A66 Northern Trans-Pennine Project
TR010062

3.2 Environmental Statement
Chapter 7 Climate

APFP Regulations 5(2)(a)

Planning Act 2008

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

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3.2 ENVIRONMENTAL STATEMENT CHAPTER 7 CLIMATE

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7 Climate

7.1 Introduction

7.1.1 This chapter assesses the likely significant Climate effects of the construction and operation of the Project, following the methodology set out in the *Design Manual for Roads and Bridges (DMRB) LA 114 Climate (DMRB LA 114)* (National Highways, 2019a)[1] and other relevant guidance, as is listed below. It details the methodology followed, summarises the legislation and policy framework relevant to the Climate assessment, and describes the existing environment in the area surrounding the Project. It then considers the design, mitigation and residual effects of the Project, including taking account of relevant characteristics of the future baseline environment. Any key assumptions and limitations applicable to the assessment are also identified.

7.1.2 Any Climate effects predicted to be significant are identified in section 7.11: Assessment of likely significant effects of this chapter. Detail is also provided in section 7.11: Assessment of likely significant effects of those effects predicted as not significant and the rationale for this assessment.

7.1.3 The Climate assessment is supported by two Technical Appendices (Application Document 3.4) as listed on the contents page.

7.1.4 This EIA has been undertaken by competent experts with the relevant and appropriate experience in their respective topics. The lead author of this chapter has:

7.1.5 MSc in Urban Water and Environmental Management, and BEng (Hons) in Mechanical Engineering

- Chartered Engineering and Member of the Institution of Mechanical Engineers (IMechE)
- 16 years of experience in professional practice relating to Climate Change.

7.1.6 In accordance with DMRB LA 114, this chapter presents the assessment under the following two headings:

- Impact of the Project on climate (Greenhouse Gas (GHG) emissions assessment) – these sections of the chapter cover the potential additional and avoided GHG emissions associated with the construction and operation of the Project, in comparison with current and future baseline GHG emissions. It will also identify mitigation measures to reduce the GHG emissions.
- Vulnerability of the Project to climate change (Climate Change Risk (CCR) assessment) – these sections of the report cover how climate change is anticipated to manifest itself in the future and the vulnerability of the Project to such climate change. It also evaluates the effectiveness and feasibility of adaptation (mitigation) measures to be integrated into the Project to increase the resilience of the Project to climate change risk.

[1] National Highways (2019a) *DMRB LA 114* Climate

7.1.7 Climate change also has the potential to act in-combination with the impacts considered under other disciplines. There will be interrelationships related to the potential effects on climate and other disciplines, and each discipline will consider the potential for climate impacts to influence the impacts identified by their topic. Therefore, please refer to the following chapters for assessments of in-combination climate impacts:

- Chapter 5: Air Quality
- Chapter 6: Biodiversity
- Chapter 8: Cultural Heritage
- Chapter 9: Geology and Soils
- Chapter 10: Landscape and Visual Effects
- Chapter 11: Materials and Waste
- Chapter 12: Noise and Vibration
- Chapter 13: Population and Human Health
- Chapter 14: Road Drainage and the Water Environment.

7.2 Key assessment parameters

7.2.1 The following key assessment parameters have been used in order to enable flexibility in the assessment and to ensure that a reasonable worst case has been assessed.

Table 7-1: Key assessment parameters

Key Assessment Parameters
The assessment has been conducted within the Limits of Deviation (LoD) and Order Limits as outlined within Chapter 2: The Project. The LoD have been considered having regard to the scope for change. The reasonable worst case has been taken into account by: using design data from the Project combined with conservative assumptions on material type and sourcing; by assessing land use change within the full Order Limit boundary; and by maximising the surrounding road network over which the assessment is carried out. It is considered that the outcome of the climate assessments contained within this chapter would not change unless the Project or the assumptions change significantly. The proposed LoD would therefore not give rise to any materially new or materially worse environmental effects from those already reported in the ES.

7.3 Legislation and policy framework

7.3.1 This section lists the legislation, policy and strategy which is considered relevant to the Project. Whilst not intended to be an exhaustive list, it considers legislation, policy and strategy at international, national and local levels considered most relevant to the assessment of climate impacts for the Project.

Legislation

7.3.2 The following key legislation is considered applicable to the assessment:

- The Kyoto Protocol: an international treaty which extends the United Nations Framework Convention on Climate Change (UNFCCC) and commits state parties to reduce GHG emissions.

