A358 Taunton to Southfields Dualling Scheme

Preliminary Environmental Information Report - Chapter 14
Climate

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14.1 Introduction

14.1.1 This chapter provides a preliminary assessment of the potential climate impacts and effects from the construction and operation of the A358 Taunton to Southfields Dualling Scheme (the 'proposed scheme'), following the methodology set out in the *Design Manual for Roads and Bridges* (DMRB) LA 114 *Climate* [1] and the Environmental Impact Assessment (EIA) Scoping Report [2].

14.1.2 This chapter summarises the legislative and policy framework related to climate change, presents the methodology followed for the assessment and describes the existing and projected future baseline for the study area surrounding the proposed scheme. The chapter presents the assessment of effects on identified receptors during construction and operation of the proposed scheme. The design, mitigation and residual effects of the proposed scheme are discussed, along with any limitations of the assessment.

14.1.3 In line with the requirements of DMRB LA 114 *Climate*, the *National Policy Statement for National Networks* (NPSNN) [3] and the *Infrastructure Planning (Environmental Impact Assessment) Regulations 2017*, this chapter describes the likely significant effects of the proposed scheme on the environment resulting from the:

- impact of the proposed scheme on climate (greenhouse gas (GHG) emissions)
- vulnerability of the proposed scheme to climate change (adaptation)

14.2 Legislative and policy framework

14.2.1 As documented in the Preliminary Environmental Information (PEI) Report Chapter 1 Introduction, the *National Policy Statement for National Networks* (NPSNN) is the primary planning policy for the proposed scheme and forms the principal basis for making decisions on Development Consent Order (DCO) applications in England. The *National Planning Policy Framework* (NPPF) is noted as being 'important and relevant' and is to be considered, however, if there is a conflict between the NPSNN and NPPF, the NPSNN takes precedence.

14.2.2 This section summarises the legislative, policy and strategy positions relating to climate change and the development of highways. This includes some which are directly applicable to the proposed scheme and some which provide wider policy context.

Legislation

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

14.2.3 The *Infrastructure Planning (Environmental Impact Assessment) Regulations 2017* place a requirement upon projects which have the potential for significant effects on the surrounding environment and communities to make a formal assessment of these effects. The important role that the EIA process can play in assessing climate change impacts is also identified. The regulations state that EIAs shall identify, describe and assess the direct and indirect significant effects of climate change relevant to the proposed scheme (i.e. GHG, climate change resilience (CCR) and in-combination climate change impacts). This chapter reports the preliminary outcomes of the GHG and CCR assessment.

Climate Change Act 2008 (2050 Target Amendment) Order 2019

14.2.4 The *Climate Change Act 2008* committed the UK to its first statutory carbon reduction target to reduce carbon emissions by at least 80% from 1990 levels by 2050. The *Climate Change Act 2008 (2050 Target Amendment) Order 2019* amended the *Climate Change Act 2008* by introducing a target for at least a 100% reduction of GHG emissions (relative to 1990 levels) in the UK by 2050, following advice from the Committee on Climate Change [4]. The 100% reduction is often referred to as 'net zero' GHG emissions.

14.2.5 The *Climate Change Act 2008* requires that that five-yearly carbon budgets are set and not exceeded to ensure that regular progress is made towards the target. The first three carbon budgets were set in 2009, with the fourth, fifth and sixth following in 2011, 2016 and 2021 respectively, as outlined in Table 14-1. The sixth carbon budget was published by the Committee on Climate Change on 9 December 2020 and was set in law in June 2021.

14.2.6 The third, fourth and fifth carbon budgets, as set out in the *Carbon Budgets Order 2009*, the *Carbon Budget Order 2011* and the *Carbon Budget Order 2016*, are based on an 80% reduction as legislated by the *Climate Change Act 2008*. The sixth carbon budget, as set out in the *Carbon Budget Order 2021* (SI2021/750) is based on the target for 100% reduction in emissions by 2050. GHG emissions from the proposed scheme are reported against the latest legislated carbon budgets, in line with the requirements of DMRB LA 114 *Climate* and the NPSNN.

Table 14-1 UK third, fourth, fifth and sixth carbon budgets

Carbon budget	Carbon budget level (million tonnes of carbon dioxide (CO_2) equivalents ($MtCO_2e$))
Third (2018-2022)	2,544
Fourth (2023-2027)	1,950
Fifth (2028-2032)	1,725
Sixth (2033-2037)	965

14.2.7 The *Climate Change Act 2008* also established a requirement for the UK government to undertake a climate change risk assessment (CCRA) every five-year period and develop a programme for adaptation action in response to the risks identified. The UK government's second CCRA was published in 2017 [5] and the third will be issued in 2022. The CCRA will be based on the *Independent Assessment of Climate Change Risk* (CCRA3) [6] published by the Committee on Climate Change in June 2021. It establishes eight priority risk areas for action over the following two years:

- Increased flooding and drought
- Emissions from natural carbon stores
- Failure of the power system
- Supply chain system
- Health and well-being from high temperatures
- Natural capital
- Food production and trade
- Climate change impacts overseas that affect the UK [7]

14.2.8 The CCRA3 identifies significant risks to national infrastructure including transport networks from embankment and bridge failure, river, surface/groundwater and coastal flooding, erosion and increases in the frequency and severity of extreme weather such as high winds, high temperatures, lightening, storms and high waves. It highlights the need for infrastructure to be located, planned and designed and maintained to be resilient to climate change including severe weather events. It also recognises that more action is needed to encourage information sharing between infrastructure operators to improve overall risk management. Section 14.8 Design, mitigation and enhancement measures and section 14.9 Assessment of likely significant effects identifies and assesses the adaptation measures adopted by the proposed scheme.

National planning policy

National Policy Statement for National Networks (2014)

14.2.9 Paragraph 5.16 of the *NPSNN* notes that the impact of road development on aggregate levels of emissions is likely to be very small (paragraph 3.8 asserts less than 0.1% of annual carbon budgets) and needs to be seen against significant projected reductions in carbon emissions because of meeting the government's legally binding carbon budgets. Paragraph 5.18 notes that an increase in carbon emissions is not a reason to refuse development consent, unless the increase is large enough to have a material impact on the ability of the government to meet its carbon reduction targets.

14.2.10 Table 14-2 identifies the *NPSNN* policies relevant to the climate assessment and specifies where in this PEI Report information is provided to address each requirement.

Table 14-2 Relevant NPSNN policies for the climate change assessment

Relevant NPSNN paragraph reference	Requirement of the NPSNN	Where information is provided in this PEI Report chapter to address the requirement
4.40	*Applications should consider the impacts of climate change when planning location, design, build and operation.*	Sections 14.9 Design, mitigation and enhancement measures and section 14.10 Assessment of likely significant effects consider how the proposed scheme would account for the projected impacts of climate change.
4.42	*Applications should consider the potential impacts of climate change over the estimated lifetime of the new infrastructure, making use of the latest UK Climate Projections available, and ensuring that any Environmental Statement (ES) which is prepared should identify appropriate mitigation or adaptation measures.*	Section 14.7 Baseline conditions details UK Climate Projections (UKCP18) high emissions scenario (Representative Concentration Pathways (RCP) 8.5) against the 2080 projections at the 50% probability level. Section 14.9 Design, mitigation and enhancement measures considers appropriate mitigation and adaption measures. Section 14.10 Assessment of likely significant effects considers the potential impacts of climate change over the estimated lifetime of the proposed scheme.

Relevant NPSNN paragraph reference	Requirement of the NPSNN	Where information is provided in this PEI Report chapter to address the requirement
4.43	*Applications 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.*	Section 14.10 Assessment of likely significant effects considers potentially critical features of the design which may be seriously affected by climate change beyond that projected in the latest UK climate projections. Additionally, the safety of the proposed scheme is assessed against the high emissions RCP 8.5 global warming scenario. An assessment using H++ climate scenarios on the safety critical features will be undertaken and reported in the ES.
4.44	*Any adaptation measures should also be based on the most recent set of UK Climate Projections, the Government's national Climate Change Risk Assessment and consultation with statutory consultation bodies. The adaptation measures must also be assessed as part of any environmental impact assessment and included in the ES.*	Adaptation measures have been based on the most recent set of UK Climate Projections and the Government's CCRA. Section 14.9 Design, mitigation and enhancement measures identifies the adaption measures that have been adopted.
5.17	*Applicants should consider carbon impacts as part of the appraisal of scheme options and need to describe an assessment of any likely significant climate factors within the Environmental Statement. It is very unlikely that the impact of a road project would, in isolation, affect the ability of the Government to meet its carbon reduction targets. However, applicants should provide both evidence of the carbon impacts of a scheme and an assessment of these impacts against the Government's carbon budgets.*	Chapter 3 Assessment of alternatives of this PEI Report sets out the appraisal of options which has included consideration of climate. Section 14.10 Assessment of likely significant effects considers the carbon impact of the proposed scheme and assesses the proposed scheme against the government's carbon budgets. Further reporting will be presented in the ES.
5.19	*Appropriate climate mitigation measures to be implemented, including both engineering plans and the use of materials, in both design and construction of a road scheme, so that the associated carbon footprint is not unnecessarily high. Of particular note is the statement that the Secretary of State's view of the adequacy of the mitigation measures relating to design and construction would be a material consideration in the decision-making process.*	Section 14.9 Design, mitigation and enhancement measures identifies the mitigation measures that have been implemented to minimise the carbon footprint of the proposed scheme.

National Planning Policy Framework

14.2.11 The *National Planning Policy Framework* (NPPF) [8] sets out the UK government's planning policies for England and how these are expected to be applied and provides a high-level framework within which other development can come forward. The *NPPF* does not contain specific policies for nationally significant infrastructure projects (including the proposed scheme), which are primarily determined in accordance with the decision-making framework in the *Planning Act 2008* and the relevant national policy statement (which for the

proposed scheme is the *NPSNN*, as described in paragraphs 14.2.9 of this report), as well as any other matters that are relevant (which may include the *NPPF*). The *NPPF* describes the role of planning policy in meeting the challenges posed by climate change and helping to shape places to secure radical reductions in GHG emissions, as well as reducing vulnerability and providing resilience to the impacts of climate change. Section 14 of the *NPPF* states that developments should avoid increased vulnerability to the range of impacts arising from climate change and should be planned for in ways that can help to reduce GHG emissions, in line with the objectives and provisions of the *Climate Change Act 2008*. Section 14.8 Design, mitigation and enhancement measures, section 14.9 Assessment of likely significant effects and Appendix 14.2 Vulnerability to climate change assessment (the latter produces in the ES) consider the identification and implementation of avoidance and mitigation measures for the proposed scheme.

The Climate Change: second national adaptation programme (2018-2023)

14.2.12 The *Climate Change: second national adaptation programme (2018-2023)* (NAP) [9] was produced by the Department for Environment, Food and Rural Affairs (Defra) and launched in 2018. The plan sets out the UK government's response to the second CCRA. It forms part of the five-yearly cycle of requirements laid down by the *Climate Change Act 2008*, with the aim of driving a dynamic and adaptive approach to building the nation's resilience to climate change. Section 3.4.4 of the NAP highlights the economic and strategic value of the strategic road network (SRN) in the UK and notes the implications of risks to severance and safety posed by climate change. It details how Highways England is embedding resilience to climate change, based on the UK Climate Projections 2009 (UKCP09) future climate projections, including measures such as safeguarding against flooding, erosion, falling trees, instability and risk of failure across the SRN to increase safety.

Clean Growth Strategy

14.2.13 In 2017, the UK government published the *Clean Growth Strategy* [10], which is a plan for meeting the legislated carbon budgets as set out in the *Carbon Budget Order 2016*. The strategy includes a key policy to accelerate the shift to low carbon transport, which primarily focuses on a transition to low emission vehicles, investing in new technologies such as autonomous vehicles and low carbon fuels, promoting cycling and walking and shifting freight from road to rail.

