidance advises Local Planning Authorities on how to identify suitable mitigation and adaptation measures in the planning process to address the impacts of climate change.	

Plan / policy document	Key requirements and objectives	How this has been considered/addressed in the assessment
Regional and Local		
Local Development Framework Core Strategy Development Plan Document (Manchester City Council, 2012)	Policy EN 4 sets out the target to reduce CO_2 emissions by enabling low and zero carbon development. Policy EN 6 sets out a target framework for CO_2 reductions from low or zero carbon energy supplies. Policy EN 8 states that all new developments will be expected to be adaptable to climate change.	Mitigation measures are embedded within the Scheme design and would be implemented (as set out in the REAC, which is contained within the First Iteration EMP (TR010064/APP/6.5)) in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 14.9 of this chapter). Energy efficient light emitting diode (LED) lighting would also be used during the operation of the Scheme, in order to reduce operational energy consumption (and associated GHG emissions).
Greater Manchester Places for Everyone Publication Plan (Greater Manchester Combined Authority (GMCA), 2022)	Policy JP-S 1 Sustainable Development states '*to help tackle climate change, development should aim to maximise its economic, social and environmental benefits simultaneously, minimise its adverse impacts, utilise sustainable construction techniques and actively seek opportunities to secure net gains across each of the different objectives. Preference will be given to using previously-developed land… to meet development needs*'. Policy JP-S 2 Carbon and Energy sets '*the aim of delivering a carbon neutral Greater Manchester no later than 2038… through a range of measures*'. This includes '*promoting the use of life cycle cost and carbon assessment tools to ensure the long term impacts from development can be captured*'.	Mitigation measures are embedded within the Scheme design and will be implemented (as set out in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)), in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 14.9 of this chapter).

Plan / policy document	Key requirements and objectives	How this has been considered/addressed in the assessment
		The mitigation hierarchy set out in paragraph 3.22.1 of DMRB LA 114 has been followed when developing GHG mitigation measures, namely firstly seeking to avoid / prevent GHG emissions, then to reduce emissions and finally to remediate emissions (where practicable to do so).
Bury Local Plan Policy Directions (Bury Metropolitan Borough Council, 2018)	The Bury Local Plan is currently in preparation. The Policy Directions document sets out the proposed scope for planning policies that the Local Plan will contain. Policy Direction OP3 states that *'it is proposed that the Local Plan should include a policy that seeks to take a proactive approach towards mitigating against and adapting to the cause and effects of climate change.'*	Mitigation measures are embedded within the Scheme design and will be implemented (as set out in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)), in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 14.9 of this chapter).
Joint Core Strategy and Development Management Policies (Oldham Metropolitan Borough Council, November 2011).	Policy 1 Climate Change and Sustainable Development states that '*development should adapt to and mitigate against climate change and address the low carbon agenda…*'	Mitigation measures are embedded within the Scheme design and will be implemented (as set out in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)), in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 14.9 of this chapter).

Plan / policy document	Key requirements and objectives	How this has been considered/addressed in the assessment
Rochdale Core Strategy (Rochdale Borough Council, February 2017).	Policy P3 – Improving design of new development, sets several design principles including to: '*minimise impact upon the environment, and help adapt to the impacts of climate change, including by re-using existing buildings and materials (maximising the benefits of existing embodied energy) and utilising sustainable drainage.*' Strategy SO4 – to promote a greener environment refers to a focus on '*minimising Rochdale's contribution to climate change and mitigating and adapting to its adverse effects; ensuring… that development is energy efficient and contributes to carbon reduction…*' Policy G1: Tackling and adapting to climate change states that '*new developments will be expected to a. Be zero carbon in line with national targets and definitions; b. Adhere to the energy hierarchy; c. Reduce CO_2 emissions through the use of renewable and low carbon decentralised energy technologies and networks; and d. address the impacts of climate change by incorporating comprehensive adaptation measures…*'	Mitigation measures are embedded within the Scheme design and will be implemented (as set out in the REAC, which is contained within the First Iteration EMP (TR010064/APP/6.5)), in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 14.9 of this chapter). The mitigation hierarchy set out in paragraph 3.22.1 of DMRB LA 114 has been followed when developing GHG mitigation measures, namely firstly seeking to avoid / prevent GHG emissions, then to reduce emissions and finally to remediate emissions (where practicable to do so).
Salford Local Plan: Development Management Policies and Designations (Salford City Council, 2023)	Policy CC1: Climate Change states that '*development shall support Salford becoming carbon neutral by 2038, through where relevant: A. Minimising carbon emissions…; B. Maximising carbon storage and sequestration…; C. Mitigating and adapting to the impacts of climate change…; and D. Responding to the economic and policy changes that are likely to accompany climate change…*'	Mitigation measures are embedded within the Scheme design and will be implemented (as set out in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)), in order to improve its resilience to climate change and reduce GHG emissions during both its construction and operation (see Section 14.9 of this chapter).

Plans and strategies

14.3.8 A number of plans and strategies have been published which are relevant to this aspect, as outlined in Table 14.5.

14.3.9 The Climate Change Committee is an independent statutory body, established under the Climate Change Act 2008, whose purpose is to advise the UK and devolved governments on GHG emissions targets and to report to Parliament on progress made in reducing GHG emissions and preparing for and adapting to the impacts of climate change. The Climate Change Committee's independent assessment of the UK's Net Zero Strategy (Climate Change Committee, 2021b) states that '*Our overall assessment is that it is an ambitious and comprehensive strategy that marks a significant step forward for UK climate policy, setting a globally leading benchmark to take to COP26. Further steps will need to follow quickly to implement the policies and proposals mapped out in the Net Zero Strategy if it is to be a success'*.

14.3.10 The Climate Change Committee also notes that '*A zero emission vehicle mandate will be the key delivery tool for electric vehicles, as recommended by the Committee*' and '*The Transport Decarbonisation Plan is a reasonably comprehensive strategy for transitioning to a system in which almost all journeys are zero-carbon*'.

Table 14.5 Climate related plans and strategies

Organisation	Plan or strategy	Brief description of plan or strategy
HM Government	Net Zero Strategy: Build Back Greener (HM Government, 2021)	This strategy sets out the UK's approach to meeting UK carbon budgets, its 2030 Nationally Determined Contribution and net zero by 2050. As such, it includes: • Decarbonisation pathways to net zero by 2050, including illustrative scenarios • Policies and proposals to reduce GHG emissions for each sector • Cross-cutting action to support the transition The High Court declared that this strategy was unlawful on 15 July 2022. This strategy was not quashed, however, and the UK Government subsequently released the Powering Up Britain paper described below.

Organisation	Plan or strategy	Brief description of plan or strategy
	Powering up Britain (Department for Energy Security and Net Zero (DESNZ), 2023a)	This paper provides an update to the 2021 Net Zero Strategy and sets out the UK Government's plan for transitioning towards domestic energy sources and for achieving net zero by 2050. It has two parts: the Energy Security Plan and the Net Zero Growth Plan. The Net Zero Growth Plan: • Sets out actions for investments into green industries such as offshore wind, carbon capture, usage and storage, and nuclear • Identifies actions towards meeting the UK's carbon budgets and acts as an annual update against the Net Zero Strategy • Meets the UK Government's statutory obligations under the Climate Change Act (2008) to: - Respond to the Climate Change Committee's 2022 Progress Report to Parliament and - Provide a Carbon Budget Delivery Update (i.e., the Carbon Budget Delivery Plan) In relation to the reduction of emissions from domestic road transport, the Net Zero Growth Plan provides a progress and delivery update on the phasing out of the sale of new non-zero emission road vehicles and the development of the UK's charging infrastructure network, in addition to increasing levels of cycling and walking.
	Carbon Budget Delivery Plan (DESNZ, 2023b)	This Plan, published alongside the Net Zero Growth Plan and Energy Security Plan, sets out a package of proposals and policies, and associated timescales and delivery risks, that enable Carbon Budgets 4-6 to be met.

Organisation	Plan or strategy	Brief description of plan or strategy
	Environmental Improvement Plan 2023 (Department for the Environment Food and Rural Affairs (Defra), 2023)	This is the first revision of the 25 Year Environment Plan (HM Government, 2019). It sets a goal for the UK to ''*take all possible action to mitigate climate change, while adapting to reduce its impact*'' and a new long-term plan to deliver against this goal, net zero and international climate commitments. The delivery plan consists of three objectives: • Reaching net zero domestically • Building resilience by adapting to climate change • Leading action internationally to tackle climate change
DfT	TDP (DfT, 2021)	This document sets out the Government's commitments and the actions needed to decarbonise the entire transport system in the UK. The plan includes commitments for zero emission vehicles, delivering a zero emission freight and logistics sector, maximising the benefits of sustainable low carbon fuels, more choice and better efficiency in the future transport system, hydrogen's role in decarbonising the transport system and increased investment in cycling and walking. The plan recognises, however, that continued high investment in our roads is, and will remain, as necessary as ever, to ensure the functioning of the nation and to reduce congestion which in itself is a major source of GHG emissions.
National Highways	Net Zero Highways: Our 2030/2040/2050 Plan (National Highways, 2021)	This document sets out National Highway's programme for a net zero future. This centres on net zero GHG emissions for National Highways own operations by 2030 (corporate emissions); net zero for maintenance and construction of the National Highways network by 2040 (maintenance and construction emissions); and net zero carbon travel from users of the National Highways Network by 2050 (road user emissions).
	Preparing for Climate Change on the Strategic Road Network (National Highways, 2022a)	This adaption report identifies key climate change related risks relevant to the Strategic Road Network (SRN), assesses progress made towards adapting the SRN to these risks and sets out actions which will be undertaken by National Highways to respond to climate change related risks going forwards.

Organisation	Plan or strategy	Brief description of plan or strategy
GMCA	The 5-Year Environment Plan for Greater Manchester (2019-2024) (GMCA, 2019)	This five year plan sets out long term aims for the environment in Greater Manchester and approaches to be taken to address them. Aim 1 relates to the mitigation of climate change: *'for the city-region to be carbon neutral by 2038 and meet carbon budgets that comply with international commitments'.* Aim 5 relates to resilience and adaptation to climate change: *'to be prepared for the impacts of climate change and already be adapting to the future changes from any increase in climate shocks and stresses'.*
Manchester Climate Change Partnership	Manchester Climate Change Framework 2020-25 (Manchester Climate Change Partnership, 2020)	This document is Manchester's high-level strategy for meeting the region's climate change commitments. Objective 1 states *'staying within our carbon budgets'* aims *'to ensure that Manchester plays its full part in helping to meet the Paris Agreement objectives by keeping our direct CO_2 emissions within a limited carbon budget… and addressing our indirect/consumption-based carbon emissions'.* Objective 2 states *'climate Adaptation and Resilience'* aims to *'adapt this city's… infrastructure… to the changing climate and to increase the climate resilience of our residents and organisations'.*
Bury Metropolitan Borough Council	Bury Climate Action Strategy (Bury Metropolitan Borough Council, 2021a) and Climate Action Plan 2021 (Bury Metropolitan Borough Council, 2021b)	These documents set the strategy and plan for achieving the following: • Recognising that climate change is happening, and the impacts have started to occur • Achieving carbon reductions in pursuit of carbon neutrality by 2038 To be better adapted to extreme weather patterns

14.4 Assessment methodology

Assessment scope

14.4.1 This assessment considers both the impact of the Scheme on climate (i.e. GHG emissions) and the vulnerability of the Scheme to climate change.

Greenhouse gas emissions

14.4.2 As per paragraphs 3.11 and 3.11.1 of DMRB LA 114, GHG emissions associated with the Scheme have been estimated and reported for the construction phase and operational phase (over a 60-year appraisal period). Therefore, the temporal scope of the assessment of GHG emissions covers the period from the commencement of construction works (i.e. Q4 2025) to 60 years after the Opening year of the Scheme (i.e. 2088).

Construction phase

14.4.3 An estimate has been made of GHG emissions which are likely to be generated during the construction phase. This has been established in alignment with the 'before use' life cycle stage and modules A1 to A5 referred to in Publicly Available Specification (PAS) 2080:2023 Carbon Management in Buildings and Infrastructure (British Standards Institution (BSI), 2023) for the following activities:

- Embodied GHG emissions associated with the required raw materials (product stage (modules A1–A3))
- Transport of materials to the construction site (construction process stage (module A4))
- Transport of waste from the construction site and subsequent treatment (construction process stage (module A5))
- Transport of construction workers, onsite staff and visitors to and from the construction site (construction process stage (module A5))
- Operation of construction plant and onsite activities (construction process stage (module A5))
- Onsite consumption of fuel, electricity and water (construction process stage (module A5))

14.4.4 The GHG emissions mobilised by vegetation losses and soil disturbance during the construction phase have also been estimated, as required by Table 3.11.1 of DMRB LA 114.

Operational phase

14.4.5 An estimate has been made of GHG emissions which are likely to be generated during the operational phase as a result of the following activities, in alignment with the 'use' life cycle stage and modules B2 to B6 and B9 identified in PAS 2080:2023:

- Maintenance, repair, replacement and refurbishment of the Scheme assets over its operational life (modules B2–B5)
- Operational energy use by Scheme lighting (module B6)
- The use of the Scheme by end users and the effect the Scheme is predicted to have on traffic flows across the wider road network (module B9)

14.4.6 The GHG emissions mobilised by ongoing changes in land use and forestry due to the presence of the Scheme have also been estimated, as required by Table 3.11.1 of DMRB LA 114.

14.4.7 It is anticipated that there will be minimal GHG emissions emitted directly from the fabric of products and materials once they have been installed as part of the Scheme and it is in normal use, therefore such emissions have been scoped out for the purposes of this assessment.

Decommissioning

14.4.8 As per paragraph 2.3 of DMRB LA 114, GHG emissions associated with decommissioning of the Scheme (i.e. modules C1 to C4 of the 'end of life' life cycle stage identified in PAS 2080:2023) are excluded from the assessment due to the length of the operational phase of the Scheme's assets (which is assumed to be greater than the 60-year appraisal period required by DMRB LA 114).

Vulnerability to changes in climate

14.4.9 As per paragraph 3.31 of DMRB LA 114, the assessment of the Scheme's vulnerability to climate change has taken the life span of the Scheme to be 60 years (i.e. from 2029 to 2088, inclusive). Climate projections for the 2030s, 2060s and 2080s, for the high emissions (i.e. RCP8.5) scenario at the 50% probability level, have, therefore, been used to represent changes in climate over the short, medium and long term, respectively, as per paragraph 3.32 of DMRB LA 114.

14.4.10 As identified in Table 14.19 (in Section 14.7 of this chapter), projected changes in climate over the longer term suggest that there could be substantial increases in both summer temperatures and winter precipitation in the area of the Scheme. Furthermore, Table 14.20 indicates that maximum daily temperatures could increase substantially over the lifespan of the Scheme, while Table 14.21 indicates that climate events, such as hot spells, heatwaves, dry spells and droughts, could occur more frequently.

14.4.11 The assessment of the vulnerability of the Scheme to climate change has therefore focused on potential impacts associated with changes in temperature and precipitation only.

Scoping Opinion

14.4.12 Table 14.6 summarises the key requirements from the Planning Inspectorate's Scoping Opinion (TR010064/APP/6.7) as relevant to the scope of the climate assessment, and identifies any matters scoped out of the assessment as agreed with the Planning Inspectorate and other stakeholders. This table also explains any changes to the assessment methodology as a result of this engagement.

Table 14.6 Scoping Opinion feedback for climate

Stakeholder	Comment	Response
Planning Inspectorate	ID 4.10.1 – *'No matters have been proposed to be scoped out of the assessment.'*	Noted.
	ID 4.10.2 – *'Scoping Report paragraph 15.7.1 states that whether GHG emissions will be significant against Government targets will be determined through professional judgement, acknowledging that construction and operational phases of the Proposed Development will extend over multiple carbon budget periods.* *The Environmental Statement should set out how this judgement has been applied to changes brought about by the Proposed Development in relation to emission sources to reach conclusions to support the definition of significance.'*	As noted in paragraphs 14.4.18 to 14.4.23, no specific guidance is provided within DMRB LA 114, or elsewhere, on the magnitude of a change in GHG emissions (relative to UK carbon budgets) which could be considered significant. Changes in GHG emissions estimated to occur as a result of the Scheme have therefore been compared to relevant UK carbon budgets in percentage terms (see Table 14.24). Professional judgement and practical experience has then been used to assess whether these percentage changes would be sufficiently large so as to have a 'material impact' on the ability of Government to meet its carbon reduction targets.
	ID 4.10.3 – *'It is noted that there are a number of peat deposits within the red line boundary which are carbon stores. Effort should be made to avoid/reduce impact to these areas to avoid/reduce impacts from GHG emissions as part of the mitigation 27mbeded into the design.'*	While British Geological Survey (BGS) 1:10,000 mapping of superficial geology identifies areas of peat within the Order Limits, the BGS does not identify peat under its mineral layers on Geoindex Onshore (BGS, 2023) or in 1:100,000 scale mineral resource mapping for Greater Manchester (Minchin *et al.,* 2006). Furthermore, the results of Scheme specific soil surveys and ground investigations indicate that there are limited existing peat soils on site. At most locations, only limited and isolated buried peat has been identified, with those peaty soils/horizons encountered tending to be clustered in the north-west of the Order Limits where there would be fewer permanent works.