- The Paris Agreement: a legally binding treaty that pledges to limit the increase in global average temperature to well below 2°C, and to aim for 1.5°C, above pre-industrial levels.
- The Climate Change Act 2008: the UK legislative basis to address climate change. In relation to climate change mitigation, it commits the UK to GHG emissions reductions and reporting (see below). On climate change adaptation it sets the requirement for a national adaptation programme and associated publication of a climate change risk assessment every five years. The following orders are of particular relevance to this assessment:
  - Climate Change Act 2008 (2050 Target Amendment) Order: This Order amended the legislated GHG emissions reduction target for the UK, contained within the Climate Change Act 2008, to 'at least 100% of 1990 levels (net zero) by 2050'.
  - Carbon Budgets Order 2009: This Order sets the carbon budget totals for the First (2008-2012), Second (2013-2017) and Third (2018-2022) Carbon Budget periods.
  - Carbon Budget Order 2011: This Order sets the carbon budget total for the Fourth (2023-2027) Carbon Budget period.
  - Carbon Budget Order 2016: This Order sets the carbon budget total for the Fifth (2028-2032) Carbon Budget period.
  - Carbon Budget Order 2021: This Order sets the carbon budget total for the Sixth (2033-2037) Carbon Budget period.
- Infrastructure Planning (Environmental Impact Assessment) Regulations 2017: UK legislative basis for Environmental Impact Assessment (EIA) for nationally significant infrastructure projects (NSIPs). It places a requirement upon nationally significant infrastructure projects which are required to undertake an EIA to identify, describe and assess the direct and indirect significant environmental effects relevant to the Project across a range of topics - in the case of this Chapter, for climate change impacts. Schedule 4 to the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 specifies the information that must be included in an Environmental Statement (ES).

National level policy

National Policy Statement for National Networks

7.3.3 The primary basis for the Secretary of State deciding whether or not to grant a Development Consent Order (DCO) for the Project is the *National Policy Statement for National Networks (NPSNN)* (Department for Transport, 2014)[2].

7.3.4 Table 7-2: Relevant *NPSNN* policies identifies the *NPSNN* policies relevant to the Climate assessment and a reference to where in this ES information is provided to address each policy.

[2] Department for Transport (2014) National Policy Statement for National Networks

Table 7-2: Relevant *NPSNN* policies

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
Climate Change Adaptation			
4.40	Applicants must consider the impacts of climate change when planning location, design, build and operation. Any accompanying environmental statement should set out how the proposal will take account of the Projected impacts of climate change.	This is considered in the Climate Change Resilience (CCR) assessment.	Chapter 7: Climate (climate change resilience sections)
4.41	Where transport infrastructure has safety-critical elements and the design life of the asset is 60 years or greater, the applicant should apply the UK Climate Projections 2009 (*UKCP09*[3]) high emissions scenario (high impact, low likelihood) against the 2080 projections at the 50% probability level.	This is considered by assessing project design assets over a 60-year appraisal period using the latest climate change projections (*UKCP18*, RCP8.5) for the 2080s in the CCR assessment.	Section 7.8: Baseline conditions Section 7.11: Assessment of likely significant effects
4.42	The applicant should take into account the potential impacts of climate change using the latest UK Climate Projections available at the time and ensure any environment statement that is prepared identifies appropriate mitigation or adaptation measures. This should cover the estimated lifetime of the new infrastructure.	This is considered by using the latest climate change projections (*UKCP18*, RCP8.5), over a 60-year appraisal period (predicted lifetime of the new infrastructure) in the CCR assessment. The CCR assessment also identifies embedded mitigation/adaptation within the proposed design as well as identifying potential additional mitigation measures required to address impacts identified by the CCR assessment.	Section 7.8: Baseline conditions Section 7.11: Assessment of likely significant effects

[3] Since the *NPSNN* was published, the latest climate change projections have been updated to *UKCP18*, published in 2018. This assessment therefore uses these latest climate projections (*UKCP18*, RCP8.5 over 60 years).