Road to Zero Strategy (2018) and Decarbonising transport: a better, greener Britain (2021)

14.2.14 In July 2018, the UK government launched the *Road to Zero Strategy* [11], a policy paper which includes a forward-looking route map to articulate the steps required to decarbonise and electrify road transport in line with their industrial strategy. The document outlines 46 policy interventions to aid in the drive to decarbonise road transport. Its main focuses are on supporting modal shift, reducing emissions from vehicles and investing in electric vehicle infrastructure. Since then, the UK government has published the *Decarbonising transport: a better, greener Britain* [12] in July 2021, which outlines 78 commitments to decarbonising all forms of transport and details key enablers and measures for achieving this. This includes a focus on achieving zero emissions for road transport through provision of infrastructure that supports the transition to zero

emissions and a phasing out of non-zero emissions road vehicles in a shift towards electric.

Highways England policy

Highways England Climate Adaptation Risk Assessment Progress Update – 2016

14.2.15 Highways England is taking action to safeguard against climate risks on the road network through a series of adaptation plans, as set out in Section 8 of their climate change adaptation risk assessment [13]. These include adaption actions related to pavements; drainage; structures; geotechnics; non-motorised users; soft estate (landscape and ecology); vehicle restraint systems; signs and signals; and road markings. For some risks doing the minimum is appropriate because the rigorous design standards or existing procedures are already sufficient to cope with the predicted impacts of climate change. In other cases, including those relating to drainage, it has been considered necessary to act. For example, updating technical standards through the DMRB or the *Manual of Contract Documents for Highway Works* (MCHW) to ensure that new designs and projects are prepared for the future climate.

Highways England's Net Zero Highways: Our 2030/2040/2050 Plan (2021)

14.2.16 Highways England's *Net Zero Highways: Our 2030/2040/2050 Plan* [14] was published in July 2021, which details three key action areas for achieving net zero for their corporate emissions by 2030, maintenance and construction emissions by 2040 and for road users' emissions by 2050. Three roadmaps outline the key actions for each of these areas, which include a focus on: cutting corporate energy use and fleet emissions through investment in renewable energy and electric vehicles; reducing emissions during construction, for example through the use of zero carbon construction products; and supporting the use of zero carbon vehicles, including heavy goods vehicles (HGV).

Highways England's Sustainable Development Strategy (2017)

14.2.17 The Highways England's *Sustainable Development Strategy* [15] outlines five key areas of focus for sustainability which are aligned with the five capitals approach. One focus is on achieving resilience through adaptation of the road network to climate change and making effective investment decisions in this respect. As such, building a climate-resilient road network is a key aspect of Highways England's sustainable development.

Highways England's Delivery Plan (2020-2025)

14.2.18 The Highways England's *Delivery Plan (2020-2025)* [16] states that Highways England will develop a more proactive approach to addressing flood risk and improving our network's resilience to climate change. For example, Highways England will improve the resilience of our concrete pavements to prolonged high temperatures as part of the maintenance and renewals programme, taking remedial action where necessary. It also states that Highways England will work to reduce the carbon emissions associated with the construction, use, management and operation of the network and support the government's ambition to achieve net zero carbon emissions by 2050.

Local planning policy

South Somerset District Council Local Plan (2006-2028)

14.2.19 The *Local Plan* [17] asserts that the potential impacts of climate change must be considered in planning for all new development, both in terms of location and design.

Taunton Deane Core Strategy (2011-2028)

14.2.20 The *Core Strategy* [18] requires all development to incorporate sustainable design features to reduce their impact on the environment, mitigate and adapt to climate change, and particularly to help deliver a reduction in carbon dioxide (CO_2) and other GHG emissions.

Somerset's Climate Emergency Strategy (2020)

14.2.21 The *Climate Emergency Strategy* [19] was adopted by all five Somerset local authorities in 2020. The strategy has a focus on transitioning to electric vehicles and changes in travel behaviours. It also notes that networks need to be resilient to climate change and therefore futureproofed. It notes that the rural nature of Somerset is a key barrier. A number of key outcomes are set out for 2030, which include a reduction in GHGs through increased electric vehicle use, reduced emissions through encouraging behaviour change; and the development and implementation of Climate Change Action Plans to build and maintain the resilience of transport infrastructure.

Somerset West and Taunton Carbon Neutrality and Climate Resilience Action Plan (2020)

14.2.22 The Councils have set out a framework to enable Somerset to become a carbon neutral county by 2030 and to have a Somerset which is resilient to the impacts of climate change [20]. The action plan includes a list of actions of which a number are focused on transport. These include the installation of electric vehicle charge points, improved active travel, improvements to the Park and Ride scheme at Taunton, improvements to its own vehicle fleet and working towards future rail link improvements.

Standards and guidance

GHG emissions

14.2.23 The following standards and guidance have been used to guide the preliminary assessment of GHG emissions:

- DMRB LA 114 *Climate*, which provides the requirements for the assessment and reporting the effects of GHG emissions for highways.
- DMRB LA 105 *Air quality* [21], which provides the calculation method for regional emissions from vehicles that use the road network.
- *Publicly Available Specification 2080* (PAS 2080) [22] on carbon management in infrastructure, a global standard for managing infrastructure carbon.
- Royal Institution of Chartered Surveyors (RICS) professional standards and guidance document on *Whole life carbon assessment for the built environment* (1st edition, 2017) [23].
- Department for Transport (DfT), *Transport Analysis Guidance (TAG) Unit A3 Environmental Impact Appraisal, Chapter 4 Greenhouse Gases* [24].
- Department for Transport, Decarbonising transport: a better, greener Britain [12].

- Highways England, Net zero highways: Our 2030 / 2040 / 2050 plan.

Vulnerability to climate change

14.2.24 The following standards and guidance have been used to guide the preliminary assessment of vulnerability to climate change:

- DMRB LA 114 *Climate*, which provides the requirements for assessment and reporting the effects of climate on Highways England highways projects (both CCR and adaptation).
- The Institute of Environmental Management and Assessment (IEMA), *Guidance on climate change resilience and adaptation* [25] in response to the requirements specified in the *Infrastructure Planning (Environmental Impact Assessment) Regulations 2017*. This guidance provides an approach to undertaking CCR assessments for EIA in the UK.

14.3 Assessment methodology

Greenhouse gas emissions

14.3.1 The preliminary assessment of the magnitude of GHG emissions has been undertaken in accordance with DMRB LA 114 *Climate*.

14.3.2 The goal of the emissions quantification exercise is to calculate the emissions anticipated to be generated or avoided by the proposed scheme, within the DCO boundary and emissions scope set out in section 14.5 Study area of this chapter. The purpose of this is to:

- determine the magnitude of the proposed scheme's emissions for the relevant scenarios: 'Do-Something' and 'Do-Minimum'.
- enable comparison of the 'Do-Something' scenario against the 'Do-Minimum' scenario and the UK carbon budgets.
- enable identification of emissions hot spots within the 'Do-Something' scenario to inform the identification and prioritisation of mitigation measures.

14.3.3 The preliminary assessment considers three sources of GHG emissions as defined in PAS 2080 and RICS guidance, during the construction and operation (use) lifecycle stages over a 60-year assessment period, including:

- **Construction emissions.** Carbon is assessed based on information provided by design teams including where available relevant drawings of the design, the use of products or materials, construction transport, construction plant and construction waste. Section 14.4 Assessment assumptions and limitations, outlines the assumptions that were made. The Highways England carbon emissions calculation tool is used, along with its carbon factors, for the calculation, supplemented with other factors where necessary as discussed in Section 14.4 Assessment assumptions and limitations.
- **Operational maintenance-related emissions.** An estimation of carbon emissions associated with maintenance of the road (calculated using the same method as the construction works).
- **Operational traffic carbon emissions (user carbon) from vehicle tailpipes**. These are calculated based on data from the traffic model, with the study area being determined by the Affected Road Network (ARN). The methodology used is consistent with that of the air quality assessment, using the DMRB screening tool. Consideration has also been given to Transport Analysis Guidance (TAG) Unit A3 Environmental Impact Appraisal, which

provides a methodology for the reporting of GHG emissions and data tables for future trends in vehicle technology changes.

14.3.4 Further details on the underlying information for the assessment is presented in Appendix 14.1 Greenhouse gas assessment assumptions, methodology and emissions factors.

14.3.5 In line with DMRB LA 114 *Climate*, 'end of life' or decommissioning impacts have not been considered due to the long design life of the asset and given that emissions associated with end of life are commonly relatively small.

14.3.6 Emissions from the considered sources are compared to a baseline 'Do-Minimum' scenario to quantify the impact of the proposed scheme. The scenarios used for the GHG emissions assessment of the proposed scheme are summarised in Table 14-3.

Table 14-3 GHG emissions assessment scenarios

Scenario	Description
'Do-Minimum'	'Business as usual' – the proposed scheme is not implemented.
'Do-Something'	The proposed scheme is implemented, taking into account embedded GHG mitigation measures.

14.3.7 GHG emissions in each scenario have been compared in order to assess the contribution of the proposed scheme to climate change. Values are reported in metric tonnes of carbon dioxide equivalents (tCO_2e). This measure considers the six Kyoto Protocol gases – CO_2; methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) – converted into tCO_2e. This calculation normalises the global warming potential of the main GHGs into one measure, based on the global warming potential of CO_2.

14.3.8 In accordance with DMRB LA 114 *Climate*, the third lifecycle stage for a project's GHG emissions (the first and second being construction and operation) comprises opportunities to reduce the production/use of GHG emissions. Measures to reduce GHG emissions as far as practicable are considered in section 14.8 Design, mitigation and enhancement measures.

Assessment of significance

14.3.9 An assessment of significance has been undertaken in accordance with DMRB LA 114 *Climate*. The emissions assessment is based on the Highways England carbon reporting tool and assessment of road user emissions in line with DMRB LA 105 Air quality.

14.3.10 A preliminary estimate of the likely magnitude of GHG emissions associated with the proposed scheme has been assessed against the national UK carbon budgets. This approach is in accordance with DMRB LA 114 *Climate*. As mentioned previously, the UK government has passed into law carbon budgets up to 2037 as follows:

- 4th carbon budget (2023 to 2027) allows the UK to emit 1,950 $MtCO_2e$.
- 5th carbon budget (2028 to 2032) allows the UK to emit 1,725 $MtCO_2e$.
- 6th carbon budget (2033 to 2037) would allow the UK to emit 965 $MtCO_2e$.

14.3.11 In accordance with paragraph 3.20 of DMRB LA 114 *Climate*, a significant effect occurs where the increase in carbon emissions resulting from the proposed scheme would have a "…*material impact on the ability of Government to meet its carbon reduction targets*". In the absence of any specific thresholds, professional

judgement has been used to determine whether the emissions predicted from the project are significant.

Vulnerability to climate change

14.3.12 The vulnerability to climate change assessment qualitatively assesses the impacts of climate change on the proposed scheme during construction and operation based on professional expertise and judgement.

14.3.13 In line with DMRB LA 114 *Climate*, and as required by the NPSNN, the preliminary assessment of the proposed scheme's vulnerability to climate impacts has been undertaken by employing the following:

- Detailed receptor identification for the construction and operation phase, in liaison with the proposed scheme design team.
- Analysis of current baseline climate conditions and projected climate hazards, utilising appropriate UKCP18 datasets in order to identify any likely significant climate changes and the likelihood of the proposed scheme to be exposed to these changes.
- The likelihood and consequence of the climate impact on the proposed scheme are qualitatively assessed to determine the significance.
- Identification of mitigation/adaptation measures for any significant effects, in liaison with the proposed scheme design team and relevant environmental discipline specialists.