Stakeholder	Comment	Response
	ID 4.10.4 – *'Traffic management measures have potential to cause congestion/vehicles to find alternative, longer routes which may increase GHG emissions. The Environmental Statement should consider this as part of the assessment of construction traffic effects and, where possible, set out traffic management measures for the Proposed Development to minimise these impacts.'*	Modelled traffic data have been used to estimate potential changes in road user GHG emissions during the construction phase, the results of which are summarised in Table 14.22 of this chapter. The results suggest that there would be a small net reduction in road user GHG emissions during the construction phase as a result of the redistribution of traffic and introduction of reduced speed limits. Traffic management measures during the construction phase are discussed in the Outline Traffic Management Plan (TR010064/APP/7.5).
	ID 4.10.5 – *'Whilst the Inspectorate acknowledges there is uncertainty surrounding the future composition of the UK's vehicle fleet towards net zero (e.g. proposed ban on petrol cars), the Environmental Statement should set out and justify a proportionate worst case scenario on which to base the Environmental Statement assessment with appropriate cross referencing to the air quality assessment.'*	Road user GHG emissions presented in this assessment have been estimated using speed band emission factors which are derived from Version 11.0 of the Emission Factors Toolkit (EFT, v11) (Defra, 2021). EFT v11 has been specifically developed to provide emissions outputs for all years up to 2050 in support of climate assessments and appraisals. The methodology used to estimate road user GHG emissions presented in this chapter is considered the most appropriate. However, it is subject to uncertainty, not least regarding the assumed uptake of electric vehicles and improvements in vehicle efficiency (i.e. fuel consumption) over time. While the vehicle fleet projections and engine efficiency factors used within EFT v11 were provided by National Highways and DfT in July 2021, it is likely that these will be updated in the near future (e.g. to account for policies within the recently published TDP (DfT, 2021)). The vehicle fleet projections and fuel consumption parameters used within this assessment are, therefore, considered likely to be conservative, as they do not yet account for more recent Government plans to summarizing the UK vehicle fleet (in particular heavy goods vehicles (HGVs)).

Stakeholder	Comment	Response
		Sensitivity testing has been undertaken to illustrate the potential impact of the TDP (DfT, 2021) on the magnitude of estimated changes in road user GHG emissions as a result of the Scheme (see Table 14.25), however, the assessment of significance presented in this chapter has been based on the more conservative estimates derived using EFT v11 derived speed band emission factors.
	ID 4.11.2 – *'The assessment proposed in the climate aspect chapter considers the Proposed Development's effect on the global climate and the effect of changes in climate on the Proposed Development (ie vulnerability to climate change).* *On the basis that consideration of the extent to which climate exacerbates or ameliorates the effects of the Proposed Development will be presented in the climate aspect chapter of the ES, the Inspectorate agrees that it can be scoped out of further specific assessment in terms of cumulative effects and this approach accords with industry standard guidance of the Institute of Environmental Management and Assessment (IEMA).'*	The assessment in this chapter considers the Scheme's effect on the global climate and the effect of changes in climate on the Scheme (i.e. vulnerability to climate change). Further assessment of cumulative effects on climate is scoped out of the cumulative effects assessment in Chapter 15: Assessment of Cumulative Effects of this Environmental Statement (TR010064/APP/6.1).
Natural England (Appendix 2 of the Scoping Opinion)	*'The impacts from damaging peat habitat and the subsequent carbon release should be carefully considered in the chapter.'*	As noted previously, the results of Scheme specific soil surveys and ground investigations indicate that there are limited existing peat soils on site. At most locations, only limited and isolated buried peat has been identified, with those peaty soils/horizons encountered tending to be clustered in the north-west of the Order Limits where there would be fewer permanent works. Agreements on the comments made by Natural England regarding the potential impacts on peat, with respect to all relevant environmental aspects, will be recorded in the Statement of Common Ground with Natural England, which will be submitted during the course of the Examination.

Stakeholder	Comment	Response
		Potential GHG emissions associated with the extraction of peat soils are presented in Section 14.10.

Statutory consultation

14.4.13 Table 14.7 identifies the key feedback received from the statutory consultation. All comments raised during the statutory consultation, as well as the Applicant's responses, are included in Annex Q of the Consultation Report Annexes (TR010064/APP/5.2).

Table 14.7 Key statutory consultation feedback for climate

Stakeholder	Comment	Response
Natural England	Concerns were raised regarding the management of peat and carbon emissions associated with peat extraction.	As noted previously, the results of Scheme specific soil surveys and ground investigations indicate that there are limited existing peat soils on site. At most locations, only limited and isolated buried peat has been identified, with those peaty soils/horizons encountered tending to be clustered in the north-west of the Order Limits where there would be fewer permanent works. Agreements on the comments made by Natural England regarding the potential impacts on peat, with respect to all relevant environmental aspects, will be recorded in the Statement of Common Ground with Natural England, which will be submitted during the course of the Examination. Potential GHG emissions associated with the extraction of peat soils are presented in Section 14.10.

14.4.14 No changes to the scope or methodology compared to that set out in the Environmental Scoping Report (TR010064/APP/6.6) for this aspect have been required as a result of the stakeholder engagement process.

Summary

14.4.15 Table 14.8 summarises the scope of the assessment, which is as detailed in the Environmental Scoping Report (TR010064/APP/6.6), other than the inclusion of an assessment of road user GHG emissions during construction at the request of the Planning Inspectorate in the Scoping Opinion (TR010064/APP/6.7) (see Table 14.6). As such, the scope presented in Table 14.8 is also in line with the Scoping Opinion (TR010064/APP/6.7).

Table 14.8 Summary of climate scope

Matter	Sub-matter	Scoped in	
		Construction	Operation
GHG emissions	Product stage (embodied carbon in construction materials)	✓	✓ [a]
	Transport of construction materials to site	✓	✓ [a]
	Fuel consumption (onsite plant and machinery)	✓	✓ [a]
	Fuel consumption (all staff vehicles)	✓	✓ [a]
	Electricity, natural gas and water consumption	✓	✓
	Transportation, treatment and disposal of waste materials	✓	✓ [a]
	Land use change and forestry	✓	✓
	Road users	✓	✓
Vulnerability of scheme to climate change	Changes in seasonal precipitation and temperature	✓	✓
	Increased frequency of extreme precipitation and temperature events	✓	✓

[a] During maintenance activities (including repair, replacement and refurbishment).

General approach

14.4.16 The methodology for the climate assessment complies with the requirements set out in DMRB LA 114.

14.4.17 The following technical guidance have informed the approach taken for the climate assessment:

- PAS 2080: Carbon Management in Buildings and Infrastructure (BSI, 2023)
- Woodland Carbon Code Carbon Calculation Guidance (Woodland Carbon Code, 2021)
- National Highways Carbon Tool Guidance (National Highways, 2022b)
- EFT v11 User Guide (Defra, 2021)
- Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation (Institute of Environmental Management and Assessment (IEMA), 2020)
- Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2022).

Greenhouse gas emissions

14.4.18 An assessment of the net change in GHG emissions associated with the Scheme against UK Government carbon budgets (in metric tonnes of carbon dioxide equivalent (tCO_2e)) has been undertaken in accordance with paragraph 3.18 of DMRB LA 114, and as required by the NPS NN (DfT, 2014). As the construction and operational phases of the Scheme extend over multiple carbon budget periods, GHG emissions have been reported against each relevant carbon budget, for the construction and operational phases respectively.

14.4.19 There is no set significance threshold for carbon. IEMA (2022) guidance indicates that the crux of significance is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether the project contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050 (see section 6.2 of the IEMA (2022) guidance).

14.4.20 The IEMA (2022) guidance addresses significance principles and criteria in section 6.3 and Figure 5 of the guidance and advises (amongst other things) that:

- A project that follows a ‘business-as-usual’ or ‘do minimum’ approach and is not compatible with the UK’s net zero trajectory or accepted aligned practice or area-based transition targets, results in significant adverse effects.
- A project that is compatible with the budgeted science-based 1.5 degree Celsius trajectory (in terms of rate of emissions reduction) and which complies with up-to-date policy and ‘good practice’ reduction measures to achieve that has a minor adverse effect that is not significant - such a project may have residual emissions but it is doing enough to align with and contribute to the relevant transition scenario to keep the UK on track towards net zero by 2050 with at least a 78% reduction by 2035 and thereby potentially avoiding significant adverse effects.
- A project that achieves emissions mitigation that goes substantially beyond the reduction trajectory, or substantially beyond existing and emerging policy compatible with that trajectory, and has minimal residual emissions, is considered to have a negligible effect that is not significant and such a project is playing a part in achieving the rate of transition required by nationally set policy commitments.

14.4.21 The adoption of a net zero target does not mean that consent cannot be granted for development that will increase carbon emissions; rather, as set out in paragraph 5.18 of the NPS NN (DfT, 2014), it is necessary to continue to evaluate whether (amongst other things) the increase in carbon emissions resulting from a proposed development would have a material impact on the ability of Government to meet its carbon reduction targets.

14.4.22 The Government has adopted the carbon budgets in order to meet the goals of the Paris Agreement. Thus, a Scheme which is compatible with the 2050 target and interim carbon budgets is consistent with the approach to addressing the adverse effects of climate change. This aligns with the approach to significance set out in the IEMA (2022) guidance. The approach set out in the NPS NN (DfT, 2014) continues to be relevant in light of international obligations and domestic obligations related to reducing carbon emissions that have come into force since the NPS NN (DfT, 2014) was designated.

14.4.23 It is also to be noted that the carbon budgets are economy-wide and not just targets in relation to transport.

14.4.24 In light of the above, an assessment has then been made, based on professional judgement, as to whether increases in GHG emissions as a result of the Scheme could have a material impact on the ability of the UK Government to meet its carbon reduction targets (and would therefore potentially be significant).

14.4.25 In order to estimate GHG emissions associated with the construction and operational phases of the Scheme, a number of different GHG emissions estimation methods were used. These methods and associated data sources are summarised in Table 14.9 for the construction phase and Table 14.10 for the operational phase. Further details on the methods and data used are provided in Appendix 14.1: Estimation of Greenhouse Gas Emissions of the Environmental Statement Appendices (TR010064/APP/6.3).

Table 14.9 Summary of construction phase GHG emissions estimation methods

Emissions source	Emission estimation method	Data sources
Product stage (embodied carbon in construction materials)	National Highways Carbon Tool v.2.5 (National Highways, 2022b), which contains carbon factors derived from the Inventory of Carbon and Energy Version 3.0 (also known as the ICE V3 database).	Types and quantities of materials and items for the preliminary Scheme design for the Scheme (for both temporary and permanent works)
Transport of construction materials to site	UK Government GHG Conversion Factors for Company Reporting (Department for Business, Energy and Industrial Strategy (BEIS)/Defra, 2022)	Assumed transport distances from suppliers to site and within site and the assumed mode of transport for all materials and items within the preliminary Scheme design
Fuel consumption (onsite plant and machinery)	National Highways Carbon Tool v.2.5 (National Highways, 2022b)	Estimated based on recorded fuel consumption for a similar Scheme (the A14 Cambridge to Huntingdon improvement scheme), adjusted to account for the relative difference in scale between the two schemes
Fuel consumption (employee transport)		Estimated total distance travelled to and from, and within, the construction site by different transport modes based on expected numbers of employees over the construction period and assumptions regarding distances travelled and modes used
Onsite electricity, gas and water consumption		Estimated based on recorded onsite electricity and water consumption for a similar Scheme (the A14 Cambridge to Huntingdon improvement scheme), adjusted to account for the relative difference in scale between the two schemes

Emissions source	Emission estimation method	Data sources
Treatment and disposal of waste materials		Estimated type and quantities of waste materials contained within the preliminary Scheme design Types and quantities of materials and items within the preliminary Scheme design and assumed wastage rates Assumed disposal methods
Transportation of waste materials from site	UK Government GHG Conversion Factors for Company Reporting (BEIS/Defra, 2022)	Assumed transportation distances for waste quantities derived above and the assumed mode of transport for all waste materials
Land use change	Natural England average carbon stock estimates (Natural England, 2021)	Area and type of different land uses within the Order Limits Assumptions regarding the proportion of carbon stock held in vegetation and soil which would be lost as a result of disturbance or loss of soils and vegetation during construction
Peat soil excavation	Carbon density of deep peats (Cannell *et al.*, 1993)	Estimated volume of peat soil to be extracted based on area of excavation and site investigation results
Changes in forestry	Woodland Carbon Code Carbon Calculation Spreadsheet v2.4 (Woodland Carbon Code, 2021)	Type, spacing and areas of trees retained, removed, and planted
Road users	Speed band emission factors derived from EFTv11 (National Highways, 2022c)	Modelled traffic data for the Do-Minimum (i.e. the scenario that represents the situation that would occur without the Scheme) and Do-Something (i.e. the scenario that represents the situation that would occur with the Scheme) scenarios in each construction year (2025 – 2029) of the Scheme. The assessment was based on the difference in GHG emissions between the Do-Minimum and Do-Something scenarios.

Table 14.10 Summary of operational phase GHG emissions estimation methodology

Emissions source	Emission estimation method	Data sources
Product stage (embodied carbon in maintenance materials and replacement items)	National Highways Carbon Tool v.2.5 (National Highways, 2022b)	Types and quantities of materials and items from the preliminary Scheme design for the Scheme (for permanent works) and assumed replacement frequencies for materials and items in accordance with their expected design life
Transport of maintenance materials and replacement items to site		Assumed transport distances from suppliers to site and within site and the assumed mode of transport for all materials and items
Transportation, treatment and disposal of waste materials	Estimated based on GHG emissions for the construction phase factored by the ratio of embodied carbon in the 'product stage' between the construction phase and operational phase, respectively	
Fuel consumption during maintenance (onsite plant and machinery)		
Fuel consumption during maintenance (employee transport)		
Onsite electricity, gas and water consumption during maintenance		
Land use change	Weighted average change in equilibrium non-organic soil carbon density for changes between different land types in England from the UK Annual National Inventory Report (DESNZ, 2023c)	Type and area of land uses within the area of permanent land use

Emissions source	Emission estimation method	Data sources
Changes in forestry	Woodland Carbon Code Carbon Calculation Spreadsheet v2.4 (Woodland Carbon Code, 2021)	Type, spacing and areas of trees retained, removed, and planted
Electricity consumption	Electricity emission factors (DESNZ, 2023d)	Anticipated annual electricity consumption based on the number, wattage and operating schedule of the Scheme lighting, plus estimated total electricity consumption for the scheme signage and cameras.
Road users	Speed band emission factors derived from EFTv11 (National Highways, 2022c)	Modelled traffic data for the Do-Minimum (i.e. the scenario that represents the situation that would occur without the Scheme in operation, which includes permitted developments) and Do-Something (i.e. the scenario that represents the situation that would occur with the Scheme in operation, which includes permitted developments) scenarios in the Opening year (i.e. 2029), Design year (i.e. 2044) and Future year (i.e. 2061) of the Scheme. Emissions were then linearly interpolated between the Opening year, Design year and Future year, and assumed to remain constant thereafter, in order to estimate GHG emissions over the assumed 60-year life span of the Scheme. The assessment was based on the difference in GHG emissions between the Do-Minimum and Do-Something scenarios.