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
4.43	The applicant should demonstrate that there are no critical features of the design of new national networks infrastructure which may be seriously affected by more radical changes to the climate beyond that projected in the latest set of UK climate projections. Any potential critical features should be assessed taking account of the latest credible scientific evidence on, for example, sea level rise and on the basis that necessary action can be taken to ensure the operation of the infrastructure over its estimated lifetime through potential further mitigation or adaptation.	This is considered by using the H++ scenarios within the CCR assessment, as outlined in *DMRB LA 114*.	Section 7.8: Baseline conditions Section 7.11: Assessment of likely significant effects
4.44	Any adaptation measures should be based on the latest set of UK Climate Projections, the Government's national Climate Change Risk Assessment and consultation with statutory consultation bodies. Any adaptation measures must themselves also be assessed as part of any environmental impact assessment and included in the environment statement, which should set out how and where such measures are proposed to be secured.	This is considered by using the latest climate change projections (*UKCP18*, RCP8.5), over a 60-year appraisal period (predicted lifetime of the new infrastructure) in the CCR assessment. The CCR assessment assesses the environmental impact of any embedded mitigation (adaptation) within the design (i.e. the Order Limits). The CCR assessment also identifies proposed additional mitigation where impacts are identified through the assessment. This mitigation also has the potential to cause environmental impacts, which is described within section 7.10: Essential mitigation and enhancement measures of this chapter.	Section 7.8: Baseline conditions Section 7.10: Essential mitigation and enhancement measures
Carbon Emissions			

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
5.17	Carbon impacts will be considered as part of the appraisal of scheme options (in the business case), prior to the submission of an application for DCO. Where the development is subject to EIA, any Environmental Statement will need to describe an assessment of any likely significant climate factors in accordance with the requirements in the EIA Directive. It is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets. However, for road projects applicants should provide evidence of the carbon impact of the Project and an assessment against the Government's carbon budgets.	Carbon impacts are a consideration in the appraisal of options within the business case for the Project, but that is not reported within this ES. GHG emissions associated with the construction and operation of the Project have been assessed as part of the GHG emissions assessment within this Climate chapter. An assessment of likely significant effects is made by comparing project emissions with the relevant UK Government carbon budgets (up to the Sixth Carbon Budget (2033-2037), which is the Carbon Budget furthest most in the future available for comparison). As per *NPSNN* and the requirement of *DMRB LA 114*, the GHG emissions assessment concludes no likely significant effect, as the *DMRB LA 114* states: *"assessment of projects on climate shall only report significant effects where increases in GHG emissions will have a material impact on the ability of Government to meet its carbon reduction targets"*.	Section 7.8: Baseline conditions Section 7.11: Assessment of likely significant effects
5.18	Any increase in carbon emissions is not a reason to refuse development consent, unless the increase in carbon emissions resulting from the proposed scheme is so significant that it would have a material impact on the ability of Government to meet its carbon reduction targets.	In line with *DMRB LA 114* and the *NPSNN*, GHG emissions associated with the construction and operation of the Project have been assessed in isolation in the GHG emissions assessment. An assessment of likely significant effect is made by comparing project emissions with the relevant UK Government carbon budgets (up to the Sixth Carbon Budget (2033-2037), which is the Carbon Budget furthest most in the future available for comparison). In addition, as per *DMRB LA 114*, GHG emissions associated with the Project have been benchmarked against other road projects as a comparison of project performance against other similar projects. As per *NPSNN* and the requirement	Section 7.11: Assessment of likely significant effects

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
		of *DMRB LA 114*, the GHG emissions assessment concludes no likely significant effect, as the *DMRB LA 114* states: *"assessment of projects on climate shall only report significant effects where increases in GHG emissions will have a material impact on the ability of Government to meet its carbon reduction targets".*	
5.19	Evidence of appropriate mitigation measures (incorporating engineering plans on configuration and layout and use of materials) in both design and construction should be presented.	Mitigation measures to address GHG emissions associated with the construction and operation of the Project are set out within this Climate Chapter and the Environmental Management Plan (EMP). Mitigation relating to construction activities will also be contained within the EMP (as referenced in this chapter). Further information/evidence should also be available through engineering plans submitted as part of the DCO application.	Section 7.10: Essential mitigation and enhancement measures and Environmental Management Plan (Application Document 2.7)

National Planning Policy Framework

7.3.5 The *National Planning Policy Framework (NPPF)* (Ministry of Housing, Communities & Local Government, 2021)[4], sets out the Government's planning policies for England and provides a framework within which locally prepared plans can be produced and applications for planning permission can be assessed. The *NPPF* is "*an important and relevant consideration in decisions on nationally significant infrastructure projects, but only to the extent relevant to that project*".

7.3.6 Chapter 14 ('Meeting the challenge of climate change, flooding and coastal change'), requires local authorities to adopt proactive strategies to mitigate and adapt to climate change in line with the objectives and provisions of the Climate Change Act 2008 and taking into account water supply, flood risk, biodiversity and landscapes, the risk of overheating and coastal change.