14.3.14 The receptors that have been considered in this preliminary assessment are presented in Table 14-4.

Table 14-4 Preliminary assessment receptors

Value/Sensitivity	Receptor	Examples within the study area
Medium	Construction process	Workforce, plant and machinery
High	Assets and their operation, maintenance and refurbishment	Road pavement surfaces, structures, earthworks and drainage, technology assets and soft estate.
Very High	End-users	Members of the public or commercial operators using the proposed scheme

14.3.15 The following primary climate change hazards, which are likely to be relevant in the vulnerability to climate change assessment include: high temperatures; high levels of precipitation; and low levels of precipitation. Additional climate change hazards considered include: windstorms and wind gusts; drought conditions; and cold weather events.

14.3.16 After identifying the climate change impacts, a risk assessment of those impacts on the identified receptors during construction and operation of the infrastructure and assets associated with the proposed scheme has been undertaken. The climate impacts are scored using a qualitative five-point scale based on the DMRB LA 114 *Climate* framework in Table 14-5 and Table 14-6.

Table 14-5 Likelihood categories

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

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

Table 14-6 Measure of consequence

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

14.3.17 The likelihood and consequence are combined to determine the significance of each effect using the matrix shown in Table 14-7. The vulnerability to climate change assessment identifies the design and mitigation measures required to protect the proposed scheme against the impacts of climate change for any effects assessed as significant.

Table 14-7 Significance matrix

		Measure of likelihood / sensitivity				
		Very Low	Low	Medium	High	Very High
Measure of consequence	Very Large	Not Significant	Significant	Significant	Significant	Significant
	Large	Not Significant	Not Significant	Significant	Significant	Significant
	Moderate	Not Significant	Not Significant	Significant	Significant	Significant
	Minor	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant
	Negligible	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant

14.3.18 For any significant effects that are identified, relevant mitigation measures have been identified in discussion with the environmental discipline specialists. This has made linkages with mitigation measures identified within other relevant PEI Report chapters.

14.3.19 The *NPPF* sets requirements for flood risk, and design guidance relating to climate change and flood risk is available. A preliminary Flood Risk Assessment (FRA) has been undertaken as part of this PEI Report and is provided in Appendix 13.1 Flood Risk Assessment. The FRA considers current Environment

Agency climate change allowances for increases in peak river flow and rainfall intensity.

14.3.20 The impact of climate change on habitats and soft landscape features is considered in Chapter 8 Biodiversity and Chapter 7 Landscape and visual of this PEI Report, respectively. The effects on ground conditions and water quality arising from land contamination are considered in Chapter 9 Geology and soils of this report. The effects on air quality arising from construction practices are considered in Chapter 5 Air quality of this PEI Report.

14.3.21 In line with DMRB LA 114 *Climate*, H++ climate scenarios are used to test the sensitivity of vulnerable safety critical features, to ensure that such features would not be affected by more extreme changes to the climate beyond that projected in UKCP18 [26]. The following safety critical features have been identified: retaining walls; bridges and structures; pavements; road restraint system; drainage; lighting and earthworks.

14.3.22 The PEI Report has considered the safety of the proposed scheme against UKCP18 and Representative Concentration Pathways 8.5 (RCP8.5). An assessment of the safety critical features against H++ climate scenarios will be undertaken to inform the ES.

14.4 Assessment assumptions and limitations

Greenhouse gas emissions

14.4.1 The GHG emissions assessment has been undertaken on the basis of the information available at the time of assessment and is therefore preliminary. Where assumptions have been made, they have been selected to present the 'worst-case' scenario for the particular item/factor.

14.4.2 Assumptions/judgements in each case have been made using:

- emerging design detail
- engineering specialist knowledge
- environmental specialist knowledge
- climate change/carbon specialist knowledge
- manufacturer specifications
- proxy engineering data from previous comparable projects

14.4.3 Appendix 14.1 GHG assessment assumptions sets out details on information used to undertake this assessment. Table 14-8 provides a summary (aligned to the structure of the PAS 2080 life-cycle modules) of the information that has formed part of the assessment along with justification where modules have been excluded.

Table 14-8 Justification for inclusion or exclusion of PAS 2080 life-cycle stages and individual modules within GHG emissions quantification

Life-cycle stage	Boundary stage	Module	Description	Included in scope?	Justification
Before use Stage	Pre-construction	A0	Preliminary studies, consultations	×	Carbon emissions from preliminary studies and works are largely office-based and are assumed to be insignificant.
	Product	A1	Raw material supply	✓	A1 - A3 emissions (i.e. from raw material extraction,

Life-cycle stage	Boundary stage	Module	Description	Included in scope?	Justification
		A2	Transport	✓	product processing, and final product manufacture, its energy use, and waste management within these processes, transportation within the supply chain, and manufacture) has been calculated using carbon emissions factors and carbon conversion factors from the Highways England carbon emissions calculation tool [27], based on preliminary information provided by design teams and relevant design drawings where available.
		A3	Manufacture	✓	
	Construction process	A4	Transport to works site	✓	A4 emissions have been calculated using the RICS guidance [23], applying transport conversion factors from Defra [28]. They are calculated using emissions factors from the Highways England carbon emissions calculation tool [27], based on information provided by design teams based on relevant drawings of the design where available.
		A5	Construction/installation processes	✓	A5 emissions have been based on an average per kilometre emissions factor derived from a sample of comparable highway schemes and applying this to the length of the proposed scheme as insufficient information was available for the PEI Report.
Use stage	Installed products and materials	B1	Use	×	B1 emissions include carbon emitted directly from the fabric of products and materials once they have been installed as part of the proposed scheme and it is in normal use. These are assumed to be insignificant.
		B2	Maintenance	✓	B2 - B5 emissions associated with maintenance, repair, replacement and refurbishment assume that certain assets (such as the road surface) are repaired and/or replaced during the 60-year design life. B2 - B5 emissions included at this stage have been based on
		B3	Repair	✓	
		B4	Replacement	✓	
		B5	Refurbishment	✓	

Life-cycle stage	Boundary stage	Module	Description	Included in scope?	Justification
					an average per kilometre emissions factor derived from a sample of comparable highway schemes and applying this to the length of the proposed scheme as insufficient information was available for the PEI Report. B2 - B5 emissions will be calculated using the same method as the construction works and supply chain carbon emissions for the ES.
		B6	Operational energy use	✓	B6 emissions have been based on an average per kilometre emissions factor derived from a sample of comparable highway schemes and applying this to the length of the proposed scheme as insufficient information was available for the PEI Report.
		B7	Operational water use	×	Carbon emissions resulting from the consumption of water required by the proposed scheme to enable it to operate and deliver its service are assumed to be insignificant.
		B8	Other operational processes	×	Other process carbon emissions arising from the proposed scheme to enable it to operate and deliver its service, such as management of operational waste, are assumed to be insignificant.
		B9	Users' utilisation of infrastructure	✓	B9 emissions have been estimated for the ARN using the DMRB Screening Tool [29], considering a 60-year assessment period. B9 emissions have been based on Project Control Framework (PCF) stage 2 data and therefore 2023 opening year with traffic growth applied. This will be updated in the ES to reflect a 2028 opening year.
End of life stage		C1	Deconstruction	×	End of life (C1 - C4) impacts have not been considered due to the long design life of the asset and given that emissions associated with end of life are commonly relatively small.
		C2	Transport		
		C3	Waste processing for recovery		
		C4	Disposal		

Life-cycle stage	Boundary stage	Module	Description	Included in scope?	Justification
Supplementary information beyond the infrastructure life-cycle		D	Boundary of benefits and loads beyond the infrastructure life cycle	×	GHG emissions associated with ongoing land use change/sequestration are not included within the PEI Report, due to a lack of data at this stage. Emissions from land use change will instead be presented within the ES, over the construction phase and 60-year operational period.

14.4.4 For transport-related emissions (module A4), data on default transport scenarios for UK projects contained within the RICS professional standards and guidance [23] document on whole life carbon assessment for the built environment (2017), were used. For locally manufactured materials and products, a transport distance of 50km by road has been applied. For nationally manufactured materials and products, a transport distance of 300km by road has been applied. Carbon emission factors and carbon conversion factors from the Highways England carbon emissions calculation tool [27] have been used exclusively.

14.4.5 GHG emissions related to the construction element of embodied carbon (A5) have been calculated using emissions factors from the Highways England carbon emissions calculation tool, based on preliminary information provided by the design team. For the PEI Report, preliminary information was available for the structures, pavement, drainage and earthworks elements of construction. Further information will become available and will be incorporated into the A5 calculation to be reported within the ES.

14.4.6 For user emissions (module B9), the assessment has used the DMRB Screening Tool (which references the UK Emission Factor Toolkit v10) [29] for consistency with the air quality assessment. As noted in the Air Quality Chapter, PCF stage 2 traffic data has been used for this PEI Report using modelled years of 2023 and 2038 (and a 60-year assessment period overall). However, it is noted that the DMRB Screening Tool [29] is limited in its projections to 2030. This means that for this assessment, any emission predictions after 2030 use 2030 assumptions. The DfT TAG methodology [24] provides data on the potential uptake of electric vehicles, which would likely substantially reduce emissions in the future. This would apply to both the 'Do-Minimum' and the 'Do-Something' scenarios equally and would therefore reduce any potential difference in emissions between the scenarios. Furthermore, this preliminary assessment likely represents a conservative scenario. This is discussed further in Section 14.9. The approach presented in this section will be reviewed for the ES in light of any new guidance that is published, such as the *Decarbonising transport: a better, greener Britain* [12].

14.4.7 For the calculation of GHG emissions associated with ongoing land use change/sequestration (module D) and in line with DMRB LA 114 *Climate*, a proportionate approach has been taken. A high-level assessment of CO_2 sequestration rates was undertaken using data from Natural England's research report [30]. It is estimated that an area of between 200-300 hectares (ha) of forest would be required to sequester the embodied carbon impacts of the proposed scheme over its design life. Therefore, an intervention to sequester the carbon

impacts of the proposed scheme is not considered feasible and has not formed part of the GHG emissions preliminary assessment. A more detailed assessment will be presented within the ES.

14.4.8 The methodology used to calculate the UK carbon budgets is different to that used for the calculation of lifecycle emissions from a road scheme and therefore caution should be used when making a direct comparison. However, for the purposes of identifying to what extent the proposed scheme may impact the ability of the UK to meet its carbon budgets, it is necessary to make this comparison to put the proposed scheme into context.

Vulnerability to climate change

14.4.9 Data on the climate baseline and future projections are based on freely available information from third-parties, including the historical meteorological variables recorded by the Meteorological Office (Met Office) and the UKCP18 developed by the Met Office [31]. This preliminary assessment has been informed by a range of existing climate change research and literature, available at the time of writing.

14.4.10 The vulnerability to climate change assessment has been undertaken using UKCP18, the latest set of probabilistic climate projections for the UK. The UKCP18 Climate Projections are based on a range of GHG emissions scenarios, which are subject to a degree of uncertainty. How the climate will react to different levels of emissions is also uncertain. There are three key sources of uncertainty within climate projections:

- Natural climate variability: either from natural external influences on climate (e.g. change in atmospheric particulates due to volcanic activity) or changes in the energy received from the sun.
- Incomplete understanding of earth system processes and their imperfect representation in climate models (modelling uncertainty).
- Uncertainty in future man-made emissions (of GHGs and other pollutants).

14.4.11 The vulnerability to climate change assessment is largely qualitative, with the exception of assessments relevant to drainage assets and flood risk, which have been informed by the Environment Agency climate change allowances for increases in peak river flow and rainfall intensity.

14.4.12 It is recognised that there can be uncertainty between the assets' performance in response to climate hazards. This uncertainty has been assessed qualitatively in the vulnerability to climate change assessment.

14.5 Study area

Greenhouse gas emissions

14.5.1 The assessment of GHG emissions has considered the following emissions sources:

- GHG emissions resulting from construction (i.e. material supply including primary extraction, manufacturing, transportation and construction process and site works associated with the proposed scheme).
- GHG emissions resulting from the operation and maintenance of the proposed scheme.
- GHG emissions resulting from the use of the proposed scheme (i.e. vehicle emissions).