Vulnerability to changes in climate

14.4.26 For the assessment of the Scheme's vulnerability to changes in climate, the following tasks have been undertaken in line with paragraphs 3.26 to 3.35 of DMRB LA 114, and as required by the NPS NN (DfT, 2014):

- Analysis of published historical regional weather data to understand the current climate impacts on the study area
- The identification of historical climate-related events (e.g. floods, landslides) in the study area to provide an indication of past vulnerability
- Analysis of projected baseline climate conditions using UKCP18 datasets (Met Office, 2020) in order to identify the type and magnitude of changes in climate to which the Scheme could potentially be exposed
- The identification of receptors, during both the construction (e.g. workforce, plant, machinery) and operational phases (e.g. Scheme assets and end users), which are potentially vulnerable to changes in climate (e.g. increased rainfall and/or temperature extremes)
- The identification of climate change related impacts (e.g. flooding or landslides) on the receptors identified, which could potentially be significant
- The identification of design and mitigation measures which would be embedded within the design of the Scheme in order to improve its resilience to climate change, in liaison with the Scheme design team and relevant EIA competent experts

Assessment criteria

Value (sensitivity) of receptors

14.4.27 In line with DMRB LA 114, the following receptors have been identified:

- With regard to GHG emissions:
  - UK carbon budgets (as a proxy for the global climate)
- With regard to the Scheme's vulnerability to climate change, key receptors (further details of which are provided in Appendix 14.2: Vulnerability Assessment of the Environmental Statement Appendices (TR010064/APP/6.3)) are summarised as:
  - Receptors associated with the construction process (including the construction workforce, plant and machinery)
  - The assets and their operation, maintenance and refurbishment (e.g. road pavement surfaces, structures, earthworks and drainage, technology assets, soft estate)
  - End-users (e.g. members of the public or commercial operators using the Scheme)

14.4.28 In the absence of specific guidance in DMRB LA 114 on the valuation of receptors with regard to climate impacts, all receptors are considered to be of high value given the global importance of climate change and the potential for climate related impacts to adversely affect the health and safety of employees and road users.

Magnitude of impact (change)

Greenhouse gases

14.4.29 There are no defined magnitude of impact criteria for changes in emissions of GHGs.

Vulnerability to changes in climate

14.4.30 For construction phase impacts, a qualitative description of the potential risk of disruption during the construction phase has been reported (as per paragraph 3.40 of DMRB LA 114).

14.4.31 For operational phase impacts, a qualitative risk assessment of the residual likelihood and consequence of each impact has been undertaken with reference to the indicative framework set out in Table 3.39a (likelihood categories) and Table 3.39b (measure of consequence) of DMRB LA 114 (replicated in Table 14.11 and Table 14.12 below).

Table 14.11 Likelihood categories

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

Table 14.12 Measure of consequence

Consequence of impact	Description
Very large adverse	Operation – national level (or greater) disruption to strategic route(s) lasting more than one week.
Large adverse	Operation – national level disruption to strategic route(s) lasting more than one day but less than one week or regional level disruption to strategic route(s) lasting more than one week.
Moderate adverse	Operation – regional level disruption to strategic route(s) lasting more than one day but less than one week.

Consequence of impact	Description
Minor adverse	Operation – regional level disruption to strategic route(s) lasting less than one day.
Negligible	Operation – disruption to an isolated section of a strategic route lasting less than one day.

Significance of effect

Greenhouse gas emissions

14.4.32 The UK Government has set the appropriate geographical scale for the assessment of the significance of GHG emissions from NSIPs at the national level. The NPS NN (DfT, 2014) requires the significance of GHG emissions from NSIPs to be assessed by reference to whether the predicted emissions would have a material impact on the Government's ability to meet carbon budgets.

14.4.33 In line with DMRB LA 114, an assessment has been made, based on professional judgement and using the methodologies set out in this chapter, as to whether estimated increases in GHG emissions as a result of the Scheme could have a material impact on the ability of the UK Government to meet its carbon reduction targets (and would therefore potentially be significant).

Vulnerability to changes in climate

14.4.34 For the operational phase, the residual likelihood and consequence of each of the potential climate related impacts identified have been combined in order to assess significance as per Table 3.41 (significance matrix) of DMRB LA 114 (replicated in Table 14.13).

Table 14.13 Evaluation of significance

		Measure of likelihood				
		Very low	**Low**	**Medium**	**High**	**Very high**
Measure of consequence	**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

Key: NS = Not significant; S = Significant

14.5 Assessment assumptions and limitations

Greenhouse gas emissions

14.5.1 The assessment of construction phase GHG emissions provided within this chapter is based on the preliminary Scheme design for the Scheme, which was produced in June 2023. Whilst it is noted that a number of localised alterations have been made to the Scheme design since this point, these changes are considered unlikely to have a material influence on material quantities, and therefore likely Scheme-related GHG emissions, compared to those presented in this chapter. This approach is in keeping with paragraph 3.14 of DMRB LA 114, which indicates that a '*proportionate approach shall be applied to capture the principal contributing factors associated with GHG emissions*'.

14.5.2 This assessment has applied a contingency factor of 15% to the material quantities to account for uncertainty in material quantities and to provide a more conservative assessment. For consistency between aspects, this has also been applied within Chapter 10: Material Assets and Waste of this Environmental Statement (TR010064/APP/6.1).

14.5.3 This assessment has been undertaken for the Scheme design (as shown on Figure 2.2: Scheme Design of the Environmental Statement Figures (TR010064/APP/6.2)) and assumes a reasonable worst-case basis afforded by the limits of deviation (see Section 2.5 of Chapter 2: The Scheme of this Environmental Statement (TR010064/APP/6.1)). The potential impact of minor changes to the vertical or horizontal alignment of the Scheme on GHG emissions are considered unlikely to result in a substantial change in material quantities. As such, they are considered unlikely to have a material impact on GHG emissions associated with the Scheme and therefore are unlikely to affect the predicted levels of likely significant effects reported in this assessment.

14.5.4 The construction GHG emissions appraisal was based, in part, on assumptions and professional judgement due to limited data availability for certain elements, which are typically unknown at this stage of a scheme. Specifically, information relating to onsite energy consumption and site utilities, the transport distances of raw materials, commuter distances, and volumes and transport distances of waste were unavailable, as is typically the case at this stage. Likewise, the maintenance frequencies of materials and assets which would be required during the operational phase are uncertain. A number of assumptions, therefore, have been made within the assessment using professional judgement, relevant guidance and experience gained from other schemes. These assumptions, which in many cases were worst case, are considered unlikely to have had a material influence on the resulting magnitude of estimated GHG emissions. A complete description of the methodology used, along with the associated limitations and assumptions, is provided in Appendix 14.1: Estimation of GHG Emissions of the Environmental Statement Appendices (TR010064/APP/6.3).

14.5.5 The road user GHG emissions estimates presented in this chapter are based on traffic data provided by the Scheme traffic modellers, based on a 2018 Base year (see the Transport Assessment (TR010064/APP/7.4) for further details). There are uncertainties inherent within all modelled road traffic data, including those on which the operational road user GHG emissions calculations presented within this chapter are based. The traffic model outputs used have, however, been appropriately validated, as discussed within the Transport Assessment (TR010064/APP/7.4) and are therefore considered suitably robust.

14.5.6 The methodology used to estimate road user GHG emissions presented in this chapter is considered the most appropriate. However, it is subject to uncertainty, not least regarding the assumed uptake of electric vehicles and improvements in vehicle efficiency (i.e. fuel consumption) over time. While the vehicle fleet projections and engine efficiency factors used within the EFT v11.0 (Defra, 2021) were provided by National Highways and DfT in July 2021, it is likely that these will be updated in the near future (e.g. to account for policies within the recently published TDP (DfT, 2021)). The vehicle fleet projections and fuel consumption parameters used within this assessment are, therefore, considered likely to be conservative, as they do not yet account for more recent Government plans to decarbonise the UK vehicle fleet (in particular HGVs). In an attempt to understand the potential impact of the TDP (DfT, 2021) on the magnitude of operational road user GHG emissions considered in this assessment, two sensitivity tests have been undertaken based on the 'upper' and 'lower' bounds of the projected rate of improvement in road user GHG emissions shown in Figure 2 of the TDP (DfT, 2021), the results of which are presented in Table 14.25.

14.5.7 There are limitations inherent within the speed band emission factors derived from EFT v11 (National Highways, 2022c), which were used to estimate changes in road user GHG emissions within this assessment. For example, there is uncertainty in the projected composition of the national vehicle fleet in Future years contained within the tool (particularly beyond 2030), which may therefore affect the road user GHG emissions estimates within the fifth and sixth carbon budget periods presented within this assessment. All modelling has its limitations, however, and as such includes a level of uncertainty, and it is considered that these emission factors are the most appropriate currently available for estimating road user GHG emissions in Future years.

14.5.8 In the absence of vehicle emission factors for any year beyond 2050, Do-Minimum (DM) and Do-Something (DS) road user GHG emissions for the 2061 Future year were estimated using emission factors for 2050 (and are therefore worst-case). Furthermore, in the absence of modelled traffic data for any year beyond 2061, DM and DS road user GHG emissions are assumed to remain constant between 2061 and 2086, whereas in reality they are likely to decrease substantially over time due to increasing proportions of electric vehicles and improvements in vehicle efficiency over time.

14.5.9 The construction phase land use change emission calculations apply average carbon stock estimates published by Natural England (Natural England, 2021). It was assumed that 25% of the carbon stock in the surface soil and 100% of the carbon stock in vegetation would be released to the atmosphere when an area is 'disturbed' during construction. This is considered to be a conservative assumption. It was assumed that all land within the Order Limits would be 'disturbed' during construction except for existing areas of vegetation which would be retained. It was further assumed that all of the carbon stock that was lost would be released in the form of CO_2 (as opposed to CH_4, for example).

14.5.10 For the calculation of operational land use change GHG emissions, emissions per hectare are assumed to be equivalent to the change in equilibrium soil carbon density with land use change outlined in the UK National Inventory Report (DESNZ, 2023c). The operational land use change GHG emissions were calculated over the area of permanent land use, with the relevant change in soil carbon density assumed to occur in full over the 60-year appraisal period. This is considered to be a conservative assumption.

14.5.11 The areas which could be affected by construction activities and operational land use change were apportioned into different land use types using the Ordnance Survey MasterMap dataset (Ordnance Survey, 2021) and ecological survey data related to the baseline habitat mapping. As described in Appendix 14.1: Estimation of GHG Emissions of the Environmental Statement Appendices (TR010064/APP/6.3), a number of assumptions were made when translating the land use categories within the Ordnance Survey MasterMap dataset into those used in the construction and operational land use change emission calculations. The outputs of these assumptions, which informed the land use change emission calculations, are illustrated visually on Figure 14.2: Construction Areas Used for Land Use Change GHG Emissions Calculations and Figure 14.3: Operational Areas Used for Land Use Change GHG Calculations of the Environmental Statement Figures (TR010064/APP/6.2).

14.5.12 The estimation of GHG emissions associated with the consumption of raw materials does not include those associated with some essential mitigation measures which have been identified as part of this Environmental Statement (i.e. after the preliminary Scheme design was developed). Any such GHG emissions are, however, considered likely to be relatively minor and therefore unlikely to have a material influence on the total Scheme GHG emissions.

14.5.13 In the absence of detailed information on existing tree planting (e.g. regarding the mix of different species and the age and spacing of trees), a number of assumptions were made to inform estimates of carbon sequestration (i.e. the amount of CO_2 captured and stored in woodland over time). Wherever possible, these assumptions were informed by the information available (e.g. the planting schedule), however, the data used in these calculations should be considered indicative. As consistent assumptions were applied in both the DM and DS scenarios, however, the outputs of these calculations are considered appropriate for estimating the potential net change in carbon sequestration as a result of the Scheme.

14.5.14 In the absence of detailed information regarding material quantities, it has not been possible to estimate operational maintenance GHG emissions in the absence of the Scheme (i.e. in the DM scenario) using the National Highways Carbon Tool v.2.5 (National Highways, 2022b). Instead, potential DM operational maintenance GHG emissions have been derived from estimated DS operational maintenance GHG emissions using a ratio of 75%. This ratio was derived based on a simple, high-level comparison of the differences between the Scheme and the existing M60/M62/M66 Simister Island Interchange which it would replace (e.g. the number of lanes).

Vulnerability to changes in climate

14.5.15 There is inherent uncertainty in the climate models which form the basis of the climate projections used to inform this assessment (i.e. the climate models used in the UKCP18 datasets (Met Office, 2020)). However, the use of the UKCP18 High Emissions RCP8.5 projections dataset (Met Office, 2020) is likely to provide a more conservative estimate of future climate change, as it represents the highest modelled GHG emissions scenario.

14.5.16 The grid cell located most centrally to the Scheme, for each of the UKCP18 datasets considered (ranging from 2.2km to 25km), was selected to describe the climatic conditions in the study area considered within this assessment. Therefore, it is assumed that climatic conditions across the study area are adequately described by the selected grid cell. This is considered appropriate as climate conditions are not expected to vary substantially over short distances (the extent of the Scheme (i.e. between M60 J17 and J18) is approximately 3.5km) and in many cases a large proportion of the Scheme falls within the grid cell used.

14.5.17 Given the number of different variables involved, there is substantial uncertainty regarding the likelihood and consequence of climate change related impacts on the performance of UK road transport infrastructure in response to a certain change in climate. A qualitative, risk-based approach has therefore been used, supported by professional judgement, where relevant.

14.5.18 Where relevant, aspect-specific measures to mitigate the vulnerability of the Scheme to climate change are detailed in the corresponding chapters of this Environmental Statement (TR010064/APP/6.1). For example, mitigation with regards to increased flood risk as a result of climate change is addressed in Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1).

14.5.19 The Scheme’s vulnerability to climate change has been assessed based on the assumption that all relevant design standards are suitable for both current and future climatic conditions.

14.5.20 DMRB LA 114 states that climate assessments should use the H++ climate scenarios to test the sensitivity of vulnerable safety-critical features, to ensure that such features would not be affected by more radical changes to the climate beyond that projected in the latest set of UK Climate Projections. The H++ scenarios cover heat waves, cold snaps, low and high rainfall, droughts, floods and windstorms. However, of these climate related events, the greatest risks to safety critical features (e.g. structures) are considered likely to be those associated with flooding.

14.5.21 The H++ scenarios were developed using a set of climate change projections which have since been superseded (i.e. UKCP09); however, the Met Office does not propose to update these scenarios using UKCP18 (Met Office, 2018a). Following the publication of updated guidance on climate change allowances, the H++ scenarios are no longer used to inform peak river flow allowances on highway schemes.

14.5.22 As discussed in Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1), however, consideration has been given to potential changes to the risk of flooding should more radical changes in climate occur. It is, however, considered unlikely that such changes would substantially increase the risk of flooding to the Scheme. As the Scheme is located in Flood Zone 1 (i.e. at less than 0.1% chance of flooding in any year), hydraulic modelling has not been undertaken, nor an assessment of a H++ scenario (see Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1) for further discussion regarding flood risk).

14.6 Study area

Greenhouse gas emissions

14.6.1 In line with DMRB LA 114, different study areas need to be defined for different types of emission source. As such, the following study areas are defined for the emission sources considered within this assessment:

- **The GHG emissions resulting from construction** – this is the study area necessary to consider all of the GHG emissions associated with construction materials and their associated transport to site from the supplier. It also includes GHG emissions associated with construction activities carried out within the Order Limits, the distances that workers travel to and from the construction site and the transport and processing of waste offsite for reuse, recycling, treatment, or disposal. As such, the study area is defined by the greatest extent of these activities, some of which, it is assumed, may occur at a national scale (i.e. within England).

- **The GHG emissions resulting from operational road users** – the study area comprises the road network included within the Traffic Reliability Area (TRA) of the traffic model developed for the Scheme (as shown in Figure 14.1: Study Area for Operational Road User GHG Emissions of the Environmental Statement Figures (TR010064/APP/6.2)). The TRA is defined in DMRB LA 105 Air quality (Highways England, 2019) as the '*area covered by the traffic model, that the competent expert for traffic has identified as reliable for inclusion in an environmental assessment*'. Paragraph 3.9 of DMRB LA 114 states that the study area shall be consistent with the Affected Road Network defined in a Scheme's traffic model (i.e. limited to those roads where changes in traffic are modelled to exceed the traffic scoping criteria defined in paragraph 2.1 of DMRB LA 105). However, the TRA, which covers a greater area than the Affected Road Network, has been considered within this assessment in order to provide a more complete assessment of changes in road user GHG emissions and to be consistent with the study area used to inform the corresponding economic appraisal of changes in GHG emissions.

- **The GHG emissions resulting from operation and maintenance** – the study area is based on a similar extent as the construction phase (e.g. to include replacement of assets which may be delivered from suppliers located across England). It also includes the GHG emissions from the energy consumed within the Order Limits required to operate the Scheme.

Vulnerability to changes in climate

14.6.2 The study area for the Scheme's vulnerability to climate comprises the construction footprint of the Scheme, including compounds and temporary land take. This is shown as the Order Limits on Figure 1.1: Location Plan of the Environmental Statement Figures (TR010064/APP/6.2).