7.3.7 Within the chapter it states: *"The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure."*

Regional and local level policy

7.3.8 Other regional and local level policies have been considered as part of the Climate assessment where these have informed the identification of receptors and resources and their sensitivity; the assessment methodology; the potential for likely significant environmental effects; and required mitigation. These policies include:

- Eden District Council, *Eden Local Plan 2014-2032* (Eden District Council, 2018)[5]
- Eden District Council, *Zero Carbon Eden Strategy* (Eden District Council, 2019)[6]
- *Eden Level 1 Strategic Flood Risk Assessment* (Eden District Council, 2020)[7]
- *County Durham Plan* 2020-2035 (County Durham, 2020)[8]
- Durham County Council *Climate Emergency (*Durham County Council, 2019)[9]
- Durham County Council *Climate Emergency Response Plan* (2020-2022) (Durham County Council, 2020)[10]

[4] Ministry of Housing, Communities & Local Government (2021) National Planning Policy Framework
[5] Eden District Council (2018) Adopted Eden Local Plan (2014 to 2032)
[6] Eden District Council (2019), Zero Carbon Eden Strategy
[7] Eden District Council (2020) Eden Level 1 Strategic Flood Risk Assessment
[8] Durham County Council (2020) County Durham Plan
[9] Durham County Council (2019) Climate emergency
[10] Durham County Council (2020) Climate Emergency Response Plan.]

- Durham County Council Level 1 *Strategic Flood Risk Assessment* (Durham County Council, 2018)[11]
- Richmondshire District Council *Local Plan 2012-2028* Core Strategy (Richmondshire District Council, 2014)[12]
- Richmondshire District Council Environment and Climate Emergency Declaration (Richmondshire District Council, 2019, updated in 2021)[13]
- North West Yorkshire Level 1 Strategic Flood Risk Assessment (SFRA) Update (Harrogate Borough Council, Craven District Council and Richmondshire District Council, 2010)[14]
- Cumbria County Council *Carbon Management Strategy 2020-2025* (Cumbria County Council, 2020)[15]

Other Relevant Policy and Guidance

7.3.9 The following Policy and guidance are also considered relevant to the assessment.

Impact of the Project on Climate (GHG emissions assessment)

- *DMRB LA 114*: provides the requirements for assessment and reporting the effect on climate of greenhouse gas from construction, operation and maintenance of National Highways projects.
- *DMRB LA 105 Air Quality (DMRB LA 105)* (National Highways, 2019b)[16]: provides the calculation method for regional emissions from vehicles that use the road network.
- *DMRB GG 103 Introduction and general requirements for sustainable development and design (DMRB GG 103)* (National Highways, 2019c)[17]: outlines the general requirements for sustainable development and design to be aligned with designing motorways and all-purpose trunk roads.
- *Transport Appraisal Guidance (TAG) Unit A3 Environmental Impact Appraisal, Chapter 4 Greenhouse Gases* (Department for Transport, 2021a)[18]: provides the methodology for consistent and transparent reporting of GHG emissions resulting from road users in operation.
- The *Road Investment Strategy 2 (RIS2)* (Department for Transport, 2020a)[19]: the five-year strategy for investment in and management of the strategic road network until 2025.

[11] Durham County Council (2018) Strategic Flood Risk Assessment
[12] Richmondshire District Council (2014) Local Plan 2012-2028
[13] Richmondshire District Council (2019) Our climate emergency declaration
[14] Harrogate Borough Council, Craven District Council and Richmondshire District Council (2010) North West Yorkshire Level 1 SFRA Update
[15] Cumbria County Council (2020) Carbon Management Strategy 2020-2025 (Corporate Estate) 2020-2025
[16] National Highways (2019b) *DMRB LA 105* Air Quality
[17] National Highways (2019c) *DMRB LA GG 103* Introduction and general requirements for sustainable development and design
[18] Department for Transport (2021a) TAG Unit A3: Environmental Impact Appraisal, Chapter 4 Greenhouse Gases
[19] Department for Transport (2020a) Road Investment Strategy 2