14.5.2 Opportunities to mitigate the effects on climate through minimising activities that generate GHG emissions, reusing and adopting low carbon materials are also considered and are outlined in section 14.8 Design, mitigation and enhancement measures.

Carbon emissions during construction

14.5.3 For the assessment of carbon emissions associated with the construction of the proposed scheme, the study area takes account of emissions associated with the extraction, processing and transport of materials (refer to paragraph 14.4.4) from outside of the DCO boundary, as well as site-based emissions that result from construction activities within the DCO boundary.

Carbon emissions during operation

14.5.4 For the assessment of carbon emissions associated with repair and/or maintenance of the proposed scheme, the study area is defined by the DCO boundary and takes account of emissions associated with the extraction, processing and transport of materials, as well as site based GHG emissions that result from maintenance activities within the DCO boundary.

Road user carbon emissions (during operation)

14.5.5 The study area for operational road user carbon emissions is consistent with the ARN, as defined by the proposed scheme's traffic model. The ARN is described in section 5.5 Study area of Chapter 5 Air quality and shown in Figure 5.5 Affected Road Network. This includes emissions from vehicles using the proposed scheme and those in the wider road network, which have been positively or negatively influenced by the proposed scheme. The assessment of road user carbon includes the total emissions across the ARN model, as described in Chapter 5 Air quality and shown in Figure 5.5 Affected Road Network.

Baseline and assessment scenarios

14.5.6 The baseline scenario is the 'Do-Minimum' approach, which represents continual operation of the existing network without the proposed scheme. The baseline scenario includes current operational maintenance GHG emissions, operational user GHG emissions and land use change/sequestration GHG emissions. A 60-year appraisal period has been adopted in line with the methodology set out in DMRB LA 114 *Climate*. The baseline scenario is set out in section 14.6 Baseline conditions.

14.5.7 The assessment scenario is the 'Do-Something' approach, i.e. implementing the proposed scheme. The assessment scenario includes the construction, operational maintenance, operational user and sequestration GHG emissions described in paragraph 14.5.1. GHG emissions in this scenario are compared to the baseline in order to assess the net contribution of the proposed scheme to climate change (in tCO_2e) from construction and operation over the 60-year appraisal period.

Vulnerability to climate change

Spatial scope

14.5.8 The study area comprises the construction footprint of the proposed scheme, including compounds and temporary land take.

Temporal scope

14.5.9 The study includes all potential climate hazards for infrastructure and assets associated with the proposed scheme. The assessment of climate effects on the proposed scheme is assessed over the 60-year operational life-cycle in line with the methodology set out in DMRB LA 114 *Climate*.

14.5.10 Assessment scenarios are based on current and future climate baselines. The vulnerability to climate change assessment is based on climate trends associated with the UKCP18 high emissions scenario (50% probability). The current climate baseline is established by using observed weather patterns and extreme weather events to assess the proposed scheme's vulnerability to climate change in the immediate future during construction. The time periods for climate projections are selected based on the assumed lifespan and stages of the proposed scheme (60 years), with construction assumed to commence in 2024 and operation assumed from 2028.

14.6 Baseline conditions

GHG emissions

Current and future baseline

14.6.1 As part of the assessment process, DMRB LA 114 *Climate* requires that GHG emissions without the proposed scheme should be identified for both the current and future baseline, including all the relevant sources of GHG emissions included in the study area. This section identifies the GHG emissions without implementing the proposed scheme for the current and future baseline ('Do-Minimum' scenarios). In these scenarios it is assumed that no construction activity would take place on any of the roads in the area, aside from maintenance, across the study period.

14.6.2 The estimated baseline GHG emissions for the 'Do-Minimum' scenario in the 2016 baseline year, future baseline years (2023 and 2038) and over the study period (60 years) are summarised in Table 14-9.

Table 14-9 Estimate of baseline GHG emissions ($ktCO_2e$) for study area

GHG emissions component	Definition	2019 baseline scenario (historic)	2023 annualised (modelled opening year)	2038 annualised design (future) modelled assessment year	Cumulative estimated GHG emissions over 60-year study period
Operational user GHG emissions	GHG emissions from the tailpipes of vehicles driving in the ARN (consistent with the study area outlined for the proposed scheme (see section 14.5 Study area).	147,000	150,000	161,000	9,883,000

Note: Values been rounded to the nearest 1,000 tCO_2e.

Note: The reported value for 2038 is currently overestimated as it does not account for widespread changes in vehicle fleets towards electric after 2030.

14.6.3 For wider context, information on emissions from all road transport is published annually by the Department for Business, Energy & Industrial Strategy (BEIS) in its *UK local authority and regional carbon dioxide emissions national statistics* series [32]. This provides estimates of CO_2 emissions from users of all roads within each UK local authority. The latest available set of data from this source is for 2018, which was published in 2020. A summary of this information is presented in Table 14-10.

14.6.4 The data shows that GHG emissions from transport sources represent approximately half of all emissions in the local authority areas within Somerset (42-58% by area in 2019). This is consistent in the three most recent years of data available. Within the transport category, almost all of these emissions are from road transport, with sources of emissions from minor roads representing the largest proportion in Somerset West and Taunton; and sources of emissions from A-roads representing the largest proportion in South Somerset. Across all of Somerset, total emissions have fallen by approximately 7% between 2016 and 2019, whilst total transport related emissions in 2019 are almost the same as those reported in 2016.

14.6.5 Total emissions in the Somerset region were estimated by BEIS to be 3,352ktCO2e in 2019, with 1,478ktCO2e attributable to transport (mainly roads) [38]. For context, total emissions in all of England in 2019 were 276,090ktCO2e of which 104,187ktCO2e was attributable to transport.

Table 14-10 Summary of estimated GHG emissions ($ktCO_2e$) for Somerset by source

Name	Somerset West and Taunton				South Somerset				Somerset (County) Total			
Year	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
Industry and Commercial Total	171	162	171	151	306	290	277	268	**977**	**908**	**883**	**848**
Domestic Total	230	215	215	209	261	242	243	236	**852**	**793**	**793**	**774**
Transport Total	420	432	424	418	375	386	375	379	**1479**	**1526**	**1501**	**1478**
of which Road Transport (A roads)	107	111	106	102	235	244	233	234	**568**	**584**	**562**	**553**
of which Road Transport (Motorways)	130	134	130	123	0	0	0	0	**357**	**379**	**372**	**348**
of which Road Transport (Minor roads)	173	177	179	184	118	120	122	125	**492**	**502**	**509**	**522**
of which Diesel Railways	5	5	4	4	20	20	19	18	**51**	**50**	**47**	**44**
of which Transport Other	5	5	5	5	2	2	2	2	**11**	**11**	**11**	**11**
LULUCF Net Emissions	-65	-69	-71	-72	4	2	2	2	**186**	**162**	**193**	**174**

Name	Somerset West and Taunton				South Somerset				Somerset (County) Total			
Grand total	**784**	**764**	**768**	**727**	**977**	**949**	**924**	**911**	**3596**	**3477**	**3458**	**3352**

[Note: LULUCF = Land Use, Land Use Change and Forestry]

Vulnerability to climate change

Current climate baseline

14.6.6 A climate baseline is provided by Met Office Historic Climate Data [33] which presents a set of 30-year averages, covering the period 1981 to 2010 for a range of parameters and locations (the data that is available from UKCP18 runs from 1981-2010 for the baseline period, there is no available data from 2010 – present day). The Met Office uses districts when generating climate data for the UK. The proposed scheme is located within Somerset, in the South-West of England and South of Wales region. This district comprises counties such as Cornwall, Devon and Somerset together with the four administrative areas around Bristol (formerly Avon) and the Isles of Scilly. The climate observations for the South-West of England and South Wales region are summarised in Table 14-11.

Table 14-11 High level climate observations for the South-West of England and South Wales region (1981-2010)

Climate conditions	Climate observations
Temperature	Mean minimum temperatures between 1-2°C in winter and mean maximum temperatures between 19-21.5°C in summer.
Rainfall	Annual rainfall averages between 800-900mm, with less rainfall occurring in the Somerset area (700mm). Monthly rainfall is variable but is highest in winter months. The number of days with rainfall greater than 1mm in the Somerset area are 12-13 days in winter months, dropping to an average of 7-9 days in summer.
Wind	South-West England is one of the more exposed areas of the UK. The strongest winds are associated with the passage of deep depressions close to or across the British Isles. The frequency and strength of these depressions is greatest during the winter, when mean speeds and gusts are strongest at approximately 80 knots.
Sunshine	Average annual sunshine totals are between 1,450 – 1,600 hours, with the coastal areas in the South-West receiving more sunshine than inland areas.
Air Frost	The average number of days with air frost varies between 35 – 60 days per year.

Future baseline

14.6.7 The future projected climate conditions and extreme weather events for the proposed scheme for the 2020s and 2080s are outlined in this section. These time periods cover the assumed construction period (commencing in 2024 for a period of 44 months) and the assumed 60-year operational life (2028 to 2088).

14.6.8 To establish the future climate baseline for the boundary of the proposed scheme, the following methods were implemented:

- The projected changes in average climate conditions were obtained from the UKCP18 probabilistic projections of climate change [31].
- The projected changes in extreme weather events were obtained using UKCP18 regional projections [31].

14.6.9 Climate change projections for a range of meteorological parameters are presented for different probability levels within the RCP8.5 high emission scenario for the short-term and long-term future time periods.

14.6.10 Table 14-12 summarises the projected changes in extreme weather events for the 2020s and 2080s, such as number of heat waves and frost days.

14.6.11 The mean number of hot days, when the maximum temperature is above 25°C, is anticipated to increase from 7.74 to 54.16 days per year in the 2080s for the high emissions scenario. The average number of days in a given year, when the mean daily temperature is below 0°C, is anticipated to decrease from 33.97 to 9.50 in the 2080s under the high emissions scenario.

14.6.12 In the case of extreme precipitation, the number of days with heavy rain (precipitation greater than 25mm/day) in a given year is expected to increase from 2.57 in the baseline period to 3.22 in the 2080s. The average annual number of dry spells (periods of at least ten consecutive days with no precipitation) is projected to decrease from 4.22 for the baseline period to 2.80 for the 2080s under the high emissions scenario. This climate trend is aligned with *The State of the UK Climate 2020 Report* which shows that there has been a general decline in the number of dry spells in the UK [34].

Table 14-12 UKCP18 climate change projections for extreme weather events for the local area (12 km grid square) for the 2020s and 2080s (under the RCP 8.5 high emissions scenario)

Climate Parameter		Baseline (1981-2010)	2020s (2010-2039)			2080s (2070-2079)*		
			Min.	Mean	Max.	Min.	Mean	Max.
Temperature	Number of frost days (daily minimum temperature equal or lower than 0°C)	33.97	13.83	23.38	36.12	4.57	9.50	15.33
	Heatwaves (2 days with maximum temperature higher than 29°C and minimum temperature higher than 15°C)	0.64	0.45	1.74	3.87	2.78	4.79	6.82
	Average summer highest daily maximum temperature (°C)	27.50	27.44	30.12	32.85	31.77	34.81	37.48
	Number of hot days (daily maximum temperature higher than 25°C)	7.74	7.25	18.67	40.18	27.50	54.16	80.28
Precipitation	Dry spells (10 days or more with no precipitation)	4.22	0.90	1.65	2.55	1.80	2.80	3.78
	Annual number of days per year when precipitation is greater than 25mm per day (Met Office definition of 'heavy rain')	2.57	1.75	2.67	4.07	2.13	3.22	4.80

[*Regional (12km) projections are only available up to 2079.]

14.6.13 Table 14-13 summarises the projected changes in climate conditions, such as mean temperature and precipitation for the 2020s and 2080s. There is no

baseline information available for wind, therefore this has been excluded from the anomalies presented in Table 14-13.