14.7 Baseline conditions

Baseline sources

Greenhouse gas emissions

14.7.1 The following key sources of information have been used to define baseline and future baseline GHG emissions in the study area relevant to the Scheme:

- The GHG emissions at a UK and county level – UK Local Authority and Regional Greenhouse Gas Emissions National Statistics (BEIS, 2022)

- Estimated DM (i.e. without the Scheme) road user GHG emissions for the Base year (2018) and over a 60-year appraisal period after the Scheme Opening year (2029), in line with DMRB LA 114

- Estimated baseline and future baseline GHG emissions associated with operational maintenance activities for the extents of the existing M60/M62/M66 Simister Island Interchange and surrounding road network, which would be replaced by the Scheme

Vulnerability to changes in climate

14.7.2 The following key sources of information have been used to define the baseline and future baseline climate in the study area relevant to the Scheme:

- Current climate data within the study area for the Scheme – HadUK-Grid regional observations dataset v1.0.1.0 for the 'climate normal' period of 1981-2010 (Met Office *et al.*, 2019), for the 25km grid square centred on National Grid Reference (NGR) SD 87500 12500.
- Climate extreme indices – State of the UK Climate 2017: Supplementary Report on Climate Extremes (Met Office, 2018b).
- Projected climate changes within the study area for the Scheme – UKCP18 relative to the baseline period of 1981-2010 (Met Office, 2018a), under the high emissions scenario (i.e. RCP8.5) and for a 50% probability of occurrence, for the 25km grid square centred on NGR SD 87500 12500.
- Projected climate data within the study area for the Scheme – UKCP18 relative to the baseline period of 1981-2010 (Met Office, 2018a), under the high emissions scenario (i.e. RCP8.5), for the 12km grid square centred on NGR SD 78000 02000 and the 2.2km grid square centred on NGR SD 82500 07500.
- Historical flooding events and areas at flood risk – see Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1) for further details.
- Geological hazards –BGS GeoIndex (BGS, 2023) and GeoClimate Open (BGS, 2020) datasets.
- Independent Assessment of UK Climate Risk. Advice to Government for The UK's CCRA3 (Climate Change Committee, 2021a)

Baseline information

Greenhouse gas emissions

14.7.3 Baseline GHG emissions have been assessed using the local authority and regional GHG emissions estimates dataset (BEIS, 2022), which provides a spatial breakdown of estimated UK CO_2e emissions on an 'end-user' basis. Within this dataset, therefore, UK CO_2e emissions are distributed according to the point of energy consumption (e.g. electricity consumed in residential properties) or point of emission (if not energy related). The data helps identify the key contributors to total UK GHG emissions in an area.

14.7.4 The Scheme is located within the area administered by Bury Metropolitan Borough Council. Table 14.14 shows GHG emissions by source for the geographical area of Bury. The data is also presented for England and the North West of England region to provide context.

14.7.5 Estimated GHG emissions within Bury in 2020 totalled 838 kilotonnes of carbon dioxide equivalent ($ktCO_2e$), representing approximately 2.0% of total estimated GHG emissions within the North West of England and 0.3% of total estimated GHG emissions within England.

14.7.6 Road transport GHG emissions are estimated to comprise a significant proportion of the total GHG emissions within Bury (42.8%), the North West of England (27.9%) and England (29.7%). Motorways, including the M62 and M66, of which the Scheme would form part, are estimated to contribute approximately 6.4% of the total GHG emissions within Bury, 8.6% of the total GHG emissions within the North West of England, and 18.0% of the total GHG emissions within England.

14.7.7 In total, road transport emissions within Bury are estimated to contribute 3.1% of total road transport GHG emissions within the North West of England and 0.4% of total road transport GHG emissions in England. Of this contribution, approximately 59% is considered potentially attributable to road traffic emissions from the strategic road network (SRN) within Bury.

14.7.8 It should be noted that the coronavirus (COVID-19) pandemic and the resulting restrictions introduced in 2020 across the UK had major impacts on various aspects of society and the economy, which led to a significant impact on greenhouse gas emissions in the UK. These impacts, such as the large reduction in the use of road transport during the nationwide lockdowns and lower energy demand during the pandemic will be reflected in the GHG emissions estimates shown in Table 14.14.

Table 14.14 England, North West of England and Bury GHG emissions estimates by source (2020)

Emission source	Estimated 2020 GHG emissions					
	England		North West of England		Bury	
	$ktCO_2e$	% of total	$ktCO_2e$	% of total	$ktCO_2e$	% of total
Industry total	**50,567**	**17.4%**	**8,400**	**20.0%**	**74**	**8.9%**
Commercial total	**20,447**	**7.0%**	**2,699**	**6.4%**	**49**	**5.9%**
Public sector total	**10,166**	**3.5%**	**1,393**	**3.3%**	**26**	**3.1%**
Domestic total	**76,632**	**26.3%**	**10,419**	**24.9%**	**274**	**32.7%**
Road transport (A-roads)	33,167	11.4%	3,357	8.0%	61	7.3%
Road transport (motorways)	18,591	6.4%	3,607	8.6%	150	18.0%
Road transport (minor roads)	34,572	11.9%	4,733	11.3%	147	17.5%
Diesel railways	1,299	0.4%	113	0.3%	-	0.0%
Transport (other)	1,882	0.6%	285	0.7%	2	0.3%

Emission source	Estimated 2020 GHG emissions					
	England		North West of England		Bury	
	$ktCO_2e$	% of total	$ktCO_2e$	% of total	$ktCO_2e$	% of total
Transport total	**89,511**	**30.7%**	**12,095**	**28.9%**	**361**	**43.1%**
Land use, land-use change, and forestry net emissions	1,582	0.5%	743	1.8%	-1	-0.1%
Agriculture total	**28,345**	**9.7%**	**4,147**	**9.9%**	**11**	**1.4%**
Waste management total	**13,884**	**4.8%**	**2,026**	**4.8%**	**43**	**5.2%**
Total	**291,135**	**-**	**41,922**	**-**	**838**	**-**

14.7.9 Estimated operational road user GHG emissions based on modelled road traffic conditions across the study area, as defined in Section 14.6 of this chapter, for the modelled Base year (2018), along with estimated GHG emissions associated with the operational maintenance in the Base year, are shown in Table 14.15.

Table 14.15 Estimated baseline GHG emissions

Source	Baseline GHG emissions (tCO_2e) (2018)
Road users	482,858
Operational maintenance	411

14.7.10 The estimated road user emissions shown in Table 14.15 equate to approximately 4% and less than 1% of 2018 national estimates of road user GHG emissions within the North West of England (14,049,049 tCO_2e) and the UK (127,886,725 tCO_2e), respectively (BEIS, 2022).

14.7.11 The results in Table 14.15 indicate that GHG emissions associated with operational maintenance are likely to be negligible in comparison to road user GHG emissions.

Vulnerability to changes in climate

14.7.12 With regard to baseline climate impacts, DMRB LA 114 states that:

- *'The assessment of a project's vulnerability to climate change shall use published historical regional weather data to demonstrate the current climate impacts on a study area'* (paragraph 3.26)
- *'Recent weather patterns and extreme weather events should be identified, to provide an indication of how the project will account for climate change in the immediate future i.e. during construction'* (paragraph 3.26.1)

- *'Historical events as a result of weather patterns and extreme weather events i.e. landslides after heavy rainfall, shall be identified to provide an indication of past vulnerability'* (paragraph 3.27)

14.7.13 As such, baseline climate data for the North West of England are summarised in Table 14.16, based on data for the most recent 'climate normal' period available from the Met Office (i.e. 1981-2010). These data have been compared to similar data for England as a whole, which indicate that:

- The climate in the North West of England region is colder compared to across England as a whole, throughout the year, with the most sizeable differences recorded during summertime.
- The climate in the North West of England region is wetter compared to across England as a whole, throughout the year, with the greatest difference in precipitation being in the autumn.

Table 14.16 Baseline climate data (1981 - 2010) for England and North West of England

Climate variable	Period	England	North West of England	Difference
Daily maximum temperature (°C)	Winter	7.1	6.4	-0.7
	Spring	12.7	11.7	-1.0
	Summer	20.1	18.4	-1.7
	Autumn	13.9	12.7	-1.2
Daily minimum temperature (°C)	Winter	1.3	1.0	-0.3
	Spring	4.4	4.1	-0.3
	Summer	10.9	10.5	-0.4
	Autumn	6.8	6.3	-0.5
Daily mean temperature (°C)	Annual	9.6	8.9	-0.7
	Winter	4.2	3.7	-0.5
	Spring	8.5	7.9	-0.6
	Summer	15.5	14.4	-1.1
	Autumn	10.3	9.5	-0.8
Mean accumulated precipitation (mm)	Annual	855	1,247	+392
	Winter	230	350	+120
	Spring	181	247	+66
	Summer	194	274	+80

Climate variable	Period	England	North West of England	Difference
	Autumn	250	376	+126

14.7.14 An overview of historical and more recent extreme weather conditions recorded in the North West of England is presented in Table 14.17, based on data contained within the State of the UK Climate 2017: Supplementary Report on Climate Extremes (Met Office, 2018b). These data indicate that:

- Maximum temperatures in the North West of England region are lower than across England as a whole and appear to be increasing
- The duration of 'warm spells' in the North West of England region, and across England as a whole, appear to be increasing
- The duration of 'cold spells' and number of 'icing days' are generally slightly higher in the North West of England region than across England as a whole, but appear to be decreasing
- Rainfall from 'extremely wet days' is higher in the North West of England region than across England as a whole and appears to be increasing
- Maximum '5-day precipitation' is higher in the North West of England region than across England as a whole and appears to be decreasing
- The 'longest dry spell' is shorter in the North West of England region than across England as a whole and appears to be decreasing

Table 14.17 Summary of climate extremes for the North West of England and England

Climate variable	Period	England	North West of England	Difference
Highest maximum temperature [a]	1961-1990	27.3	26.2	-1.1
	1981-2010	28.3	26.9	-1.4
	2008-2017	28.5	26.8	-1.7
Warm spell duration index (days) [b]	1961-1990	5.3	6.5	+1.2
	1981-2010	10.0	10.4	+0.4
	2008-2017	15.0	12.7	-2.3
Cold spell duration index (days) [c]	1961-1990	3.1	2.9	-0.2
	1981-2010	2.8	3.5	+0.7
	2008-2017	2.0	3.1	+1.1
	1961-1990	3.6	4.3	+0.7

Climate variable	Period	England	North West of England	Difference
Number of icing days [d]	1981-2010	2.5	3.1	+0.6
	2008-2017	1.9	2.9	+1.0
Rainfall from extremely wet days (mm) [e]	1961-1990	64.8	92.9	+28.1
	1981-2010	69.3	93.1	+23.8
	2008-2017	72.0	104.2	+32.2
Maximum 5-day precipitation (mm) [f]	1961-1990	64.7	88.0	+23.3
	1981-2010	67.3	91.3	+24.0
	2008-2017	65.7	93.0	+27.3
Longest dry spell (days) [g]	1961-1990	22.7	20.0	-2.7
	1981-2010	22.2	18.8	-3.4
	2008-2017	20.1	17.0	-3.1

[a] Average highest daily maximum temperature recorded on an annual basis

[b] Count of days with at least 6 consecutive days when daily maximum temperature is above the 90th percentile centred on a 5-day window for the base period of 1961-1990

[c] Count of days with at least 6 consecutive days when daily minimum temperature is below the 10th percentile centred on a 5-day window for the base period of 1961-1990

[d] Number of days when the daily minimum temperature is below 0ºC

[e] Total rainfall falling on days with daily rainfall total in excess of the 99th percentile of daily rainfall

[f] Highest value of rainfall accumulated over 5 days

[g] Largest number of consecutive days with < 1 mm rainfall

14.7.15 Section 13.7 of Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1) uses the Environment Agency's Flood Map for Planning (Environment Agency, 2023a) to identify baseline fluvial flood risk, and indicates that the majority of the study area is located within Flood Zone 1 (i.e. at very low risk (less than 0.1% (1 in 1000) Annual Exceedance Probability (AEP)) and there are no areas of the Scheme that interact with Flood Zones 2 and 3.

14.7.16 Section 13.7 of Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1) also indicates that in terms of surface water flood risk, the Environment Agency's Risk of Flooding from Surface Water (RoFSW) mapping (Environment Agency, 2023b) shows that there are areas shown to be at risk of surface water flooding immediately adjacent to the main rivers and ordinary watercourses. However, these areas are within floodplains and therefore likely to be associated with fluvial flood risk. Other areas at risk of surface water flooding are mainly located within localised topographic depressions or against existing road embankments.

14.7.17 There is also an area of surface water ponding to the north-east of M60 J18 where the Northern Loop would be. However, as this length of carriageway would be elevated it is unlikely to be at risk of surface water flooding. There are other areas of high surface water flood risk and overland flow routes within the study area and these are detailed further in the FRA Report (Appendix 13.6 of the Environmental Statement Appendices (TR010064/APP/6.3)).

14.7.18 Based on GeoIndex (BGS, 2023), no historical landslide events are recorded in the vicinity of the Scheme, and therefore no such past vulnerability has been identified at this point.

14.7.19 No records were available at the time of writing regarding past incidences of subsidence within the footprint of the Scheme.

Future baseline

14.7.20 The estimated DM operational road user GHG emissions and GHG emissions associated with the operational maintenance in the Opening year (2029), Design year (2044), Future year (2061) and over a 60-year appraisal period after Scheme opening (2029–2088, inclusive) are shown in Table 14.18.

Table 14.18 Estimated future DM GHG emissions

Source	Future baseline GHG emissions (tCO_2e)			
	Opening year (2029)	Design year (2044)	Future year (2061)	Appraisal period (2029–2088)
Road users	479,901	366,479	358,240	22,599,511
Operational maintenance	411	411	411	24,633

14.7.21 The estimates of road user emissions shown in Table 14.18 indicate that road user GHG emissions would decrease by approximately 24% between the modelled Opening year (2029) and modelled Design year (2044). This is despite the total number of vehicle kilometres travelled within the study area being modelled to increase by approximately 11% over this period. An overall decrease in road user GHG emissions occurs because of a substantial projected increase in the proportion of electric vehicles in the national vehicle fleet (which result in much lower GHG emissions than conventionally fuelled vehicles), coupled with improvements in vehicle efficiency. A much smaller reduction in road user GHG emissions (2%) is estimated to occur between 2044 and 2061 (compared to an increase in vehicle kilometres travelled within the study of approximately 4%), because, as noted in paragraph 14.5.8, no allowance has been made for improvements to the national vehicle fleet beyond 2050. This illustrates the overriding influence that national policy (e.g. future bans on the sale of conventionally fuelled cars and vans) is expected to have on road user GHG emissions in Future years.

14.7.22 It is noted that the magnitudes of estimated DM road user GHG emissions shown in Table 14.18 are slightly greater over the appraisal period than those reported within the Preliminary Environmental Information Report (PEIR) (Annex L of the Consultation Report Annexes (TR010064/APP/5.2)), as they are based on more recent traffic modelling.

14.7.23 The results in Table 14.18 indicate that GHG emissions associated with operational maintenance are likely to be negligible in comparison to road user GHG emissions.

14.7.24 The Adaptation Committee's Independent Assessment of UK Climate Risk sets out the priority climate change risks and opportunities for the UK. In June 2021, the Committee published the UK's CCRA3 (Climate Change Committee, 2021a).

14.7.25 CCRA3 (Climate Change Committee, 2021a) notes that the UK is likely to experience an approximate additional 0.5°C increase in annual average temperature by 2050, even under ambitious global scenarios for cutting GHG emissions. The general pattern of change in the UK is towards warmer and wetter winters, hotter and drier summers, with high levels of variability. These changes will increase the UK's exposure to weather-related hazards including:

- Increases in average and extreme temperatures, in winter and summer
- Changes to rainfall patterns, leading to flooding in some places and water scarcity in others
- Increased coastal flooding and erosion, alongside increasing sea temperatures and ocean acidification
- Increased frequency and intensity of wildfire
- Potential changes to other weather variables including wind strength and direction, sunshine and ultraviolet (UV) levels, cloudiness, and sea conditions such as wave height.

14.7.26 Current and projected future changes in climate at the location of the Scheme, in terms of temperature and precipitation, are presented in Table 14.19. These data utilise the 25km spatial resolution UKCP18 probabilistic dataset for the grid cell centred at NGR SD 87500 12500. The current climate conditions (i.e. observed baseline) refer to the most recent historic climate dataset of 1981–2010. The future climate conditions (i.e. climate projections) refer to projections made under the high emissions scenario (i.e. RCP8.5) with a 50% probability of occurrence for the 2030s (2020–2049), 2060s (2050–2079) and 2080s (2070–2099) respectively. These 30-year periods cover the lifespan of the Scheme (which is taken to be 60 years in accordance with paragraph 3.31 of DMRB LA 114).