- *Decarbonising Transport: Setting the Challenge* (Department for Transport, 2020b)[20]: a policy paper stating the current challenges and steps to be taken to develop a national transport decarbonisation plan
- The *Transport Decarbonisation Plan* (Department for Transport, 2021b)[21]: sets out the current challenges and steps to be taken to decarbonise transport, outlining six strategic priorities to deliver a vision of a net zero transport system.
- *Net Zero Highways: our 2030 / 2040 / 2050 plan* (National Highways, 2021)[22]: sets out National Highways' commitments to net zero, for corporate emissions (net zero by 2030), maintenance and construction emissions (net zero by 2040) and road user emissions (net zero by 2050).
- *Highways England Licence* (Department for Transport, 2015)[23]: Provides directions and guidance from the Department for Transport. Directs the license holder to account for carbon emissions into design decisions and minimise carbon emissions from its operations.
- *Publicly Available Specification (PAS) 2080*: 2016 Carbon Management in Infrastructure: a global standard for managing infrastructure carbon (British Standards Institute, 2016)[24].
- *The Clean Growth Strategy* (Department for Business, Energy & Industrial Strategy, 2017)[25]: a plan for meeting the legislated carbon budgets, including a key policy to accelerate the shift to low carbon transport.
- *Road to Zero Strategy* (Office for Low Emission Vehicles & Office for Zero Emission Vehicles, 2018)[26]: a forward-looking route map of the steps required to decarbonise and electrify road transport in line with UK Government's Industrial Strategy.
- *A Green Future: Our 25 Year Plan to Improve the Environment* (Department for Environment, Food & Rural Affairs, 2018)[27]: sets goals and targets for improving the environment for the next 25 years, with goal 7 on 'mitigating and adapting to climate change'.
- The Institute of Environmental Management and Assessment (IEMA) *Institute of Environmental Management & Assessment Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance* (Institute of Environmental Management and Assessment, 2021c)28 provides an approach to undertaking assessment of GHG emissions within the EIA process in the UK.

[20] Department for Transport (2020b) Decarbonising Transport: Setting the Challenge
[21] Department for Transport (2021b) Decarbonising transport: a better, greener Britain,
[22] National Highways (2021) Net zero highways: our 2030 / 2040 / 2050 plan,
[23] Department for Transport (2015) Highways England: Licence
[24] British Standards Institute (2016) PAS 2080:2016 Carbon Management in Infrastructure
[25] Department for Business, Energy & Industrial Strategy (2017) The Clean Growth Strategy Leading the way to a low carbon future
[26] Office for Low Emission Vehicles & Office for Zero Emission Vehicles (2018) Road to Zero Strategy
[27] Department for Environment, Food & Rural Affairs (2018) A Green Future: Our 25 Year Plan to Improve the Environment
[28] The Institute of Environmental Management and Assessment (2021) Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance

Vulnerability of the Project to climate change (CCR Assessment)

- *Highways England Licence*: provides directions and guidance from the Department for Transport. It directs the license holder to adapt its network to operate in a changing climate and manage/mitigate risks posed by climate change to operation, maintenance, and improvement of the network.
- *Preparing for climate change on the strategic road network* (National Highways, 2022)[29]: the key climate risks to the strategic road network and the action that National Highways is taking to adapt to climate change and address these risks.
- *Climate Adaptation Risk Assessment Progress Update* (National Highways, 2016)30: National Highways' report to satisfy the requirement of the Climate Change Act 2008, to report on climate risks and provide their proposals for adapting to climate change.
- *Climate Change: second national adaptation programme 2018-2023* (Department for Environment Food & Rural Affairs, 2018)[31]: the 5-year strategy that sets out the Government's priorities to adapt to the challenges of climate change in the UK.
- *UK Climate Change Risk Assessment* (UK Climate Risk, 2021)[32]: an independent assessment of the risks and opportunities facing the UK from climate change, an update from the second national adaptation programme 2018-2023.
- *UK Climate Risk Assessment 2022* (Department for Environment Food & Rural Affairs, 2022)[33]: sets out the UK Government and devolved administrations' position on key climate change risks and opportunities in the UK.
- The Environment Agency *Flood risk assessments: climate change allowances* (Environment Agency, 2021)[34]: UK Government guidance detailing the predicted changes in peak river flow, peak rainfall intensity, sea level rise, offshore wind speed and extreme wave height until 2100.
- *A Green Future: Our 25 Year Plan to Improve the Environment* (Department for Environment, Food & Rural Affairs, 2018)[35]: sets goals and targets for the next 25 years, with goal 7 on 'mitigating and adapting to climate change'.
- *DMRB LA 114*: provides the methodology for assessment and reporting the effects of climate on National Highways projects (climate change resilience and adaptation).