14.6.14 Temperatures within the boundary of the proposed scheme are projected to increase in winter and summer. The largest increase in temperature is projected to be in the mean daily maximum temperature in summer, which is expected to increase by between 2.14°C and 9.75°C in the 2080s, relative to the baseline in the high emissions scenario.

14.6.15 Precipitation within the boundary of the proposed scheme is projected to decrease in the summer and increase in the winter. The largest decrease in precipitation is projected to be in the summer, which is expected to decrease between 5.9% and 72.3% in the 2080s, relative to the baseline in the high emissions scenario.

14.6.16 In general, climatic changes in the region of the proposed scheme are projected to result in increasingly wetter and warmer winters and drier and warmer summers.

Table 14-13 UKCP18 climate change projections for average climate variables for the local area (25km grid square) for the 2020s and 2080s (under the RCP 8.5 high emissions scenario)

Climate parameter		Baseline (1981-2010)	Anomalies from baseline for 2020s (2010-2039)			Anomalies from baseline for 2080s (2070-2099)		
			10th P.*	50th P.	90th P.	10th P.	50th P.	90th P.
Temperature (°C) (change from baseline)	Mean winter daily temperature	5.25	0.33	0.74	1.10	1.71	3.04	4.46
	Mean summer daily temperature	15.54	-0.01	0.63	1.09	2.35	5.14	7.92
	Mean daily summer maximum temperature	19.68	0.55	1.24	1.94	2.14	5.76	9.75
	Mean daily winter minimum temperature	2.62	-0.16	0.63	1.48	0.90	3.07	5.65
Precipitation (%) (change from the baseline)	Winter mean precipitation rate	3.53mm	-2.16%	6.16%	17.87%	2.47%	24.60%	50.66%
	Summer mean precipitation rate	1.77mm	-29.24%	-10.46%	6.73%	-72.35%	-40.77%	-5.91%

[P. = Percentiles which is a percentage of values that fall below a particular value in a set of data scores.]

14.7 Potential impacts

GHG emissions

14.7.1 The proposed scheme would result in GHG emissions during construction as well as changes to emissions during operation. Potential impacts are identified in this section and a preliminary assessment of effects is provided in section 14.9 Assessment of likely significant effects.

14.7.2 Sources of GHG emissions during construction include:

- GHG emissions associated with the required raw materials, including raw material supply, transport and manufacture.

- GHG emissions associated with construction processes, including transport to/from works site and construction/installation processes.
- GHG emissions associated with land use change, e.g. those mobilised from vegetation or soil loss during construction.

14.7.3 Sources of potential GHG emissions during operation include:

- GHG emissions from vehicles using the highway infrastructure (road users).
- GHG emissions from the maintenance, repair and refurbishment of the proposed scheme, for example emissions associated with raw materials and transport required to replace the road surface.
- GHG emissions associated with ongoing land use change/sequestration.

14.7.4 Opportunities identified for reduction of GHG emissions and mitigation measures incorporated in the design and construction of the proposed scheme are set out in section 14.8 Design, mitigation and enhancement measures.

Vulnerability to climate change

14.7.5 The A358 provides an important transport link for the Somerset region and is a part of the SRN in the region. The proposed scheme is expected to increase the resilience of transport systems in the region to hazards arising from climate change. The proposed scheme would improve safety for all road users and provide benefits for the overall resilience of the region. Potential impacts are identified in this section and a preliminary assessment of effects is provided in section 14.9 Assessment of likely significant effects.

Construction impacts

14.7.6 A change in climate conditions and extreme weather events in the short-term has the potential to cause significant effects on elements of the proposed scheme during construction.

14.7.7 Examples of the climate impacts that have been identified include:

- Intense rainfall events that could lead to flooding of excavations and obstructions to access roads.
- Wind gusts that could damage construction materials such as earthworks and stockpiles.
- Unsuitable conditions for construction activities such as pouring concrete and asphalt causing programme delays and increased costs.
- Impacts on the health and safety of site personnel during severe weather events.

14.7.8 The potential climate risks are anticipated to be mitigated through the use of appropriate design standards and following best practice construction measures.

Operational impacts

14.7.9 Climate change and more frequent severe weather events in the medium to longer-term have the potential to cause significant effects on elements of the proposed scheme during operation. Examples of the climate impacts that have been identified include:

- Intense rainfall events that could increase the risk of debris and sediment run-off washing into drainage gullies causing a blockage leading to flooding of road surfaces
- Damage to or deterioration of the road pavement from intense rainfall events leading to health and safety risks to road users.

- Extreme heat events leading to the soft landscape design (trees and shrubs) being compromised.
- Damage to signs/signals and minor structures (e.g. gantries) and vegetation as a result of wind loading or wind-blown debris leading to health and safety risks to road users.

14.7.10 The potential climate impacts are anticipated to be mitigated through following appropriate asset management procedures.

14.8 Design, mitigation and enhancement measures

Greenhouse gas emissions

14.8.1 In accordance with DMRB LA 114 *Climate*, the third lifecycle stage for a project's GHG emissions (the first and second being construction and operation) comprises opportunities to reduce the production of GHG emissions.

14.8.2 In line with Highways England's *Net zero highways: Our 2030/2040/2050 plan* (2021) [14], which sets out Highways England's ambition to decarbonise the road network in order to reach net zero by 2050, and the UK government's carbon reduction targets, the proposed scheme has sought and would continue to seek to reduce GHG emissions as far as reasonably practicable to contribute to the UK's net reduction in carbon emissions and maximise its potential for reducing GHG emissions.

14.8.3 This PEI Report includes a range of environmental mitigation measures. Mitigation measures of relevance to GHG emissions are set out in this section under the following categories:

- Embedded mitigation: measures that form part of the engineering design, developed through the iterative design process.
- Essential mitigation: any additional proposed scheme-specific measures needed to avoid, reduce or offset potential impacts that could otherwise result in effects considered to be significant in the context of the *Infrastructure Planning (Environmental Impact Assessment) Regulations 2017*. Essential mitigation has been identified taking into account the embedded mitigation measures.

Design and construction mitigation

14.8.4 Mitigation measures presented in Table 14-14 have been and will continue to be considered during the design process to reduce GHG emissions from the proposed scheme. Key GHG emissions impacts during construction will be from construction activities and the embedded/embodied carbon of the materials. Mitigation measures identified in Table 14-14 are divided into the following hierarchy options:

- Avoid/prevent – maximise the potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required, and/or explore alternative lower carbon options to deliver the proposed scheme objectives.
- Reduce – low carbon and/or reduced resource consumption solutions (including technologies, materials and products) to minimise resource consumption during the construction, operation, and at end of life.
- Remediate – measures to further reduce carbon through on or off-site offsetting or sequestration.

Table 14-14 GHG mitigation measures during design and construction

Mitigation measure	Delivery mechanism	Embedded/ Essential	Method of reduction
The proposed scheme looked at a variety of alternative options to solve the identified capacity problem on the existing A358 before defining and refining the preferred option. A preliminary assessment of carbon was undertaken during option selection, which identified the pink option as having a small benefit (lower construction emissions) compared to the orange and blue options (these options are described in Chapter 3 Assessment of alternatives of this PEI Report).	Proposed scheme design	Embedded	Avoid/ prevent
As the proposed scheme design has been refined during the preliminary design stage, consideration has been given to options that reduce or avoid carbon emissions. This included: • removal of retaining walls at Stoke Road/Henlade. • simplification of overbridge and connecting road junction at Mattock's Tree Green junction which reduces overall material demand compared to the baseline option. Further refinements to the design will be reported in the ES.	Proposed scheme design	Embedded	Avoid/ prevent
The construction contractor will develop and implement a plan to reduce energy consumption and associated carbon emissions. This could include the consideration of renewable and/or low or zero carbon energy sources and recording the savings implemented. Highways England is committed to reducing carbon emissions and works closely with suppliers to reduce emissions from network related activity. Energy consumption and materials use will be recorded and reported on an ongoing basis during the construction phase of the proposed scheme using the Highways England Carbon Reporting Tool.	Environmental Management Plan (EMP)	Essential	Reduce
Where practicable, measures would be implemented to manage material resource use during construction including: • using materials with lower embedded GHG emissions and water consumption • using sustainably sourced materials • using recycled or secondary materials	EMP	Essential	Reduce
Material excavated during construction would be processed for use in the works wherever possible to reduce the amount of material disposed of off-site as well as imported from other sources, and associated GHG emissions. The preliminary assessment indicates that most of the excavated materials are suitable for reuse elsewhere within the proposed scheme. Possible uses include general fill and other graded materials. Processing of material would take place on-site.	EMP	Essential	Reduce
Existing pavements would be retained wherever possible within the proposed scheme to reduce the requirement for additional materials and construction.	EMP	Embedded	Avoid/ prevent

Operational mitigation

14.8.5 In addition to the embedded design mitigation measures identified within Table 14-14, no essential operational mitigation measures have been proposed. It is not considered appropriate to monitor GHG emissions from road users during the operational phase of the proposed scheme as Highways England does not have direct control over road user emissions.

Vulnerability to climate change

Construction mitigation

14.8.6 The proposed scheme has been designed to improve its resilience to climate change through a range of design and construction standards, good engineering practice and material specification measures including:

- The use of construction materials with appropriate durability requirements (such as increased resilience to thermal loading from fluctuating temperatures).
- Incorporation of current road design standards and future climate change allowances.
- Structures to be prefabricated off-site where feasible to reduce on-site construction activities.
- Construction materials to be delivered 'just-in-time' to avoid on-site storage of materials and construction materials and allowing materials which are stored on-site to be protected to minimise damage and thereby enter the waste stream, e.g. by periods of heavy precipitation.
- Risk of heat stress to site personnel from exposure to extreme temperatures to be managed through the provision of necessary personal protective equipment and facilities.
- Sufficient time to be included within the construction programme or consider changing the timing of construction activities to reduce risks relating to site personnel, plant and machinery associated with high temperatures and prolonged periods of heavy precipitation.
- Material stockpiles and structures to be inspected before and after extreme weather events to ensure stability and incorporate such measures into materials management plans.

14.8.7 A comprehensive list of embedded mitigation and adaption measures during construction for all climate impacts identified will be further developed in the ES.

14.8.8 All weather and climate-related impacts to construction activities are expected to be mitigated through best practice site management, including specific measures which would be set out in a Register of Environmental Actions and Commitments within an EMP, which would be submitted with the ES. The best practice site management measures and relevant specific measures will provide a level of resilience to the proposed scheme throughout construction.

Operational mitigation

14.8.9 A number of preliminary general mitigation and adaptation measures to address the potential impacts associated with climate change events have been considered. Most weather and climate-related resilience effects during operation are expected to be mitigated through measures embedded in the design of the proposed scheme, providing a level of resilience throughout operation. Mitigation measures considered in this preliminary assessment include:

- Drainage infrastructure has been designed with sufficient allowance to account for climate change and to withstand extreme rainfall events.
- The number of structures constructed within the floodplain have been avoided or reduced.
- Flood compensation storage areas will be provided.
- The material properties of the pavement (i.e. use of phenylmagnesium bromide) will be considered to enhance the durability of the pavement during high temperatures.
- Soft landscape features are to be maintained following establishment through watering in periods of dry weather and carrying out periodic inspections to monitor the establishment of new planting.
- Regular inspection of drainage infrastructure and structures has been specified to assess the condition after extreme weather events.

14.8.10 A comprehensive list of embedded mitigation and adaption measures for the operation of the proposed scheme for all climate impacts identified will be further developed in the ES.

14.9 Assessment of likely significant effects

GHG emissions

14.9.1 This assessment presents a preliminary calculation of the GHG emissions for the 'Do Something' scenario, a comparison against the 'Do Minimum' baseline, and assessment against UK government's carbon budgets. The GHG emissions in this section are a high-level indication only and will be updated and refined for the ES as the proposed scheme design develops and updated traffic and air quality modelling becomes available.