Table 14.19 Projected changes in climate at the location of the Scheme

Climate metric	Observed baseline 1981–2010	Projected change (UKCP18 RCP8.5 (50% probability))		
		2030s (2020–2049)	2060s (2050–2079)	2080s (2070–2099)
Annual mean accumulated precipitation	1,278.5mm	+0.3%	+0.3%	+0.7%
Winter mean accumulated precipitation	362.8mm	+1.7%	+9.6%	+13.5%
Summer mean accumulated precipitation	283.1mm	-5.4%	-21.2%	-30.8%
Annual mean temperature	8.9°C	+0.9°C	+2.2°C	+3.4°C
Mean winter minimum temperature	3.6°C	+0.9°C	+2.0°C	+3.0°C
Mean summer maximum temperature	14.6°C	+1.2°C	+3.0°C	+4.8°C

14.7.27 Under the climate scenario considered, annual mean accumulated precipitation at the location of the Scheme is projected to increase slightly over time, and by the 2080s is projected to have increased by 0.7% compared to the observed baseline. However, projected changes in seasonal precipitation by the 2080s, i.e. +13.5% during wintertime and -30.8% during summertime, indicate wetter winters and substantially drier summers could occur.

14.7.28 All of the temperature related metrics considered indicate that there could be a steady increase in temperatures, with the largest increase occurring during summertime. Specifically, the annual mean, mean winter minimum and mean summer maximum temperatures are projected to increase by 3.4°C, 3.0°C and 4.8°C, respectively, by the 2080s compared to the observed baseline values.

14.7.29 Other climate variables selected to represent more extreme conditions (i.e. the 10th and 90th percentiles of projected values) are presented in Table 14.20. These variables were derived utilising the regional (12km) and, where relevant, local (2.2km) spatial resolution UKCP18 high emissions scenario (i.e. RCP8.5) datasets for the grid squares centred at NGR SD 78000 02000 and SD 82500 07500, respectively.

14.7.30 Daily projections for the period 2061–2080 were used to assess potential changes in more extreme daily temperature, precipitation and wind events. The 90th percentile of projected values has been used to represent the value above which any event happening within a day (e.g. a precipitation event) is likely to occur less frequently. For instance, for the period 2061–2080, maximum daily precipitation events greater than 14.1mm are likely to occur relatively infrequently. Similarly, the 10th percentile has been used to represent the value below which any event happening within a day is likely to occur less frequently. The corresponding metrics for the observed baseline period 1981–2010 (which is the baseline for the 12km and 2.2km projection datasets) are also presented for comparison.

Table 14.20 Projected changes in climate extremes at the location of the Scheme

Meteorological parameter	Observed baseline 1981–2010		Projected (RCP8.5) 2061–2080		Projected change	
	10th %ile	90th %ile	10th %ile	90th %ile	10th %ile	90th %ile
Daily precipitation (mm/day)	-	10.4 to 13.4	-	10.9 to 14.1	-	+0.5 to +0.7
Minimum daily temperature (°C)	-0.9 to 1.7	12.2 to 14.5	2.2 to 4.1	15.4 to 18.4	+2.4 to +3.1	+3.2 to +3.9
Maximum daily temperature (°C)	3.0 to 5.7	18.7 to 21.4	6.1 to 8.2	22.7 to 27.1	+2.5 to +3.1	+4.0 to +5.7
Daily temperature (°C)	1.2 to 3.8	15.2 to 17.7	4.3 to 6.3	18.8 to 22.5	+2.5 to +3.1	+3.6 to +4.8
Maximum daily wind gusts (m/s)	7.3 to 8.6	18.6 to 19.7	7.3 to 8.0	18.1 to 19.7	-0.6 to 0.0	-0.5 to 0.0

Note: Ranges are provided for each variable to account for differences in the outputs of the 12 ensembles (i.e. model runs) included within the UKCP18.

14.7.31 Under the climate scenario considered, the 90th percentile of daily precipitation values is projected to increase slightly from 13.4mm/day during 1981–2010 to 14.1mm/day during 2061–2080 (upper limits used), indicating that more extreme precipitation events have the potential to occur slightly more frequently. However, it should be noted in this instance that when even more extreme events are considered, i.e. in excess of the 90th percentile, precipitation intensity appears to increase between the two periods, suggesting that, while more extreme precipitation events could occur only slightly more frequently, very extreme precipitation events could be of higher intensity when they do occur. For instance, the 99th percentile of daily precipitation values is projected to increase by approximately 13% from 29.9mm/day during 1981–2010 to 33.7mm/day during 2061–2080 (upper limits used).

14.7.32 The 10th percentile of minimum daily temperatures is projected to increase from -0.9°C to 2.2°C (lower limits used), indicating that days with more extreme low temperatures have the potential to occur less frequently. The 90th percentile of maximum daily temperatures is projected to increase from 21.4°C to 27.1°C (upper limits used), indicating that days with more extreme high temperatures will potentially occur more frequently.

14.7.33 The intensity of the 90th percentile of maximum wind gusts is projected to remain the same at 19.7m/s (upper limits used) both during 1981–2010 and 2061–2080, indicating that higher wind speeds will potentially occur at the same frequency.

14.7.34 Utilising the same dataset as for Table 14.20, a number of climate extreme indices for the study area were also calculated (see Table 14.21), which underpin the warmer and drier conditions identified above. For example, the number of annual air frost days (upper limit) during 2061–2080 will potentially be substantially lower than during 1981–2010, i.e. from up to 24 events to up to two events. Hot spells and heatwaves will potentially increase from up to four events and up to three events per year during 1981–2010, to up to 25 events and up to 18 events per year, respectively, during 2061–2080. In addition, drought events and dry spells will potentially increase from up to one event to up to four events and from up to seven events to up to 14 events, respectively. The annual number of days with wind gust events exceeding 45mph will potentially remain the same at up to 32 days.

Table 14.21 Projected changes in climate extreme indices at the location of the Scheme

Climate extreme indices	Observed baseline 1981–2010	Projected (RCP8.5) 2061–2080	Change
Annual number of days when mean temperature >25°C	0 to 1	2 to 13	+2 to +11
Annual air frost days	4 to 24	0 to 2	-4 to -22
Annual hot spells (days)	0 to 4	5 to 25	+5 to +21
Annual heatwaves (days)	0 to 3	3 to 18	+3 to +15
Annual heavy rain days	3 to 7	5 to 11	+2 to +4
Annual drought events	0 to 1	0 to 4	0 to +3
Annual dry spells	1 to 7	5 to 14	+4 to +7
Annual number of days when maximum wind gust >45mph	19 to 32	18 to 32	0 to +1

Note: Ranges are provided for each variable to account for differences in the outputs of the 12 ensembles (i.e. model runs) included within the UKCP18.

14.7.35 As noted in Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1), over the anticipated lifetime of the Scheme, changes to the baseline as a consequence of climate change would likely occur. This includes a likely increase in the frequency and magnitude of flood events, as well as changes in both the low and high flows in watercourses leading to subsequent changes in dilution capacity and surface water quality.

14.7.36 Based on GeoIndex (BGS, 2023), and specifically the GeoClimateUKCP18 dataset, subsidence is considered '*improbable*' under '*average*' soil humidity conditions in the region of the Scheme in the 2080s.

14.7.37 Future changes in climate could exacerbate or reduce the effects of the Scheme on the environment (i.e. to result in 'in combination' effects). This issue has been considered within each of the relevant aspect chapters of this Environmental Statement using aspect-specific significance criteria, rather than within this chapter, as recommended within IEMA (2020) Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation.

14.7.38 The UK Government is required to conduct a UK Climate Change Risk Assessment (CCRA) every five years as set out in the Climate Change Act 2008. In advance of CCRA3, the UK Government requested the Climate Change Committee to prepare an independent assessment setting out the risks and opportunities to the UK from climate change up to 2100, including the Committee's advice on priorities for adaptation for the coming five-year period.

14.7.39 The Independent Assessment of UK Climate Risk (Climate Change Committee, 2021a) provides the Committee's statutory advice to Government on priorities for the forthcoming national adaptation plans and wider action. It is informed by new evidence gathered for the accompanying CCRA3 Technical Report (Climate Change Committee, 2021c). The CCRA3 Technical Report highlights that the gap between the level of risk faced and the level of adaptation underway has widened, where adaptation action has failed to keep pace with the worsening reality of climate risk.

14.7.40 In relation to infrastructure specifically, Chapter 4 of the CCRA3 Technical Report (Climate Change Committee, 2021c) identifies the following key risk areas of relevance to the Scheme:

- Risks to infrastructure networks (including transport) from cascading failures
- Risks to infrastructure services from river and surface water flooding
- Risks to bridges from flooding and erosion
- Risks to transport networks from slope and embankment failure
- Risks to surface infrastructure from subsidence
- Risks to transport from high and low temperatures, high winds and lightning

14.7.41 The key messages of the CCRA3 Technical Report (Climate Change Committee, 2021c) relevant to the Scheme include the following:

- Flooding remains a key risk to infrastructure with the latest climate projections indicating an increased likelihood of heavy precipitation.
- A changing climate continues to be a problem for the transport sector. Significant risks are still posed to roads, where problems are more likely to occur on local roads and smaller schemes and there is an underlying need to assess the impact of single points of failure more broadly (e.g. bridges, earthworks and subsidence).
- The systems nature of infrastructure means that any unmitigated risk could have a propagating impact across the network or lead to cascading failures across multiple networks.

Value (sensitivity) of receptors

14.7.42 The receptors identified for this assessment have been reported in Section 14.4, subsection 'Value (sensitivity) of receptors'.

14.7.43 As stated in Section 14.4, in the absence of specific guidance in DMRB LA 114 on the valuation of receptors with regard to climate impacts, all receptors are considered to be of high value given the global importance of climate change and the potential for climate related impacts to adversely affect the health and safety of employees and road users.

14.8 Potential impacts

Greenhouse gas emissions

14.8.1 Increases in GHG emissions could impact climate by contributing to the cumulative impact that GHG emissions have on climate change. It is not possible, however, to attribute the resulting impact of a certain quantity of GHG emissions to effects on a specific receptor. Instead, the most appropriate geographic level for an assessment of the impact of a certain quantity of GHG emissions is at a national level (i.e. by comparison to UK carbon budgets) as that is the level at which the UK Government has jurisdiction and has specified in NPS NN (DfT, 2014) paragraph 5.18 the assessment shall be undertaken. It is very unlikely, however, that the impact of a road scheme will, in isolation, affect the ability of the Government to meet its carbon reduction plan targets.

Construction

14.8.2 The GHG emissions during the construction phase of the Scheme would be associated with:

- Embodied carbon (i.e. GHGs generated during the manufacture of the raw materials required to build the Scheme)
- Energy consumption (e.g. through petrol or diesel combustion and use of electricity) and water consumption as a result of:
  - The transportation of raw materials to the construction site
  - The transportation and treatment of waste

  - The transportation of construction workers, onsite staff and visitors to, from and within the construction site
  - Construction activities and the operation of onsite construction plant, machinery and equipment

- Changes in road user GHG emissions as a result of traffic management measures implemented during the construction phase
- The disturbance or removal of carbon stored within vegetation, peaty soil and soil within the Order Limits
- Changes in the GHG emissions/sequestration balance within the Order Limits associated with changes in land use, for example through changes in the spatial extents and management of carbon sinks such as woodland

Operation

14.8.3 GHG emissions during the operational phase of the Scheme would be associated with:

- Maintenance and operation of the road infrastructure – through consumption of energy (e.g. through petrol or diesel combustion and use of electricity) and materials to support activities such as the repair and replacement of lighting and structures (including fencing) and highway resurfacing.
- Consumption of energy (e.g. through petrol and diesel combustion and use of electricity) by motorised vehicles using the road infrastructure – the Scheme has the potential to alter traffic volumes, composition and speeds on the local road network, both positively and negatively, which could act to alter the overall magnitude of road user GHG emissions.
- Ongoing changes in the emissions/sequestration balance within the scheme footprint associated with changes in land use, for example through changes in the spatial extents and management of carbon sinks such as woodland and soil.

Vulnerability to changes in climate

Construction

14.8.4 As identified in Table 14.17, the North West of England region appears to have experienced increasing temperatures and precipitation events of higher intensity in recent years. Furthermore, the projected changes in climate variables over the relatively short term (2020–2049) shown in Table 14.19 suggest that further increases in temperature have the potential to occur (especially during summer) and that precipitation has the potential to increase during winter and decrease during summer. As a result, during the construction process, receptors may be vulnerable to a range of short-term climate risks, including:

- Increased precipitation during winter months resulting in flooding of the construction site, compounds, haul roads and excavations; this could result in damage to equipment and materials stored onsite, machinery and plant being damaged or trapped, site roads becoming impassable, contamination of water bodies through runoff, adverse impacts on health, safety and welfare of construction workforce, delays to the construction programme and increased costs
- Flooding of the local road network and site access roads from increased precipitation during winter months resulting in a disruption to the supply of materials and goods required to support construction activities and associated delays to the construction programme
- Increased precipitation during winter months resulting in higher pore water pressure in embankments and earthworks or increased erosion, leading to instability and risk of failure and increased maintenance requirements
- Very high summer temperatures and an increased number of hot spells leading to an increased risk of heat stress or sunstroke for outdoor construction workers and the risk of mechanical failure of equipment due to overheating
- Fewer very cold days with freezing conditions due to increased temperatures resulting in reduced health, safety and welfare risks to construction workers associated with icy conditions or very cold temperatures and more favourable conditions for some construction activities, processes and equipment, benefiting the construction programme
- Higher temperatures and lower rainfall during summer leading to increased desiccation of soils and potential reductions in slope stability and increased risk of earthworks failure during or immediately after rain from summer storm events falling on desiccated soils
- Higher temperatures during summer months leading to accelerated hardening of bitumen and inappropriate conditions to lay pavements (e.g. very hot weather) resulting in delays to the construction programme

14.8.5 Further details on potential climate change hazards and opportunities, potential climate change related impacts and affected assets and receptors are presented in Appendix 14.2: Vulnerability Assessment of the Environmental Statement Appendices (TR010064/APP/6.3).

Operation

14.8.6 As identified in Table 14.19, projected changes in climate over the longer term suggest that there could be substantial increases in temperature especially during summer and precipitation during winter in the area of the Scheme. Furthermore, Table 14.20 indicates that maximum daily temperatures have the potential to increase substantially over the lifespan of the Scheme, while Table 14.21 indicates that climate events, such as hot spells, heatwaves, dry spells and droughts, have the potential to occur more frequently.

14.8.7 The key potential operational impacts on assets (including their operation, maintenance and refurbishment) are outlined below, with further details provided in Appendix 14.2: Vulnerability Assessment of the Environmental Statement Appendices (TR010064/APP/6.3):

- Increased precipitation during winter months and more extreme rainfall events could cause:
  - Road surface flooding, should drainage capacity be exceeded, which could result in danger or delay and disruption to road users, damage to road pavements and increased management or maintenance requirements and costs
  - Fluvial flooding of roads and road infrastructure resulting in potential danger or delay and disruption to road users on a strategic route; damage to or accelerated degradation of Scheme structures and assets; and increased management or maintenance requirements and costs
  - Erosion at toe of embankments could result in the potential failure of embankments or increased maintenance requirements and costs
  - Water ingress to cables and electrical equipment (e.g. signage and lighting) could lead to the potential damage to equipment, which could result in danger or delay and disruption to road users and increased maintenance requirements and costs
  - Changes in groundwater levels which could affect earth pressures for retaining walls, resulting in damage to retaining walls and subsequent ground movement and associated increased maintenance requirements and costs
  - Variations in groundwater levels, which could cause softening of embankment fill through capillary action and accelerated weathering effects, weakening embankments
  - Higher pore water pressure in embankments and earthworks, which could lead to instability and risk of failure resulting in delay and disruption to road users along this strategic route and increased maintenance requirements and costs
  - Flooding of roads, hard shoulders, verges and access routes, which could lead to challenges, delays, and disruption for the maintenance regime
  - Increased debris and sediment runoff, which could result in a capacity reduction of the SuDS
  - Increased debris washing into drainage infrastructure (e.g. gullies and culverts), which could lead to blockages of the drainage system, resulting in danger or delay and disruption to road users and increased maintenance requirements and costs

- Increased number of heavy rain days, which could result in higher stripping rates of pavements leading to texture depth reduction, which could endanger road users and increase maintenance requirements and costs
- Potholing, rutting and cracking from moisture entering and remaining in pavements (particularly in combination with frost formation) which could result in damage to road users' vehicles and increased maintenance requirements and costs

- Lower rainfall during the summer months and more frequent drought events and dry spells could cause:
  - Soil shrinkage or subsidence, which could result in adverse impacts on foundations, including for bridges and other structures, which may lead to increased maintenance requirements or failure
  - Reduced inflow into SuDS, which could result in planting/seeding failure and a reduction in the functional capacity of the SuDS
  - Increases in the desiccation of soils, which could lead to slope stability reduction and earthworks failure during or immediately after summer storm events falling on desiccated soils
- An increase in the maximum summer temperatures, and the number and duration of hot days, hot spells and heatwaves could cause:
  - Heating and thermal expansion beyond the design capability of structures and assets leading to the damage or failure of structures and assets
  - Permanent deformation of asphalt (part of the paving mixture, i.e. flexible surfacing), particularly during prolonged hot weather conditions
  - Surface rutting leading to water ponding in ruts and the reduced skid resistance due to fatting (accumulation of bituminous mix on the surface of the pavement)
  - Acceleration of bitumen binder hardening, which could lead to pavements cracking and fretting with age and traffic loads
  - Longer growing season, which could lead to stability impacts on structures and deformation of pavements due to overgrown tree roots and also additional maintenance needs for the soft estate and SuDS, due to overgrown vegetation
  - Impacts on the performance of electrical equipment leading to reduced efficiency and lifespan of LED luminaires, for example

14.8.8 It should be noted that Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1) has identified that the risk of surface water flooding is likely to increase as a result of climate change. This may impact the magnitude and frequency of flooding and, if unmitigated, result in additional areas of the Scheme becoming at risk of flooding in a 1% AEP event. As discussed in Section 13.9 of Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1), mitigation has therefore been identified to account for the increases in surface water flood risk identified as a result of climate change.

14.9 Design, mitigation and enhancement measures

Net Zero Highways

14.9.1 The 'Net Zero Highways' plan (National Highways, 2021) sets out National Highways' programme for achieving net zero GHG emissions for the SRN by 2050. The plan commits National Highways to achieving:

- Net zero for its own operations by 2030
- Net zero for maintenance and construction by 2040
- Net zero carbon travel on the SRN by 2050

14.9.2 Within the plan, a number of key targets have been set to achieve each of these commitments (from 2022 onwards). Many of these targets involve research and / or the development of future policies and procedures as National Highways transition towards achieving net zero, the outcomes of which would inform the design, development and operation of the Scheme going forwards (where applicable).

Embedded mitigation

14.9.3 The environment team has worked in close collaboration with the infrastructure design team to avoid or reduce environmental impacts through the scheme design. This is referred to as embedded (or design) mitigation. Chapter 3: Assessment of Alternatives of this Environmental Statement (TR010064/APP/6.1) details the design alternatives that have been considered, including the environmental factors which have influenced the decision-making.

Greenhouse gas emissions

14.9.4 Embedded mitigation relevant to this aspect includes:

- Measures which have been taken which have reduced the magnitude of GHG emissions associated with construction phase activities, including:
  - The redesign of the Northern Loop and M66 southbound slip road pairing from an over/over to an over/under configuration, resulting in substantial reductions to earthworks cut and fill and the removal of a concrete retaining wall from the design

- Retention of a section of slip road between the M60 northbound and the M60 westbound, resulting in the reuse of the existing merge paved area, resulting in reductions to required earthwork volumes and reductions in GHG emissions associated with land use change
- Modifying the vertical alignment of the Northern Loop to allow a better tangential vertical tie-in to the M66 southbound and to remove the requirement for a 100m concrete retaining wall.
- Existing drainage infrastructure would be utilised where feasible, thus reducing the embodied carbon and transport emissions associated with the use of new drainage materials
- Retention of the pavements on the M60 eastbound off-slip to the existing J18 and the southbound on-slip to the M60, with access to be provided to authorised vehicles only, therefore reducing the GHG emissions associated with demolition activities, waste treatment and transport
- Pavements have been designed to utilise existing pavement as much as possible, based on the pavement assessments, to eliminate as far as possible full reconstruction of existing pavements
- The widening of pavements has been minimised, for example, to minimise modifications to the Simister Pike Fold Viaduct spans and to avoid impact on the existing M60 J18 circulatory carriageway bridge structures
- Use of low noise pavement, which removed the requirement for any additional height or length of noise barriers in certain locations, therefore eliminating the need for substantial additional civil works to accommodate such structures

- Measures which have been taken in order to reduce carbon losses from existing carbon stores (such as soil and vegetation) and improve carbon sequestration, including:
  - Modifications to the Scheme design in order to reduce land take and the disturbance of existing carbon stores such as vegetation and woodland
  - Planting of new areas of woodland and vegetation within the Order Limits

Vulnerability to changes in climate

14.9.5 Embedded mitigation relevant to this matter includes:

- Measures which have been or would be taken to mitigate climate related impacts on road surfaces and pavements including:

- The highway drainage system is designed to DMRB CG 501 Design of Highway Drainage Systems (National Highways, 2022e) with allowances for climate change in line with those set out in the national Environment Agency Climate Change Guidance (Environment Agency, 2022).
- Edge of pavement drains would be as detailed in pavement drainage design guidance DMRB CD 524 Edge of Pavement Details (Highways England, 2021b) to mitigate the risk of standing water and flooding of the carriageway areas. This includes incorporating the current climate change allowance requirements set out in the national Environment Agency Climate Change Guidance (Environment Agency, 2022).
- The road pavement is designed to DMRB CD 226 Design for New Pavement Construction (Highways England, 2021c), the foundation designed to DMRB CD 225 Design for New Pavement Foundations (Highways England, 2020b) and materials would be laid to the Manual of Contract Documents for Highways Works (MCHW) standards (National Highways, 2023).
- Worst case groundwater conditions, based on the results of site-specific ground water monitoring, would be used to inform the Scheme design at the detailed design stage. The most appropriate drainage type would be selected and designed to meet the requirements of DMRB CG 501 (National Highways, 2022e) to allow for ground water interception.
- The road surface would be laid as per DMRB CD 236 Surface Course Materials for Construction (Highways England, 2021d) to ensure adequate Polished Stone Value (PSV) is adopted to reduce the risk of skidding caused by increased rainfall, especially for high-risk areas.
- As per DMRB LD 117 Landscape Design (Highways England, 2020c), large trees would be planted at least 9m from the edge of carriageway, medium trees at least 7m from the edge of carriageway and shrubs at least 4.5m from edge of the carriageway, thereby limiting potential damage caused by the accelerated growth of tree roots.
- Where widening would be undertaken, the design approach would consider requirements to maintain drainage continuity between the existing carriageway and the widening.

- Measures which have been or would be taken to mitigate climate related impacts on structures (including embankments, earthworks and bridges) including:
  - A drainage blanket would be installed on a portion of the route around the Northern Loop to aid drainage of the formation and improve slope stability following heavy rainfall.

- Retaining structures, earthworks and embankment slopes would be designed for the worst-case groundwater conditions considering climate change.
- Positive drainage measures (i.e. measures which encourage water to drain away from an area rather than pooling) would be installed behind all retaining walls with accessible maintenance rodding points. Weepholes would also be provided as an additional drainage measure.
- Drainage systems would be installed to prevent water build-up at toes of slopes and erosion protection measures would be installed where risk of erosion of the slope surface could lead to shallow slip failures.
- Raking drains would be installed if groundwater is required to be lowered to increase slope stability.
- Adequate long and crossfalls would be provided on all new bridge decks and positive drainage would be installed in the form of combined bridge deck drainage units to prevent build-up of water over the deck.
- Sub-surface deck drainage systems would be installed on top of deck waterproofing systems at low points adjacent to deck joints to collect and dispose of seeping water through the surfacing material.
- Embankments would be designed from slope-stability analysis using site specific soil parameters and compacted and constructed in line with best practice including alignment with DMRB standards.
- Water filled tension cracks that could have an impact on retaining wall or slope stability would be considered in the detailed design to improve slope stability.
- The structures would be designed in accordance with the current version of Eurocode standard EN 1991-1-5 (British Standards Institution, 2010) and its associated National Annex (British Standards Institution, 2007).
- The bridges are designed as fully integral structures where practicable, meaning there are no bridge bearings or deck movement joints, which may be impacted (i.e. expand) as a result of increases in temperature.
- Temperature effects in the structure would be taken into account through the soil and structure interaction in accordance with Eurocode 7: Geotechnical Design (BSI, 2004) and DMRB standards.
- Loading due to wind actions would be in accordance with BS EN 1991-1-4:2005 as modified by the National Annex, using partial safety factors which takes account of climate change and the location and local topography of individual gantry sites.

- Measures which have been or would be taken to mitigate climate related impacts on drainage systems including:

- Additional storage capacity through sediment forebays at attenuation ponds that would allow sediment to settle out from surface water runoff caused by periods of increased precipitation or more intense rainfall events. Gullies and catchpits forming part of the surface water drainage systems would also provide further additional silt-trapping capacity at the ponds.

- The drainage design would include accessible sediment traps (catchpits) that would be regularly cleared. Catchpits would have sumps where silt can be trapped and more easily removed than manholes.

- Ponds would be designed to include a pool of water at the base of the pond (to create a wetland) that would retain the operational functionality of the ponds (i.e. so that vegetation is not lost during hot and dry periods and the treatment capacity of SuDS reduced).

- Embankments would be compacted and grassed, and topsoil retention systems would be used, if deemed necessary, in order to mitigate the effects of lower summer rainfall and more frequent drought events and dry spells on the SuDS.

- Measures which have been or would be taken to mitigate climate related impacts on road technology and street furniture (e.g. signs, signals and lighting) including:

  - Cabinet and equipment housings are designed to mitigate and reduce water ingress during periods of increased precipitation and more intense rainfall events.

  - The Scheme design would include the specification of suitable Ingress Protection ratings for both feeder pillars and luminaires to protect from water ingress during periods of increased precipitation and more intense rainfall events.

  - Cables would be specified correctly including a medium density polyethylene (MDPE) sheath where there is a risk of being located in water, particularly during periods of increased precipitation and more intense rainfall events.

  - Electrical equipment would be protected against main electrical supply surge and lightning current by surge protection devices.

  - For feeder pillar locations the design would ensure there is sufficient free space to dissipate heat and passive cooling as required, particularly during periods of increased temperatures and periods of excessive temperatures, such as heat waves and hot spells.

  - Luminaires selected for the Scheme design are tested to withstand heat in extreme weather climates such as the United Arab Emirates.

- The design includes the use of LED units with breather glands to remove heat to maintain a 'constant ambient temperature', keeping the heat-sink free of debris which is essential in keeping the LED within the required temperature range, particularly during periods of increased temperatures and periods of excessive temperatures, such as heat waves and hot spells.

- Measures which have been or would be taken to mitigate climate related impacts on landscaping, including:

  - The landscape design would futureproof the Scheme in terms of climate change as well as in terms of pests and diseases by adhering to best practice. This would include diversifying planting species as much as practicable, including using drought tolerant species, whilst still having regard to the local character, and generally planting only native species.

  - In terms of increased future flood risk, the landscape design would futureproof the Scheme by including species tolerant of flooding, such as willow and alder, on floodplains and next to watercourses.

Essential mitigation

14.9.6 Essential mitigation would occur as a matter of course due to legislative requirements or standard sector practices.

14.9.7 Essential mitigation is included within the REAC, contained within the First Iteration EMP (TR010064/APP/6.5), which forms part of the DCO submission. The First Iteration EMP will be developed into the Second Iteration EMP for implementation during construction, and is secured by Requirement 4 of the draft DCO (TR010064/APP/3.1).

14.9.8 It should also be noted that the National Highways Net Zero Highways Plan (National Highways, 2021) indicates all of National Highways Tier 1 (design and project management) and Tier 2 (specialist sub-contractors) suppliers will be required to have certified carbon management systems by 2025.

Greenhouse gas emissions

14.9.9 Essential mitigation for this matter includes the following commitments in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5), which would reduce the magnitude of GHG emissions associated with construction phase activities:

- Commitment C1 –A Logistics Management Plan (or similar) will be prepared and implemented to manage the transport to/from and onsite of employees and materials required for the construction of the Scheme. The Logistics Management Plan (or similar) will set out measures where practicable, to reduce distances travelled, optimise journeys and use low emission modes of transport (such as public transport) or vehicles (e.g. electric vehicles) to reduce GHG emissions associated with transport.

- Commitment C2 –Materials will be sourced from local suppliers, where practical and cost-effective to do so, to reduce the travel distance of materials and associated GHG emissions.

14.9.10 Measures to reduce the magnitude of GHG emissions associated with the use of materials and waste disposal (for further details refer to Section 10.9 of Chapter 10: Material Assets and Waste of this Environmental Statement (TR010064/APP/6.1)).

Vulnerability to changes in climate

14.9.11 Essential mitigation for this matter includes the following commitments in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5):

- Measures which reduce the vulnerability of construction phase activities to climate related impacts, including:
  - Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the Construction Industry Research and Information Association (CIRIA) Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented.
  - Commitment C4 – Suitable management of site drainage, as will be specified within the Surface and Ground Water Management Plan in the Second Iteration EMP (to be developed from the Outline Surface and Ground Water Management Plan, which is Appendix H of the First Iteration EMP (TR010064/APP/6.5)).
  - Commitment C5 – The Second Iteration EMP will incorporate the use of weather forecasting and plans for extreme weather events (e.g. very high intensity rainfall events or heat waves).
- Measures which reduce the vulnerability of the Scheme to potential future changes in climate, including:
  - Commitment C6 – The Principal Contractor will, in the choice of permitted materials for sub-bases and bases during detailed design, and in accordance with DMRB CD 226 (Highways England, 2021c), have regard to the nature of those materials and of the sub-grade or any capping and the need to protect them from deterioration due to the ingress of water, the adverse effects of weather and the use of constructional plant.
  - Commitment C7 – The Principal Contractor will programme the laying and compaction of the sub-base and the subsequent pavement courses, where practicable, and take other steps, if necessary, to afford protection to the base, sub-base and subgrade to changes in climatic conditions, such as increases in heavy rainfall periods.

- Commitment C8 – An appropriate asset management strategy will be implemented to proactively identify and, where necessary, rectify potential climate related impacts (e.g. additional visual inspections of the Scheme's assets after extreme weather events).

Enhancement

Greenhouse gas emissions

14.9.12 Opportunities for enhancement which have been identified that are relevant to this matter, but which have not been taken into account within this assessment (as they are not necessary to mitigate impacts nor are able to be confirmed at this stage), include:

- Measures which would be taken to further avoid or reduce GHG emissions during the construction stage, where practicable and cost-effective, including:
  - Using electric (or alternative lower-carbon fuel) construction equipment instead of conventional diesel-powered construction plant
  - Provision of electric vehicle charging points in the site compound
  - Using vehicles fitted with telematics and start/stop technology
  - Using onsite renewable energy generation and storage to reduce diesel generator use and power taken from the grid
  - Using low resource and low energy solutions for the site compound, offices and welfare facilities
  - Ensuring availability of grid connections for compounds (maximising access to lower carbon-intensity energy from grid electricity)
  - Use of alternative fuels for modes for transport of materials to site, if available
- Measures which would be taken to further avoid or reduce GHG emissions associated with the consumption of raw materials, where practicable and cost effective, including:
  - The design specification, which would be developed as part of the detailed design, would aim to reduce or avoid, where practicable, the use of carbon intensive materials (e.g. concrete and cement). Where this is not practicable, material volumes or processes would be substituted with lower intensity replacements where practicable and if achievable within the bounds of the design standards for safety and quality. In order to help guide this process, an Outline Carbon Management Plan has been developed (Appendix O of the First Iteration EMP (TR010064/APP/6.5)). Going forwards this document will be developed into a Carbon Management Plan and implemented.

- Implementation of quality processes during the construction phase to ensure inspections are done at a specified frequency to reduce the probability of rework being required. Any rework would be dealt with a robust non-conformance process that would detail the most efficient necessary remediation required.
- Consideration of the use of recycled aggregate in the construction of embankments.