14.9.2 Due to the embedded nature of the mitigation measures proposed, as outlined in Section 14.8 Design, mitigation and enhancement measures, some of which have already been incorporated into the design and some of which are yet to be incorporated, it is not practicable to complete a quantitative assessment of 'before' and 'after' mitigation. Rather, the assessment shows a snapshot of the current design.

Do Something scenario GHG emissions

Construction effects

14.9.3 A high-level breakdown of construction phase emissions is presented in Table 14-15. All assumptions used in the calculations are contained within Appendix 14.1 GHG assessment assumptions, methodology and emissions factors and section 14.4 Assessment assumptions and limitations.

Table 14-15 Construction stage GHG emissions

Main stage of project life cycle	Sub-stage of life cycle*		Emissions (tCO_2e)	% of total construction emissions**
Construction stage	Product stage including raw material supply, transport and manufacture (A1 - A3)		40,000	50%
	Construction process stage including:	Transport to/from works site (A4)	6,000	8%
		Construction/installation processes (A5)	34,000	43%
	Construction stage total		**80,000**	**100%**

Note: Values which are over 1,000 tCO_2e have been rounded to the nearest 1,000 tCO_2e.

* Sub-stages of the construction life cycle and modules shown in this table align with PAS 2080 boundary stages and individual modules as shown in Table 14-8.

** Due to rounding, percentages may not always appear to add up to 100%

14.9.4 GHG emissions from the construction phase are predicted to total in the region of 80,000 tCO_2e.The largest magnitude of emissions during construction (50%) is likely to arise from the production of materials. Emissions from on-site construction processes, particularly from fuel used in construction plant equate to 43% of the total, and transport of materials totals 8% of GHG emissions. Further information on the construction and installation processes will become available and will be incorporated into the A5 calculation to be reported within the ES. This will increase the total A5 emissions and may also change the relative percentages.

Operational effects

14.9.5 As noted in Table 14-8, road users' emissions have been based on PCF stage 2 data and therefore 2023 opening year with traffic growth applied. This will be updated in the ES to reflect a 2028 opening year.

14.9.6 As noted in Table 14-8, information relative to direct emissions associated with operating the proposed scheme is not available at this stage. GHG emissions have therefore been based on an average per kilometre emissions factor derived from a sample of comparable highway schemes and applying this to the length of the proposed scheme PEI Report.

14.9.7 Emissions associated with maintenance assume that certain assets are replaced periodically during the assumed 60-year design life. Road user GHG emissions are expected to constitute the majority of the whole life GHG emissions of the proposed scheme. Operational phase emissions for the modelled opening and design years and total over the modelled 60-year operational period are shown in Table 14-16.

Table 14-16 Operation ('use stage') emissions for modelled opening year (2023), design year (2038) and total over the assumed 60-year operational period (2023-2082)

Main stage of project lifecycle	Sub-stage of lifecycle*	Emissions (tCO_2e)		
		2023 annualised (modelled opening year)	2038 annualised design (future) modelled assessment year	Total (cumulative) over modelled 60-year operation (2023 – 2082)
Operation ('use-stage')	Use of the infrastructure by the end-user (road user emissions) (B9)	169,000	188,000	11,718,000
	Maintenance, refurbishment and lighting energy use (B2 - B6)	2,000	2,000	127,000
Operation ('use-stage') total		**171,000**	**190,000**	**11,846,000**

Note: Values which are over 1,000 tCO_2e have been rounded to the nearest 1,000 tCO_2e.

* Sub-stages of the operation ('use-stage') life cycle and modules shown in this table align with PAS 2080 boundary stages and individual modules as shown in Table 14-8.

Comparing 'Do-Minimum' and 'Do-Something' scenarios

14.9.8 As GHG emissions associated with construction do not occur in the 'Do-Minimum' scenario, it can be considered that the construction stage of the proposed scheme would have the effect of releasing an additional emission of 80,000 tCO_2e into the atmosphere in the 'Do-Something' scenario.

14.9.9 The calculated annualised operation stage emissions for the modelled 2023 and 2038 'Do-Minimum' and 'Do-Something' scenarios and the cumulative operation stage emissions over the 60-year operation for the 'Do-Minimum' and 'Do-Something' scenarios (with the difference between them being the impact) are compared in Table 14-17.

Table 14-17 'Do-Something' and 'Do-Minimum' operation ('use stage') emissions comparison over the 60-year operational period modelled (2023 – 2082)

Main stage of project lifecycle	Emissions (tCO_{2e})								
	2023 (annualised) Do-Minimum	2023 (annualised) Do-Something	Difference	2038 (annualised) Do-Minimum	2038 (annualised) Do-Something	Difference	Total (cumulative) over 60-year operation (2023 – 2082) Do-Minimum	Total (cumulative) over 60-year operation (2023 – 2082) Do-Something	Difference
Total operational 'use stage' emissions (maintenance and road user)	150,000	171,000	21,000	161,000	190,000	29,000	9,883,000	11,846,000	1,963,000

Note: Values which are over 1,000 tCO2e have been rounded to the nearest 1,000 tCO2e.

14.9.10 The proposed scheme is estimated to lead to an increase of approximately 1,963,000tCO_2e during the modelled 60-year operational period (2023-2082), relative to the 'Do-Minimum' scenario.

Assessment against total UK carbon budgets

14.9.11 Table 14-18 shows the relevant carbon budgets to which emissions from the proposed scheme would contribute. This approximation assumes an even distribution of emissions across the assumed overall construction period.

14.9.12 If the DCO is granted, construction is planned to start in 2024/5 and the proposed scheme is due to open to traffic in 2028. Note that the traffic data modelled in this assessment represents 2023. It is assumed however, that these emissions would occur from 2028 for the purposes of comparing to the carbon budgets. Therefore, the construction period for the proposed scheme falls wholly within the 4th carbon budget. Operation of the proposed scheme would commence in 2028 and is assessed against the 4th, 5th and 6th carbon budgets, up to 2037. Operational and maintenance emissions after 2037 are not assessed since a carbon budget has not yet been set for after this date.

Table 14-18 Assessment of proposed scheme net emissions (up to 2037) against UK government carbon budgets

Project stage	Estimated total (cumulative) GHG emissions over carbon budgets (tCO_{2e}) ('Do-Something' scenario)	Net (cumulative) GHG emissions over carbon budgets (tCO_{2e}) ('Do-Something'- 'Do-Minimum')	Net (cumulative) proposed scheme GHG emissions per relevant carbon budget (tCO_{2e})		
			4th (2023-2027)	5th (2028-2032)	6th (2033-2037)
Construction (between 2023-2027)	80,000	80,000	80,000	n/a	n/a

Operation (modelled from 2023, represented here as if occurring from 2028 and 2043)	1,834,000	265,000	n/a	126,000	139,000
Total	**1,914,000**	**345,000**	**80,000**	**126,000**	**139,000**
UK Carbon Budget	**-**	**-**	**1,950,000,000**	**1,725,000,000**	**965,000,000**

Note: Values which are over 1,000 tCO2e have been rounded to the nearest 1,000 tCO2e.

Significance of effects

14.9.13 Construction of the proposed scheme is estimated to contribute approximately 0.004% of the 4th carbon budget. Operation of the proposed scheme is estimated to contribute approximately 0.007% of the 5th carbon budget and 0.014% of the 6th carbon budget. It is considered that this magnitude of emissions from the proposed scheme in isolation would not have a material impact on the ability of the Government to meet its carbon budgets, and therefore is not anticipated to give rise to a significant effect on climate, in line with the position set out within Section 5.18 of the NPSNN.

14.9.14 Further information on construction process emissions will become available and will be incorporated into the final GHG calculations to be published in the ES. This will increase the total estimated construction emissions. Additionally, operational emissions are currently overestimated as they do not account for widespread changes in vehicle fleets towards electric after 2030. However, these additions are not expected to change the conclusion that the proposed scheme would not have a significant impact on the ability of the government to meet its carbon budgets.

Comparison with other schemes

14.9.15 Table 14-19 compares the estimated GHG emissions performance of the proposed scheme against other comparable highway projects, normalised to take account of differences in size and scale.

Table 14-19 Comparison of the proposed scheme's GHG emissions with other road infrastructure projects

Carbon footprint lifecycle modules	Project/length and width component												
	M4 [35]	A14 [35]	A417 [36]	A428 [37]	A465 [35]	A47 [38]	A47 / A11 [39]	HA Project A [35]	HA Project B [35]	HA Project C [35]	HA Project D [35]	HA Project E [35]	Proposed scheme
	14.3 miles (23km) new relief road	23 miles (37km) improvement scheme	3.4 miles (5.5km) widening of A road	10 miles (16km) new dual 2-lane carriageway + 1.8 miles (3km) of tie-in	4.8 miles (7.8km) embankment section	5.6 miles (9km) dualling of A road	1 mile (1.65km) new slip road	16.5 miles (26.6km) widening of A road	4 miles (6.5km) single to 2 lane dual carriageway	2.5 miles (4km) upgrade of existing junction	0.4 miles (0.7km) refurbished existing viaduct	13.7 miles (22.1km) upgrade from dual to 3 lanes	8.5 miles (13.6km) new, rural all-purpose dual carriageway
Capital (embodied) CO_2e (tCO_2e)													
Material	436,600	740,100	40,698	163,230	44,300	25,865	15,235	74,500	77,300	36,100	5,800	213,700	40,000
Labour + plant	42,800	243,800	23,486	51,000	5,800	3,509	1,998	38,500	27,500	8,200	4,000	20,900	34,000
Earthworks	43,200	n/a			2,500	52,873	13,775	n/a	n/a	n/a	n/a	n/a	n/a
Transport													6,000
Construction tCO_2e/km	*21,800*	*26,600*	*11,670*	*13,024*	*6,700*	*9,747*	*15,725*	*4,300*	*16,100*	*11,100*	*13,900*	*10,600*	6,000
Operational CO_2e (tCO_2e)													
Operation + Maintenance/ annum	1,600	2,400	858	n/a	2,600	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2,000
Use/annum (road users)	2,268,700	4,386,400	209,642	1,835,778	882,000	894,192	894,033	n/a	n/a	n/a	n/a	n/a	197,000

Note: HA stands for Highways Agency, which is the former name for Highways England.

14.9.16 With the current information available, construction related emissions are expected to be lower than other projects on a per kilometre basis. Operational and maintenance GHG emissions are also expected to be significantly lower than other projects. On a per kilometre basis, estimated use phase emissions per annum are notably lower than comparable projects. However, it is noted that the current footprint is based on incomplete data due to limited availability of information at this stage. As such, it is expected that the carbon footprint of the proposed scheme will increase at the ES stage, due to more detailed information being available, which may change the conclusions drawn here.

Vulnerability to climate change

Construction effects

14.9.17 Projected changes in climate variables such as temperature, precipitation and wind over the short term (2020-2039), have the potential to affect receptors during the construction of the proposed scheme. Table 14-20 summarises the climate impacts on receptors including human health (i.e. site personnel and road users), drainage assets and earthworks and qualitatively assesses the likelihood and consequence of the climate impact on the proposed scheme to determine the significance.

Table 14-20 Construction vulnerability to climate (change) impacts

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
Increased frequency and intensity of extreme weather events: Intense rainfall events	Intense rainfall events could result in the erosion of stockpiles and earthworks and resultant silting of drainage assets. This could result in secondary impacts such as localised flooding or release of pollutants to watercourses.	Infrastructure (drainage assets and earthworks)	The proposed scheme is predominately situated in Flood Zone 1 and crosses some areas in Flood Zones 2 and 3. As stated in Section 4.1 of the Drainage Strategy, fluvial flooding will be mitigated by raising the highway above flood levels for a 1 in 100-year event +40% for climate change. As stated in Section 13.8 of Chapter 13 Road drainage and water resources, the EMP will specify standard good practice measures to be implemented by the construction partner including: • Measures such as temporary silt fencing, cut off ditches, settlement ponds and bunds to capture all runoff and prevent ingress of sediments and contaminants into existing drainage ditches. • Areas of exposed sediment should be protected using temporary measures (e.g. sheeting) or semi-permanent measures (for example coir matting) until vegetation is able to establish on these surfaces. • Works would be suspended during intense rainstorms. The EMP will specify that stockpiles are placed outside of flood zone areas and	Low	Minor	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
			local surface water flow paths wherever possible.			
	Intense rainfall events could affect the ability to undertake certain construction activities leading to programme delays and increased project costs. (e.g. pouring of concrete, earthworks and asphalt).	Infrastructure	The EMP is anticipated to specify that specific site activities, such as pouring concrete, trimming formation and laying asphalt, should be postponed during rainfall events. Protect sub-base surface from rainfall before laying the asphalt by laying an extra 100mm sub-base and remove the top layer and recompact prior to placing the asphalt. Earthworks operations will be suspended during intense rainfall events and the exposed surfaces sealed/finished to a slope if there is an extended break in works, to facilitate drainage and minimise deterioration of the fill already placed or any exposed formation.	Low	Moderate	NS
	Increased frequency of intense rainfall events could lead to flooding of excavations and obstructions to access roads. This could result in secondary impacts such as safety risk of slips, trips and falls to site personnel.	Infrastructure (drainage assets) Human health (site personnel)	As stated in section 3.4 of the FRA in Appendix 13.1, dewatering activities may be required to remove groundwater seepage from excavations enabling the works to be undertaken safely. As stated in section 13.8 of Chapter 13 Road drainage and water resources, discharge from dewatering activities such as earthworks, works within a floodplain or within eight metres of a watercourse will have a tailored risk assessment, consent and licences from the Environment Agency.	Low	Moderate	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
			A Health and Safety Plan is anticipated to be specified within the proposed Construction EMP.			
	Increased frequency of intense rainfall events could result in flooding of the drainage assets which could result in overflow of contaminated water (containing fuels, oil and de-icing salts) from the foul and surface water infrastructure impacting the water quality and ecology of nearby watercourses.	Environment (watercourses and ecology)	As stated in section 13.8 of Chapter 13 Road drainage and water resources, the EMP is anticipated to specify standard good practice measures to be implemented by the construction partner including: • Measures such as temporary silt fencing, cut off ditches, settlement ponds and bunds to capture all runoff and prevent ingress of sediments and contaminants into existing drainage ditches. • Water with a higher risk of contamination which requires discharge, to be contained and treated using appropriate measures such as coagulation of sediments, dewatering and pH neutralisation prior to discharge. Contractor to assess requirements for the temporary drainage design during construction which would typically accommodate 1 in 10-year events +30% for climate change.	Very Low	Minor	NS
	Increased frequency of intense rainfall events could lead to contaminants (from historic landfill sites or	Environment (watercourses)	As stated in section 9.7 of Chapter 9 Geology and soils, disturbance of potentially contaminated soils could be caused due to earthworks and/ or use of	Low	Minor	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
	contained within soils) entering watercourses during ground excavations.		piled foundations for structures. This may cause an increase in leaching of contaminants in soils and mobilising of contaminants. The EMP, an action plan and procedures on how to manage and assess unexpected contamination will mitigate this risk. As stated in section 13.8 of Chapter 13 Road drainage and water resources, the EMP is anticipated to specify standard good practice measures to be implemented by the construction partner including: • Water with a higher risk of contamination which requires discharge, including groundwater pumped out of pilings to be contained and treated using appropriate measures such as coagulation of sediments or dewatering prior to discharge.			
	Intense rainfall events could result in risk of earthworks failure and landslides caused by the variation of soil moisture levels from high and low rainfall events.	Infrastructure (earthworks)	The geotechnical design of cutting and embankment slopes will incorporate appropriate groundwater assumptions to minimise the risk of failure. As the materials on-site are generally cohesive, rainfall will not tend to infiltrate the earthworks.	Low	Large	NS
	Intense rainfall events could lead to flooding of water crossings resulting in risk to	Infrastructure (drainage assets)	Contractor to assess requirements for a temporary drainage design during construction on a case-by-case basis, as	Low	Large	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
	site personnel working on water diversions or temporary works over water crossings for access tracks.	Human health (site personnel)	the risks and requirements will be dependent on the topography and hydrology of each watercourse. The drainage design would typically accommodate 1 in 10-year events +30% for climate change.			
Increased frequency of extreme weather events: windstorms and wind gusts	Windstorms or wind gusts could result in the damage of earthworks and stockpiles.	Infrastructure (earthworks)	The EMP is anticipated to specify best practice measures to reduce damage to stockpiles and earthworks. Measures include management of stockpiled materials by rolling, covering and/or revegetating as soon as appropriate.	Low	Minor	NS
	Windstorms or wind gusts could result in damage to temporary hoarding or temporary traffic signage and cones leading to damage to site personnel or road users.	Infrastructure (hoarding) Equipment (signage and cones) Human health (site personnel and road users)	The EMP is anticipated to specify best practice construction measures to ensure that hoarding would be designed to account for wind loading, would be strengthened along the boundaries of the site and kept in good working order. This would ensure that hoardings would be resilient to windstorms/gusts and could be erected and removed safely. Traffic signage and cones would be weighed down and signs could be removed during storm events to prevent damage to site personnel.	Low	Minor	NS
	Windstorms could result in inability to undertake specific construction activities (e.g. site crane operations, laying concrete and asphalt)	Infrastructure	The EMP is anticipated to specify safe working procedures such as undertaking vulnerable activities including operating cranes, heavy equipment and laying pavement surfaces during appropriate	Low	Moderate	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
	increasing programme delays.		weather conditions. Health and Safety Plans are anticipated to be specified within the proposed EMP.			
	Windstorms or wind gusts could impact on construction and maintenance site personnel and road users.	Human health (site personnel and road users)	The EMP is anticipated to specify best practice measures to reduce effects from construction dust including: • minimising areas to be stripped of vegetation • dampening down of dust generating activities and materials • ensuring vehicles are covered to prevent escape of materials during transport Dust monitoring could be undertaken to identify and further reduce the impacts of soiling.	Low	Large	NS
Increased frequency and intensity of high temperatures: Heatwaves	Heatwaves and higher temperatures leading to the delay of construction activities such as laying asphalt pavement surface layers.	Infrastructure (pavement)	The EMP is anticipated to specify best practice working procedures such as undertaking vulnerable activities (i.e. laying asphalt) during appropriate weather conditions.	Low	Minor	NS
	Heatwaves and higher temperatures could impact the welfare of construction and maintenance site personnel, for example, heat stress and unsafe working conditions.	Human health (site personnel)	The proposed EMP is anticipated to specify the risks associated with heat stress to ensure that Highways England's health and safety requirements are met.	Low	Large	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
Increased frequency and intensity of high temperatures: Drought conditions	Higher temperatures and drought conditions could increase risks to construction and maintenance site personnel associated with increased potential for dust generation and dispersal.	Human health (site personnel and road users)	The EMP is anticipated to specify best practice mitigation measures to reduce effects from construction dust. It is anticipated that dust monitoring will be undertaken to identify and further reduce the impacts of soiling.	Low	Minor	NS

Operational effects

14.9.18 The climate change impacts to assets designed and constructed as part of the proposed scheme have been assessed during operation.

14.9.19 Projected changes in climate variables such as temperature, precipitation and wind over the long-term by the end of the century (2080-2099), have the potential to affect receptors during the operation of the proposed scheme.

14.9.20 Table 14-21 summarises the climate impacts on receptors including infrastructure elements (e.g. structures, drainage assets, bridges and pavement), earthworks, soft landscape design and human health (i.e. site personnel and road users). It assesses the likelihood and consequence of the climate impact on the proposed scheme qualitatively to determine the significance.