- Measures to further reduce the magnitude of GHG emissions associated with the use of materials and waste disposal, including:
  - Undertaking a pre-demolition assessment of all highway structures and assets and third-party buildings to be removed or demolished as part of the Scheme (commitment M4 in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)). This assessment will be used to determine the quantities of demolition assets, elements, components, products and materials; and to make recommendations for their re-use (on and off-site), recycling, other recovery or final disposal. This assessment will also support the production of the Site Waste Management Plan and Sustainable Procurement Plan by identifying the types and quantities of each waste to be produced during demolition and any opportunities to use these site-won materials to offset the use of primary materials (refer to Section 10.9 of Chapter 10: Material Assets and Waste of this Environmental Statement (TR010064/APP/6.1)).

14.9.13 Consideration was given to whether some Scheme-related GHG emissions could potentially be offset through on-site peat restoration. However, the soil survey found that most of the peat soils are heavily degraded to the point that they are no longer classified as peat. Furthermore, as the soil survey and ground investigation found isolated pockets of thin peat layers and remnant buried peat that are not contiguous and are unlikely part of a wider hydrological unit, they would therefore be ineligible for restoration according to the International Union for Conservation of Nature (IUCN) classification (IUCN, 2023).

Vulnerability to changes in climate

14.9.14 Opportunities for enhancement which have been identified that are relevant to this matter include:

- Measures would be taken, where reasonably practical, to further mitigate climate related impacts on road surfaces and pavements including:
  - Consideration of special materials such as polymer modified bitumen, which is less sensitive to temperature than plain temperature, for areas subject to rutting

- Consideration of the use of special material selection, such as Enrobé à Module Élevé 2 (EME2) binder course (high strength, long life asphalt base and binder course), to mitigate against cracking and fretting of the carriageway, thereby reducing maintenance requirements

- Measures would be taken, where reasonably practical, to further mitigate climate related impacts on structures (e.g. embankments, earthworks, bridges) including:

  - Consideration of the use of granular materials in earthwork embankments that are less susceptible to weathering

  - If capillary action is considered an issue, additional drainage or sub-surface drainage would be considered where groundwater levels are close to the base of embankments

14.10 Assessment of likely significant effects

14.10.1 This section presents the assessment of likely significant effects on and of climate during both construction and operation of the Scheme. The assessment of effects takes into account the potential impacts on each receptor following the implementation of embedded and essential mitigation measures (but not including potential enhancements) to determine the significance of the residual effects.

Greenhouse gas emissions

Construction

14.10.2 Estimated construction phase GHG emissions are summarised in Table 14.22, with a more detailed breakdown provided in Appendix 14.1: Estimation of GHG Emissions of the Environmental Statement Appendices (TR010064/APP/6.3). The GHG emissions from the construction phase are estimated to total 62,013tCO_2e.

Table 14.22 Construction phase GHG emissions

Sub-stage of Scheme life cycle* construction phase		GHG emissions (tCO_2e)	% of total construction GHG emissions (excluding road user GHG emissions)
Product stage; including raw material supply, transport and manufacture (A1–A3)		29,058	39.3
Construction process stage; including:	Transport of materials to works site (A4)	8,289	11.2
	Transport and treatment of waste (A5)	5,385	7.3
	Employee transport (A5)	2,745	3.7

Sub-stage of Scheme life cycle* construction phase		GHG emissions (tCO_2e)	% of total construction GHG emissions (excluding road user GHG emissions)
	Construction/installation processes (A5)	16,010	21.7
Use of the existing road network during the construction phase (road user GHG emissions)		-11,913	-
Land use change (net change in carbon stocks in soil and vegetation)		9,034	12.2
Peat soil excavation (net change in carbon stocks in the soil)		3,140	4.2
Forestry (net change in carbon sequestration)		266	0.4
Construction stage total		**62,013**	**-**

*Sub-stages of the construction life cycle and modules shown in this table align with PAS 2080 boundary stages.

14.10.3 The largest proportion of construction phase GHG emissions (43.9% in total) is associated with the construction process stage, which includes the transport of materials to the site, the transport and treatment of waste, employee transport, and construction and installation processes. The GHG emissions associated with the production of materials are estimated to contribute 39.3%. The GHG emissions associated with changes in land use, peat soil excavation and forestry during the construction phase are estimated to contribute 16.8%. The total GHG emissions from road users during the construction period are estimated to decrease as a result of rerouting away from the construction works and enforced speed limits near the Scheme.

Operation

14.10.4 Estimated operational phase GHG emissions over a 60-year appraisal period after the Scheme opening (i.e. between 2029 and 2088, inclusive) are presented in Table 14.23, with a more detailed breakdown provided in Appendix 14.1: Estimation of GHG of the Environmental Statement Appendices (TR010064/APP/6.3).

Table 14.23 Operation phase GHG emissions

Sub-stage of Scheme life cycle* operation ('use-stage')	Estimated GHG emissions (tCO_2e) over appraisal period (2029–2088)		
	DM	DS	Change
Use of the infrastructure by the end-user (road user GHG emissions) (B9)	22,599,511	22,743,511	144,000

Sub-stage of Scheme life cycle* operation ('use-stage')	Estimated GHG emissions (tCO_2e) over appraisal period (2029–2088)		
	DM	DS	Change
Maintenance and refurbishment (B2–B5)	24,633	32,843	8,211
Operational energy use (B6)	Not known	407	407
Land use change (net change in carbon stocks in soil and vegetation)	N/A	-566	-566
Forestry (carbon sequestration)	-2,148	-3,110	-962
Operation ('use-stage') total	**22,621,995**	**22,773,085**	**151,090**

*Sub-stages of the operation ('use-stage') life cycle and modules shown in this table align with PAS 2080 boundary stages.

14.10.5 The results in Table 14.23 indicate that operational phase GHG emissions are dominated by road user GHG emissions. It should be noted, however, that changes in land use and forestry as a result of the Scheme are estimated to result in a slight increase in carbon sequestration (i.e. a net benefit) during its operation.

Comparison with carbon budgets

14.10.6 Estimates of total DS GHG emissions and the net change in GHG emissions (i.e. DS minus DM GHG emissions) within relevant UK carbon budget periods are shown in Table 14.24.

14.10.7 The construction phase GHG emissions are assumed to occur in both the fourth and fifth carbon budget periods (i.e. between Q4 2025 and Q2 2029). Emissions generated during the first few years of operation (2029 – 2032) are included in the fifth carbon budget period. Only operational GHG emissions would occur in the sixth carbon budget period.

Table 14.24 Estimated GHG emissions compared to UK carbon budgets

Scheme stage	Estimated total GHG emissions over carbon budget periods (tCO_2e) (DS scenario)	Net change in GHG emissions with Scheme over carbon budget periods (tCO_2e)	Net change in GHG emissions with Scheme within relevant carbon budget period (tCO_2e) (and as % of relevant carbon budget)		
			Fourth carbon budget (2023–2027)	Fifth carbon budget (2028–2032)	Sixth carbon budget (2033–2037)
Construction	1,918,002	62,013	38,414 (0.002%)	23,600 (0.001%)	-

Scheme stage	Estimated total GHG emissions over carbon budget periods (tCO_2e) (DS scenario)	Net change in GHG emissions with Scheme over carbon budget periods (tCO_2e)	Net change in GHG emissions with Scheme within relevant carbon budget period (tCO_2e) (and as % of relevant carbon budget)		
			Fourth carbon budget (2023–2027)	Fifth carbon budget (2028–2032)	Sixth carbon budget (2033–2037)
Operation	4,085,080	34,807	-	16,914 (0.001%)	17,893 (0.002%)
Total	**6,003,082**	**96,820**	**38,414 (0.002%)**	**40,513 (0.002%)**	**17,893 (0.002%)**

14.10.8 The results in Table 14.24 indicate that estimated changes in GHG emissions as a result of the Scheme are negligible in comparison to relevant UK carbon budgets. On this basis, GHG emissions associated with the Scheme are considered unlikely to have a material impact on the ability of the UK Government to meet its carbon reduction targets and are therefore considered to be **not significant**, in line with DMRB LA 114, the NPS NN (DfT, 2014) and draft NPS NN (DfT, 2023a).

14.10.9 It should also be noted that this assessment is considered likely to be worst case as the estimated operational road user GHG emissions presented in this report (derived using Defra's EFT v11 (Defra, 2021)) do not fully account for the most recent projections for the uptake of electric cars and vans described in the latest version of DfT's TAG data book (DfT, 2023c). Nor do they take account of the projected reductions in GHG emissions depicted in Figure 2 of the TDP (DfT, 2021, page 45). The impacts of the TDP are expected to lead to a substantive decrease in GHG emissions from all forms of road transport between now and 2050. As the TDP has only recently been published, vehicle composition projections and emission factors have not yet been updated to reflect the emerging policy position described by the TDP. DfT have advised the Applicant that a sensitivity test based on the impact of the policy measures set out in TDP can now, however, be undertaken for schemes. The DfT have approved a sensitivity test based on the rate of improvement shown in Figure 2 of the TDP which can be applied to road user GHG emissions calculated for the Scheme assessment.

14.10.10 Table 14.25 presents total operation phase GHG emissions in the DS scenario and the change in operation stage GHG emissions compared to the DM scenario, split by carbon budgets, for the TDP sensitivity test (upper and lower bounds). Construction phase GHG emissions are not presented, as these remain the same as presented in Table 14.24.

14.10.11 The results in Table 14.25 indicate that the implementation of the TDP will result in substantially lower operational phase GHG emissions and changes in operational phase GHG emissions than presented in Table 14.24 within both the fifth and sixth carbon budget periods and in Future years.

Table 14.25 TDP Sensitivity Test GHG emissions compared to UK carbon budgets

Scheme stage	Estimated total GHG emissions over carbon budget periods (tCO_2e) (DS scenario)	Net change in GHG emissions with Scheme over carbon budget periods (tCO_2e)	Net change in GHG emissions with Scheme within relevant carbon budget period (tCO_2e) (and as % of relevant carbon budget)		
			Fourth carbon budget (2023–2027)	Fifth carbon budget (2028–2032)	Sixth carbon budget (2033–2037)
Operation (TDP upper bound)	3,230,983	28,020	-	15,369 (0.001%)	12,651 (0.001%)
Operation (TDP lower bound)	1,935,875	17,408	-	10,444 (0.001%)	6,964 (0.001%)

14.10.12 In addition to the TDP, National Highways has recently published its Net Zero Highways Plan (National Highways, 2021). This plan includes commitments to ensure that National Highways' corporate GHG emissions will become net zero by 2030, its maintenance and construction activities will become net zero by 2040 and road user GHG emissions on the strategic road network will become net zero by 2050. Again, the impacts of these commitments have not been factored into this assessment.

14.10.13 National Highways recognise it has a key role in the development and maintenance of the SRN that will facilitate the journey to net zero GHG emissions. As part of this, the Net Zero Highways Plan (National Highways, 2021) sets out commitments to develop a blueprint for electric vehicle charging and energy storage by 2023, and to report to Government on global HGV technology trials and set out proposals for trials in the UK in 2022.

Potential cumulative effects

14.10.14 The traffic model used for the Scheme has been developed in line with DfT requirements (as described in the Transport Assessment (TR010064/APP/7.4)) and is inherently cumulative. This is because, in brief, traffic models used to support scheme assessment contain data about the following:

- The Scheme and adjoining SRN and local road network
- Other transport schemes promoted by National Highways or local authorities in the near vicinity of the Scheme with high certainty that they are to be progressed, i.e. progressed beyond the preferred route announcement stage. Details of the specific transport schemes included within the traffic model used to inform this assessment can be found in the Transport Assessment (TR010064/APP/7.4).

- Foreseeable developments promoted by third parties that are likely (based on discussions with relevant local planning authorities) to be developed in a similar timeline to the Scheme; knowing where the proposed third-party development is to be sited, the extents and types of development, and the timescales of when it is to be completed are requirements to ensure that the third-party developments can be reasonably described in the traffic model. Details of the specific developments included within the traffic model used to inform this assessment can be found in the Transport Assessment (TR010064/APP/7.4).

- National Government regional growth rates which include a representation of likely growth rates excluding known planning developments already included in the traffic model; this is represented by DfT's National Trip End Model (NTEM)/Trip End Model Presentation Program (TEMPRO) growth factors for car usage, and growth in freight is derived from DfT's National Transport Model.

14.10.15 Changes in operational road user GHG emissions as a result of the Scheme have been evaluated within this assessment by comparing changes in road user GHG emissions on the SRN and local road network between the DS and the DM scenario. This takes into account the assessment of the Scheme and all other developments likely to have an influence on the Scheme and on the area the Scheme is likely to influence.

14.10.16 In essence, as both with and without scheme scenarios already include all likely developments and traffic growth factors, the assessment presented above is inherently cumulative as regards operational GHG emissions.

14.10.17 Climate impacts (that is those as a consequence of global heating) are observable at a national and global scale. Assessment of significance is based on whether the increase in global GHG emissions represent a significant contribution to global atmospheric GHG concentrations in the context of national carbon budgets.

14.10.18 The approach to the assessment of cumulative effects arising from GHG emissions is incorporated into the methodology for appraising emissions from construction and operation as set out in DMRB LA 114. The assessment of cumulative GHG emissions cannot be carried out in a process analogous to other environmental aspects because there is no causal link between the location of GHG emissions and the impacts arising from the cumulative aggregation of GHGs in the atmosphere. This limitation has also been recognised in the recent update to guidance on the assessment of GHG emissions produced by IEMA (IEMA, 2022). Because of this limitation – and because it is necessary to consider GHGs in the context of a scientifically based trajectory compliant with the planetary limits for GHG emissions – the best available comparison benchmark are the carbon budgets adopted by the UK that provide a series of five-yearly budgets within which the UK must stay in order to remain on track to achieve Net Zero by 2050.

14.10.19 The net GHG impacts of the Scheme have been assessed and reported within the context of national carbon budgets. The approach to climate assessment within the methodology set out in DMRB LA 114 is inherently cumulative through the inclusion of the Scheme and other locally committed transport schemes within the traffic model on which the GHG emissions calculations are based (see paragraph 14.10.14 of this chapter), and through the consideration of the GHG emissions associated with the Scheme against the UK carbon budgets. The assessment of construction stage emissions is based on design data and estimates of construction activity. The assessment of operational emissions is based on the validated traffic model for the Scheme (as directed by DMRB LA 114). These are then presented in the context of the national carbon budgets for the periods where budgets have been set. The total emissions are presented in the context of the relevant carbon budget period in which they are expected to fall. No separate cumulative assessment has therefore been undertaken on GHG emissions.

Benchmarking

14.10.20 Paragraph 3.21 of DMRB LA 114 requires that the performance of a scheme should be benchmarked by comparing estimated GHG emissions with those associated with other highway schemes. As such, Table 14.26 compares estimated construction phase GHG emissions associated with the Scheme against a selection of other highway schemes for which comparable data were readily available.

14.10.21 In order to enable a more direct comparison, and as per paragraph 3.21.1 of DMRB LA 114, estimated construction phase GHG emissions for each scheme have also been normalised by dividing total construction phase GHG emissions by the length of the scheme. It should be noted, however, that factors other than length will influence the magnitude of construction phase GHG emissions associated with any particular scheme (e.g. the number of lanes, junctions and structures).

14.10.22 The GHG emissions associated with changes in land use and forestry have been excluded from Table 14.26 in order to provide a like-for-like comparison as GHG emissions have not been estimated for this emission source for the majority of the other schemes considered.

14.10.23 A similar comparison has not been undertaken for operational phase GHG emissions as operational phase GHG emissions are dominated by road user GHG emissions, changes in which will be specific to each scheme based on a number of factors (not just scheme length), including not least the schemes' geographical location and existing levels of traffic flows and congestion.

14.10.24 The data presented in Table 14.26 indicates that the Scheme is estimated to result in normalised construction phase GHG emissions towards the middle of the range of the schemes considered.

Table 14.26 Comparison of Scheme's construction GHG emissions with other road schemes (tCO_2e)

Sub-stage of Scheme life cycle	Element	Scheme and approximate scheme length						
		Scheme	A12 Chelmsford to A120 Widening [a]	M54 to M6 Link Road [b]	A14 Cambridge to Huntingdon improvement [c]	A57 Link Roads [d]	A417 Missing Link [e]	A428 Black Cat to Caxton Gibbet improvements [f]
		3.5km	24km	2.5km	37km	3.1km	5.5km	19km
Product stage; including raw material supply, transport and manufacture (A1–A3)	All	29,058	238,050	49,620	740,062	22,796	40,698	163,230
Construction process stage (A4–A5):	Employee commuting	2,745	5,784	2,420	210,278	371	2,668	4,430
	Transport of fuel	48	1,444	Not given	518	20		Not given
	Transport of materials	8,289	59,071	15,940	22,391	8,490		Included in product stage
	HGVs onsite	Included in above	Included in above	Not given	2,792	Not given		Not given
	Onsite consumption of fuel, energy and water	15,962	63,838	4,250	5,110	7,273	20,818	45,210

Sub-stage of Scheme life cycle	Element	Scheme and approximate scheme length						
		Scheme	**A12 Chelmsford to A120 Widening [a]**	**M54 to M6 Link Road [b]**	**A14 Cambridge to Huntingdon improvement [c]**	**A57 Link Roads [d]**	**A417 Missing Link [e]**	**A428 Black Cat to Caxton Gibbet improvements [f]**
		3.5km	**24km**	**2.5km**	**37km**	**3.1km**	**5.5km**	**19km**
	Waste treatment and transport	5,385	19,938	7,780	281	19		1,360
Construction phase total (excluding GHG emissions associated with changes in road users, land use and forestry)		61,486	388,124	80,010	981,432	38,970	64,184	214,230
Construction phase total (tCO_2e per km)		17,568	16,172	32,004	26,525	12,571	11,670	11,275

Data sources

[a] National Highways (2022d); [b] Highways England (2020d); [c] Highways England (2015); [d] Highways England (2021f); [e] Highways England (2021g); [f] Highways England (2021h).

Vulnerability to changes in climate

Construction

14.10.25 Potential climate change related hazards and opportunities, potential climate change related impacts, impacted assets and receptors and measures identified to mitigate such impacts during the construction phase are presented in Table 2.1 of Appendix 14.2: Vulnerability Assessment of the Environmental Statement Appendices (TR010064/APP/6.3).

14.10.26 As shown in Table 2.1 of Appendix 14.2: Vulnerability Assessment of the Environmental Statement Appendices (TR010064/APP/6.3), the risks of substantial disruption to construction phase activities (following mitigation) are likely to be negligible and are therefore considered to be **not significant**.

Operation

14.10.27 Potential climate change related hazards and opportunities, potential climate change related impacts, impacted assets and receptors, and measures identified to mitigate such impacts during the operational phase are presented in Table 2.2 of Appendix 14.2: Vulnerability Assessment of the Environmental Statement Appendices (TR010064/APP/6.3).

14.10.28 The likelihood of each potential impact occurring during the operational phase, with embedded and essential mitigation in place, has been assessed along with the consequence of that impact if it occurred. This assessment, along with the resulting significance of each impact, is presented in Table 2.2 of Appendix 14.2: Vulnerability Assessment of the Environmental Statement Appendices (TR010064/APP/6.3) using the approach and methodology outlined in Section 14.4 of this chapter.

14.10.29 Based on the assessment undertaken it is considered that with the embedded and essential measures in place, the potential climate-related hazards and impacts identified during the operational phase are anticipated to be **not significant**.

Potential cumulative effects

14.10.30 Whilst a range of climate change impacts may occur within the Order Limits, affecting the Scheme, the physical effects of climate events may also occur beyond the Scheme boundary and affect other nearby strategic transport infrastructure, potentially resulting in a cumulative impact, which may have a significant effect. An additional assessment is therefore made here to consider whether other strategic transport infrastructure beyond the boundary of the Scheme may, when also subject to climate impacts, result in significant effects.

14.10.31 Given the Scheme's importance to regional transport, cumulative climate vulnerability effects are considered at both local and regional scales. The main transport networks at these scales include:

- At a local level, alternate road routes around the Scheme are provided by the A56 and A58 and A627(M) and A663, which would provide local resilience in the event of climate vulnerability impacts in the area.

- At a regional level, traffic travelling from the north of the Scheme (e.g. from Blackburn) towards Manchester (or vice versa) could use the M65 and M61 for longer distance journeys.

14.10.32 The Scheme would improve transport resilience by providing additional capacity around the existing M60 J18. A number of assets being replaced or improved on the Scheme would also be designed so they are more resilient to climate change compared to the existing infrastructure assets. Further details on the climate change mitigation that is embedded into the Scheme design can be found in Table 2.2 of Appendix 14.2: Vulnerability Assessment of the Environmental Statement Appendices (TR010064/APP/6.3). For example, with regards to flood risk and anticipated climate change, the Scheme has been designed to appropriate standards (see Chapter 13: Road Drainage and the Water Environment of this Environmental Statement (TR010064/APP/6.1)).

14.10.33 Were significant climate vulnerability events to occur and affect one or more strategic routes, it is likely that the alternative journey options available, coupled with the level of mitigation embedded in the design of the Scheme would provide a sufficient level of systemic resilience to avoid a significant effect when considered against the consequence and likelihood criteria described in Tables 14.11 and 14.12 of this chapter and criteria for significance in Table 14.13 of this chapter.

14.11 Monitoring

Construction

Greenhouse gas emissions

14.11.1 Quarterly GHG emissions reporting, using the National Highways Carbon Tool (National Highways, 2022b), during the construction phase will be undertaken by the Principal Contractor in line with DMRB LA 114. This facilitates reviewing the performance of the Scheme against the carbon estimates developed at the detailed design stage utilising data available in the construction phase, thereby allowing identification of further GHG emissions reduction opportunities. This measure is included as commitment C9 in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5).

Vulnerability to changes in climate

14.11.2 No monitoring is required of climate-related impacts during the construction phase.

Operation

Greenhouse gas emissions

14.11.3 Quarterly GHG emissions reporting of operational maintenance-related GHG emissions, using the National Highways Carbon Tool (National Highways, 2022b), or subsequent updates, during the operational phase will be undertaken by the Applicant's maintenance contractors in line with DMRB LA 114. This measure is included as commitment C10 in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5). The reports will be informed by actual materials, and fuel and energy consumption data and will facilitate reviewing the performance of the Scheme against the carbon estimates in the Environmental Statement, allowing the identification of further GHG emissions reduction opportunities. This requirement will be included in the Third Iteration EMP.

Vulnerability to changes in climate

14.11.4 Operational maintenance plans will include the visual inspection of the Scheme's assets to ensure that appropriate maintenance is undertaken in addition to the pre-defined maintenance intervals. The inspections will primarily occur in:

- Wintertime: when the mean accumulated precipitation is highest and projected to increase, and will include one-off inspections after certain precipitation events, e.g. intense storm events
- Summertime: when the mean maximum temperature is highest and projected to increase, and will include one-off inspections after heat waves and hot spells and periods of drought

14.11.5 This measure is included as commitment C8 in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)).

14.12 Summary

Greenhouse gas emissions

14.12.1 Whilst mitigation measures have been and will be implemented to reduce GHG emissions (e.g. through the implementation of the Outline Carbon Management Plan, which is included in Appendix O of the First Iteration EMP (TR010064/APP/6.5)), the Scheme is estimated to result in an increase in GHG emissions during both its construction and operation. The impact of the Scheme on climate (i.e. GHG emissions) is, however, considered to be **not significant** as it is considered unlikely to have a material impact on the ability of UK Government to meet its carbon reduction targets.

14.12.2 Therefore, **no significant residual effects** are expected to occur, and the Scheme is considered to comply with the relevant requirements of the NPS NN (DfT, 2014) and, to the extent possible and going forwards, the draft NPS NN (DfT, 2023a).

Vulnerability to changes in climate

14.12.3 Assets and infrastructure designed as part of the Scheme are likely to be affected by climate change. A number of potential risks have been identified and assessed which would be mitigated by applying robust design standards as part of the embedded design measures or implementing relevant mitigation measures and incorporating such measures into relevant asset management processes.

14.12.4 The assessment indicates that, with embedded and essential mitigation measures in place, it is unlikely the potential climate-related hazards identified would result in significant impacts during the construction or operational phases of the Scheme.

14.12.5 Therefore, **no significant residual effects** are deemed likely during construction and operation due to vulnerability to changes in climate and the Scheme is considered to comply with the relevant requirements of the NPS NN (DfT, 2014) and, to the extent possible and going forwards, the draft NPS NN (DfT, 2023a).

Summary

14.12.6 Table 14.27 summarises residual significant effects identified for the climate aspect.

Table 14.27 Summary of residual significant effects for climate

Summary of residual significant effects	
Construction	**Operation**
No significant effects identified.	No significant effects identified.

Acronyms and initialisms

Acronym or initialism	Term
%ile	Percentile
AEP	Annual Exceedance Probability
BEIS	Department for Business, Energy and Industrial Strategy
BGS	British Geological Survey
BSI	British Standards Institution
CCRA	Climate Change Risk Assessment
CCRA3	UK's third Climate Change Risk Assessment
CEnv	Chartered Environmentalist
CH_4	Methane
CIRIA	Construction Industry Research and Information Association
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DCO	Development Consent Order
Defra	Department for Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero
DfT	Department for Transport
DLUHC	Department for Levelling Up, Housing and Communities
DM	Do-Minimum scenario
DMRB	Design Manual for Roads and Bridges
DS	Do-Something scenario
EFT v11	Emission Factors Toolkit Version 11.0 (Defra, 2021)
EIA	Environmental Impact Assessment
EME2	Enrobé à Module Élevé 2
EMP	Environmental Management Plan
FRA	Flood Risk Assessment
GHG	Greenhouse gas
GMCA	Greater Manchester Combined Authority
GWP	Global-warming potential

Acronym or initialism	Term
HFCs	Hydrofluorocarbons
HGV	Heavy Goods Vehicle
HM Government	Her Majesty's Government
IAS	International Aviation and Shipping
IEMA	Institute of Environmental Management and Assessment
IUCN	International Union for Conservation of Nature
km	Kilometres
kt	Kilotonnes
LED	Light emitting diode
MDPE	Medium Density Polyethylene
MHCLG	Ministry of Housing, Communities and Local Government (now called the Department for Levelling Up, Housing and Communities)
MIEnvSci	Member of the Institution of Environmental Science
Mt	Million tonnes
N_2O	Nitrous oxide
NF_3	Nitrogen trifluoride
NGR	National Grid Reference
NPPF	National Planning Policy Framework
NPPG	National Planning Practice Guidance
NPS NN	National Policy Statement for National Networks
NSIP	Nationally Significant Infrastructure Project
NTEM	National Trip End Model
PAS	Publicly Available Specification
PEIR	Preliminary Environmental Information Report
PFCs	Perfluorocarbons
PSV	Polished Stone Value
RCP	Receptor Concentration Pathway
REAC	Register of Environmental Actions and Commitments
RoFSW	Risk of Flooding from Surface Water
SF_6	Sulphur hexafluoride

Acronym or initialism	Term
SRN	Strategic Road Network
SuDS	Sustainable drainage systems
t	Tonnes
TAG	Transport Analysis Guidance
tCO_2e	Tonnes of carbon dioxide equivalent
TDP	Transport Decarbonisation Plan
TEMPRO	Trip End Model Presentation Program
TfGM	Transport for Greater Manchester
TRA	Traffic Reliability Area
UK	United Kingdom
UKCP	UK Climate Projections
UV	Ultraviolet

Glossary

Term	Definition
Annual Exceedance Probability (AEP)	Annual Exceedance Probability (AEP) refers to the probability of a flood event occurring in any year. The probability is expressed as a percentage. For example, a large flood which may be calculated to have a 1% chance to occur in any one year, is described as a 1% AEP event.
Carbon budgets	A carbon budget, defined in accordance with the Climate Change Act 2008, places a restriction on the total amount of greenhouse gases the UK can emit over a defined five-year period.
Carbon dioxide equivalent (CO_2e)	Carbon dioxide equivalent (abbreviated as CO_2e) is a metric used to compare the emissions of various greenhouse gases, based on their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of CO_2 with the same GWP. For example, the GWP for methane (CH_4) is 25, and for nitrous oxide (N_2O) it is 298. This means that an emission of 1 tonne of CH_4 is equivalent to an emission of 25 tonnes of CO_2 and an emission of 1 tonne of N_2O is equivalent to 298 tonnes of CO_2.
Carbon emissions	Shorthand for emissions of any of the seven GHGs that contribute to climate change under the Kyoto Protocol, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3)
Climate	Long-term weather conditions prevailing over a region.

Term	Definition
Climate extreme indices	With regard to climate change, extreme weather events and climate events are often referred to collectively as climate extremes. The World Climate Research Programme (WCRP) and World Meteorological Organization (WMO) expert team on climate change detection and indices (ETCCDI) coordinate, organise and collaborate on climate extremes, indices and climate change detection. This team have defined a set of 27 core indices (the 'ETCCDI' indices) which can be derived from land surface observations of daily temperature and precipitation.
Climate scenario	UKCP18 uses emissions scenarios, called Representative Concentration Pathways (RCPs). RCPs specify the concentrations of greenhouse gases that would result in target amounts of radiative forcing at the top of the atmosphere by 2100, relative to pre-industrial levels. Four forcing levels have been set: 2.6, 4.5, 6.0 and 8.5 W/m^2. These create four RCPs that are used in UKCP18: RCP2.6, RCP4.5, RCP6.0 and RCP8.5.
Cold spell duration index	Count of days with at least six consecutive days when daily minimum temperature is below the 10^{th} percentile.
DM	A Future year scenario including other committed developments and infrastructure schemes, but not the Scheme.
DS	A Future year scenario including other committed developments and infrastructure schemes together with the Scheme.
Embodied carbon	Carbon (GHG) emissions associated with energy consumption and chemical processes during the extraction, transport and/or manufacture of construction materials or products.
Greenhouse gases (GHGs)	A gaseous compound that absorbs infrared radiation and traps heat in the atmosphere. Greenhouse gases are usually expressed in terms of carbon dioxide equivalent (CO_2e).
H++	Defined as plausible 'high-end' climate change scenarios, which are typically extreme climate change scenarios on the margins or outside of the 10^{th} to 90^{th} percentile range presented in the 2009 UK climate change projections (also known as 'UKCP09').
In-combination effects	When a projected future climate impact (e.g. increase in temperatures) interacts with an effect identified by another topic and exacerbates its impact.
Life cycle stage	PAS 2080:2023 refers to a modular approach for the quantification of infrastructure related GHG emissions over a number of stages over the 'life cycle' of a project, namely 'before use (A)', 'use (B)' and 'end of life (C)'. These stages are further disaggregated into modules (e.g. product stage (A1–A3) and construction process stage (A4–A5)).
Longest dry spell	Highest number of consecutive days with <1mm rainfall.

Term	Definition
Main rivers	Main rivers are usually larger rivers and streams, designated as such, and shown on the Main River Map. The Environment Agency carries out maintenance, improvement or construction work on main rivers to manage flood risk.
Material impact	An event/outcome that is a key decision-making consideration.
Maximum five-day precipitation	Highest value of rainfall accumulated over five days.
Net zero	Net zero means any emissions would be balanced by schemes to offset an equivalent amount of greenhouse gases from the atmosphere, such as planting trees or using technology like carbon capture and storage.
Ordinary watercourses	Ordinary watercourses include every river, stream, ditch, drain, cut, dike, sluice, sewer (other than a public sewer) and passage through which water flows and which does not form part of a main river. Lead local flood authorities, district councils and internal drainage boards carry out flood risk management work on ordinary watercourses.
PAS 2080	PAS 2080:2023 'Carbon Management in Buildings and Infrastructure' specifies requirements for the management of whole-life carbon in buildings and infrastructure.
Pore water pressure	The pressure exerted on its surroundings by water held in pore spaces in rock or soil, an increase in which can result in a decrease in the shear strength of a slope material, reducing slope stability.
Rainfall from extremely wet days	Total rainfall falling on days with daily rainfall total in excess of the 99th percentile of daily rainfall.
RCP8.5	RCP8.5 refers to the concentration of carbon that delivers global warming at an average of 8.5 watts per square meter across the planet. The RCP8.5 pathway delivers a temperature increase of about 4.3°C by 2100, relative to pre-industrial temperatures.
Traffic Reliability Area	Defined in DMRB LA 105 Air Quality (Highways England, 2019) as the 'area covered by the traffic model, that the competent expert for traffic has identified as reliable for inclusion in an environmental assessment'.
UKCP18	The UK Climate Projections 2018 (UKCP18) are a set of UK climate projection tools designed to help decision-makers assess their risk exposure to climate change. The UKCP18 project uses cutting-edge climate science to provide climate change projections out to 2100. UKCP18 provides probabilistic projections over land and a set of high-resolution, spatially coherent future climate projections for the UK at 25km and 12km scale. The 12km climate model has been further downscaled to 2.2km scale – a level previously only used for short-term weather forecasts, allowing realistic simulation of high impact events such as localised heavy rainfall in summer.
Vulnerability	The degree to which a system/asset is exposed and resilient to adverse effects of climate change.

Term	Definition
Warm spell duration index	Count of days with at least six consecutive days when daily maximum temperature is above the 90th percentile.

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