Table 14-21 Operational vulnerability to climate (change) impacts

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
Increased frequency and intensity of extreme weather events: Intense rainfall events	Intense rainfall events could result in risk of earthworks failure and landslides caused by the variation of soil moisture levels from high and low rainfall events. This could result in secondary impacts such as earthworks material causing obstruction on the road creating dangerous driving conditions for road users.	Infrastructure (earthworks) Human health (road users)	Landslides are a known hazard in the boundary of the proposed scheme. Appropriate design measures will manage the risk such as designing shallow slopes, checking for landslide prone materials, incorporating slope drainage for unstable areas and increasing stability of slopes through engineered measures. The geotechnical design of cutting and embankment slopes will incorporate appropriate groundwater assumptions to minimise the risk of failure. As the materials on-site are generally cohesive, rainfall will not tend to infiltrate the earthworks.	Low	Large	NS
	Increased frequency of intense rainfall events could result in water ingress to signalling, lighting and other operational electrical equipment. This could result in secondary impacts such as creating dangerous driving conditions for road users.	Electrical equipment Human health (road users)	Electrical cables will be housed in watertight plastic ducts preventing water ingress to underground cables. Electrical cabinets will be fitted with heaters to prevent moisture from forming. The electrical cabinets will be located outside of floodplains.	Very Low	Large	NS
	Increased risk of debris and sediment run-off washing into drainage gullies causing a blockage. This could result in secondary impacts such as	Infrastructure (drainage assets) Human health (road users)	As stated in Section 4.6 of the Drainage Strategy, active system (i.e. values and penstocks), and passive system (i.e. Sustainable Drainage Systems or SuDS, swales/grassed channels, silt traps)	Low	Large	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
	localised flooding creating dangerous driving conditions for road users.		mitigation measures will reduce the proportion of suspended solids from entering the drainage system. A proposed Maintenance and Repair Strategy Statement (MRSS) is anticipated to specify maintenance proposals for drainage assets and how these assets would be maintained during operation.			
	Increased frequency of intense rainfall events could result in overwhelming of drainage assets leading to flooding of road surfaces. This could result in secondary impacts such as hydroplaning and unsafe driving conditions.	Infrastructure (drainage assets) Human health (road users)	As stated in Section 4.1 of the Drainage Strategy, fluvial flooding will be mitigated by raising the highway above flood levels for a 1 in 100-year event +40% climate change allowance plus a freeboard of 600mm. Where an existing floodplain storage has been impeded by the construction of the highway, appropriate flood storage compensation will be provided. The drainage systems will be designed to manage 1 in 100-year event +40% climate change allowance. The risks associated with exceedance events will also be evaluated and appropriate design measures will be implemented (i.e. exceedance routes which minimise adverse impacts to people and property).	Low	Large	NS
	Increased frequency of intense rainfall events could result in damage to pavements, bridges and culverts due to scour.	Infrastructure (pavement, bridges and drainage assets)	As stated in Section 4.1 of the Drainage Strategy, the pavements and culverts will be protected from scour by designing a freeboard of 600mm above carriageway levels. Sections 4.7 and 4.8 state that	Low	Minor	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
			scour protection for culverts will be assessed and an appropriate form of protection will be proposed. Ditches will be located at the crest of cut slopes and toe of embankments to prevent flows scouring the earthworks or inundating the highway.			
	Increased frequency of intense rainfall events could result in potholing, rutting and cracking from moisture entering and remaining in road surfaces.	Infrastructure (pavement)	The proposed MRSS for road surfaces will ensure that the pavement surface is kept in good condition. Pavement surface materials will be selected that are resistant to deformation and cracking. The risk of water infiltration will be minimised by ensuring the void content of the compacted bituminous materials is less than 5%. A bond coat will be applied within each layer to provide a waterproofing layer.	Medium	Minor	NS
	Increased frequency of intense rainfall events could result in wet pavement surface leading to reduced skid resistance creating dangerous driving conditions for road users.	Infrastructure (pavement) Human Health (road users)	Suitable road surface materials will be selected to improve skid resistance which will be maintained through the proposed MRSS for road surfaces.	Low	Large	NS
	Increased frequency of intense rainfall events could result in increased groundwater flow causing accelerated weathering effects, weakening the embankment.	Infrastructure (earthworks)	This risk is anticipated to be accounted for by appropriately conservative assumptions made during design.	Very Low	Large	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
	Increased groundwater level in winter may lead to flooding of underpasses deterring Walkers, Cyclists and Horse riders (WCH) from their journey and preventing site personnel from completing maintenance work.	Infrastructure (drainage assets) Human health (WCHs, site personnel)	As stated in Section 4.1 of the Drainage Strategy, the drainage systems will be designed to manage 1 in 100-year event +40% allowance for climate change. The risks associated with events that exceed the capacity of the drainage system will be evaluated and appropriate design measures will be implemented where significant risks of flooding are identified. The design will ensure that, flows in excess of a 1 in 100-year storm event are managed in exceedance routes that minimise adverse impacts to people and property.	Very Low	Moderate	NS
	Increased frequency of intense rainfall events could result in flooding of the drainage assets which could result in overflow of contaminated water (containing fuels, oil and de-icing salts) from the foul and surface water infrastructure impacting the water quality and ecology of nearby watercourses	Infrastructure (drainage assets) Environment (watercourses and ecology)	As stated in Section 4.6 of the Drainage Strategy, mitigation measures such as active systems (i.e. values and penstocks) and passive systems (i.e. SuDS, filter drains, oil separators) will reduce the amount of contaminants from entering the drainage system. The EMP is anticipated to specify further mitigation measures to manage wastewater and foul discharge.	Low	Moderate	NS
Increased frequency of extreme weather events:	Windstorms could impact on maintenance site personnel and road users.	Human health (site personnel and road users)	The proposed MRSS is anticipated to specify safe working procedures such as undertaking vulnerable activities, including operating heavy equipment, during appropriate weather conditions.	Low	Moderate	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
Windstorms and wind gusts			Health and Safety Plans to be further specified within the EMP.			
	Windstorms could damage signs, signals and structures (e.g. gantries or light columns) as a result of wind loading or wind-blown debris. This could result in secondary impacts such as unsafe driving conditions.	Infrastructure (signs, signals, and structures) Human health (road users)	The structural design of the gantries and light columns will account for appropriate wind loading in accordance with Eurocode standards and DMRB guidance.	Very Low	Large	NS
	Windstorms or wind gusts could damage the soft landscape design as a result of or wind-blown debris.	Environmental (soft landscape)	As stated in section 7.10 of Chapter 7 Landscape and visual, mitigation planting will be monitored every year for the first three years to ensure successful establishment and then inspected every 2-5 years for the next 12 years. Full details will be provided in the Landscape and Ecological Management Plan (LEMP) which will set out a framework in which the successful establishment of these measures can be managed and ensured.	Low	Minor	NS
Extreme weather events: cold weather events	Cold weather events leading to the presence of ice and frost conditions requiring the use of de-icers, e.g. grit salt which could result in corrosive action on bridge components.	Infrastructure (bridges)	The structural design of bridges will account for corrosive action on bridge components from grit salt in accordance with Eurocode standards and DMRB guidance.	Very Low	Moderate	NS
Increased frequency and	Heatwaves and higher temperatures leading to the delay of maintenance activities	Infrastructure	The proposed MRSS is anticipated to specify that specific site activities, such as	Low	Minor	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
intensity of high temperatures: Heatwaves	such as laying asphalt pavement surface layers.		laying asphalt, should be postponed during heatwaves.			
	Heatwaves and higher temperatures could impact the welfare of maintenance site personnel, for example, heat stress and unsafe working conditions.	Human health (site personnel)	The proposed Health and Safety Plans are anticipated to specify maintenance regimes to ensure that site personnel are prepared to work safely in higher temperatures.	Low	Large	NS
	Heatwaves and higher temperatures could lead to deformation of the asphalt pavement surface. This could result in secondary impacts such as unsafe driving conditions for road users.	Infrastructure (pavement) Human health (road users)	This risk will be managed through the selection of suitable road surface material including the use of polymer modified binder and quality control on site. The pavement is anticipated to be monitored, maintained and replaced in line with the proposed MRSS.	Low	Large	NS
	Heatwaves and higher temperatures could lead to vegetation drying out, increasing the risk of spontaneous grassland fires near the proposed scheme, affecting safety of road users. This could result in secondary impacts such as damage to soft landscape design and habitats.	Human health (site personnel and road users) Environmental (soft landscape and habitats)	The standard emergency procedures are anticipated to mitigate this risk and the proposed Health and Safety Plans are anticipated to specify appropriate response to grassland fires.	Very Low	Very Large	NS
	Freeze-thaw during cold snaps and extreme high temperatures can cause damage to road surfaces including pavement	Infrastructure (pavement)	The selection of suitable road surface material including use of polymer modified binder to enhance the resistance to deformation and cracking properties of	Medium	Minor	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
	cracking and deformation resulting in a reduction of road service life.		the bituminous materials and quality control on site will mitigate this risk. The pavement will be monitored, maintained and replaced in line with the proposed MRSS.			
	Heatwaves and higher temperatures could lead to stress on pavement surfaces (i.e. degradation of macrotexture and reduction of texture depth, wearing away of asphalt compromising support layers).	Infrastructure (pavement)	Suitable road surface materials will be selected that are more resilient to warm temperatures and the pavement will be monitored, maintained and replaced in line with the proposed MRSS.	Medium	Minor	NS
	Heatwaves and higher temperatures could lead to increased thermal loading overstressed bearings that could eventually compromise structural stability of the asset.	Infrastructure (bridges)	The structural design of bridges will account for thermal loading overstressed bearings in accordance with Eurocode standards and DMRB guidance.	Very Low	Very Large	NS
	Heatwaves and higher temperatures could result in the soft landscape design (trees and shrubs) being compromised (e.g. plant failures).	Environmental (soft landscape)	As stated in Section 7.10 of Chapter 7 Landscape, mitigation planting will be monitored every year for the first three years to ensure successful establishment and then inspected every 2 - 5 years for the next 12 years. Full details will be provided in the LEMP which will set out a framework in which the successful establishment of these measures can be managed and ensured.	Medium	Minor	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
Increased frequency and intensity of high temperatures: Drought conditions	Higher temperatures and drought conditions could increase risks to maintenance site personnel associated with increased potential for dust generation and dispersal.	Human health (site personnel and road users)	The EMP is anticipated to specify best practice mitigation measures to reduce effects from construction dust.	Low	Moderate	NS
	Higher temperatures and drought conditions could lead to soil shrinkage impacting foundations, including bridges and other structures.	Infrastructure (earthworks and bridges)	This risk is likely to be accounted for by appropriately conservative assumptions made during design. The bridge foundations should be below the shrink/ swell zone.	Very Low	Large	NS
	Higher temperatures and drought conditions could lead to the vegetation failure of the soft landscape design.	Environmental (soft landscape)	As stated in section 7.10 of Chapter 7 Landscape and visual, mitigation planting will be monitored every year for the first three years to ensure successful establishment and then inspected every 2-5 years for the next 12 years. Full details will be provided in the LEMP which will set out a framework in which the successful establishment of these measures can be managed and ensured.	Medium	Minor	NS
	Higher temperatures and drought conditions could increase the risk of ignition of diesel resulting in damage to roads or fires. This could result in secondary impacts such as damage to soft landscape design and habitats or the	Infrastructure (pavement) Environmental (soft landscape and watercourses)	The EMP is anticipated to specify mitigation to reduce the risk of fuel ignition from damaging roads and causing fires. The standard emergency procedures will further mitigate this risk and the proposed Health and Safety Plans are anticipated to specify appropriate response to fuel spills and fires.	Very Low	Very Large	NS

Climate trend	Climate (change) impact on receptor	Asset type / receptor	Design or mitigation measure	Likelihood of climate impact	Consequence of climate impact (should the impact occur)	Significance of effect (NS – Not Significant)
	release of pollutants to watercourses.					
	Higher temperatures and drought conditions could lead to shrink swell processes resulting in desiccation, cracking and embankment and earthwork instability. This is a particular risk when drought conditions are followed by intense rainfall events.	Infrastructure (earthworks)	This risk is anticipated to be accounted for by appropriately conservative assumptions made during design. Shrink swell of earthworks should be avoided by proper compaction.	Very Low	Large	NS

14.10 Monitoring

GHG emissions

14.10.1 As no preliminary significant effects have been identified for the GHG emissions assessment, no monitoring of significant effects is expected to be required.

14.10.2 In line with the monitoring requirements set out in DMRB LA 114 *Climate*, and to be secured through the EMP, quarterly GHG emissions returns during construction and operation shall be reported in accordance with Highways England's requirements. Data provided for the GHG returns shall be evaluated to inform any ongoing monitoring of GHG emissions and feed back into future assessment of projects during design development and planning approval.

14.10.3 Highways England is committed to reducing carbon emissions and working closely with suppliers to reduce emissions from network related activity. An EMP, will be prepared and submitted with the DCO application, which will require energy consumption and materials use to be recorded and reported on an ongoing basis during the construction phase of the proposed scheme using the Highways England Carbon Reporting Tool. It is not considered beneficial to monitor GHG emissions from road users during the operational phase of the proposed scheme.

Vulnerability to climate change

14.10.4 The vulnerability to climate change assessment identified no preliminary likely significant effects therefore, no monitoring of significant effects is proposed at this stage.

14.10.5 During the construction stage, the EMP would specify monitoring to be undertaken to ensure that the mitigation measures embedded in the proposed scheme design are implemented.

14.10.6 In line with the monitoring requirements of DMRB LA 114 *Climate*, once the proposed scheme is operational, asset data would be managed, maintained and monitored. During the operational stage, asset management measures would evolve to respond appropriately to climate impacts. Where a design issue is identified, an assessment shall be made to determine if corrective action is required.

14.11 Summary

GHG emissions

14.11.1 The proposed scheme would result in GHG emissions due to construction materials and activities during the construction phase, maintenance during the operation phase and vehicles using the road during the operation phase.

14.11.2 Based on the preliminary assessment presented in this PEI Report, no significant effects in relation to GHG emissions are predicted during the construction and operation phases. The preliminary assessment indicates that the expected change in GHG emissions is very small in comparison with the national carbon budgets. The preliminary assessment of proposed scheme impacts is considered to be not significant based on evidence that in isolation the proposed scheme would not have a material impact on the ability of the UK government to meet its carbon reduction targets.

Vulnerability to climate change

14.11.3 The preliminary vulnerability of the proposed scheme to climate change assessment during the construction stage is not anticipated to be significant due to relevant design and mitigation measures that have been identified to improve resilience to current climate and reduce any potential impacts.

14.11.4 The preliminary vulnerability to climate change assessment during the operational stage indicates that all impacts are likely to be 'not significant' because of mitigation measures proposed to be included in the design and assumed management practices to be implemented.

Further work

GHG emissions

14.11.5 Between the PEI Report and the ES, further work will be done on proposed design of the proposed scheme. As part of the design process, GHG emissions are one of the criteria considered for option selection and further workshops and reviews will be held to consider potential mitigation measures. The ES will report on the potential impacts of the final proposed design and include an updated assessment of GHG emissions associated with the construction phase using updated design information and of operation phase emissions using the PCF stage 3 traffic model data and latest GHG calculation methodologies.

14.11.6 Climate policy continues to evolve, and the ES will also take account of any changes in Government policy that are relevant to the proposed scheme.

Vulnerability to climate change

14.11.7 The focus of the work between the PEI Report and the ES will be to discuss planned mitigation measures with the design team and relevant environmental discipline specialists to confirm if any effects that have been identified are potentially significant and mitigate them where possible.

Abbreviations List

Please refer to PEI Report Chapter 17 Abbreviations.

Glossary

Please refer to PEI Report Chapter 18 Glossary.

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