[29] National Highways (2022) Preparing for climate change on the strategic road network
[30] National Highways (2016) Climate Adaptation Risk Assessment Progress Update
[31] Department for Environment Food & Rural Affairs (2018) Climate change: second national adaptation programme (2018 to 2023)
[32] UK Climate Risk (2021) Independent Assessment of UK Climate Risk (CCRA3),
[33] Department for Environment Food & Rural Affairs (2022) UK Climate Change Risk Assessment 2022
[34] The Environment Agency (2021) Flood risk assessments: climate change allowances
[35] Department for Environment, Food & Rural Affairs (2018) A Green Future: Our 25 Year Plan to Improve the Environment

- *DMRB GG 103*: outlines the general requirements for sustainable development and design to be aligned with designing motorways and all-purpose trunk roads.
- The *Road Investment Strategy 2 (RIS2)*: the five-year strategy for investment in and management of the strategic road network until 2025.
- The Institute of Environmental Management and Assessment (IEMA) *Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation* (Institute of Environmental Management and Assessment, 2020)[36]: provides an approach to undertaking assessments of climate change resilience within the EIA process in the UK.
- *Preparing for Climate Change: A Climate Change Adaptation Strategy* (Ministry of Justice, 2020)[37]: building on the UK Government's 25 Year Environment Plan, this strategy sets out actions to address the effects of climate change that are already being observed or anticipated.

7.4 Assessment methodology

7.4.1 The methodology for the Climate assessment follows the guidance set out within *DMRB LA 114*.

7.4.2 Aligned with the requirements of *DMRB LA 114*, this assessment covers two assessments, on the:

- Impact of the Project on climate (GHG emissions assessment) - impacts on climate from carbon emissions arising from the Project, including whether the Project may affect the ability of the UK Government to meet its carbon reduction targets (in accordance with the *NPSNN*).
- Vulnerability of the Project to climate change (CCR assessment) - the ability of the Project to operate as intended despite climate change impacts and associated weather effects, including how the Project will take account of the Projected climate change (in accordance with *NPSNN* and the Infrastructure Planning (EIA) Regulations 2017).

7.4.3 In accordance with *DMRB LA 114*, *"Early engagement between design engineers and environmental assessment professionals is the most effective way of eliminating and reducing impacts on the project from climate, thereby reducing the need for additional / subsequent design and mitigation measures."* Details of this engagement can be found in the Project Development Overview Report (Application Document 4.1), the appended Route Development Report and the Project Design Principles (Application Document 5.11). These documents provide the approach to design development and collaboration and demonstrate there has been early and on-going engagement throughout the development of the Project between stakeholders, engineering design team and environmental disciplines to incorporate appropriate climate

[36] The Institute of Environmental Management and Assessment (2020) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation.]
[37] Ministry of Justice (2020) Preparing for Climate Change: A Climate Change Adaptation Strategy.]

mitigation measures into the design as it has evolved. Further details can be found in section 7.10: Essential mitigation and enhancement measures.

7.4.4 Additional sources of guidance on the assessment of Climate are those produced by the IEMA for both GHG assessment (IEMA, 2021c), and CCR/ICCI assessment (IEMA 2020). Both documents provide guidance on appropriate methods and standards for assessing the scale of impacts and also on determining the significance of those impacts. This IEMA guidance is largely in accordance with D*MRB LA 114* with regards to GHG emissions assessment methodology and the importance of mitigation. It also notes that a spatial approach to a cumulative assessment for GHG emissions is not appropriate. The climate assessment against carbon budgets in the ES, and the mitigation presented which seeks to minimise GHGs, follows *DMRB LA 114* and therefore broadly aligns with IEMA guidance. The IEMA guidance does differ from *DMRB LA 114* in the assessment of significance. It is considered that *DMRB LA 114* is more aligned with current policy (i.e. the *NPSNN*) given that it requires significance to be considered in the context of national carbon budget setting, and the likely impact of the project on the achievement of national carbon budgets. On this basis the approach adopted in this ES to the assessment of significance aligns with that specified within *DMRB LA 114*, rather than adopting the guidance approach proposed by IEMA. In all other aspects of both GHG and CCR/ICCI assessments the approach adopted follows *DMRB LA 114*, which in turn aligns on most pertinent issues with the guidance developed by IEMA.

7.5 Scoping

7.5.1 Table 7-3: Summary of scoping opinion and response sets out the key points from the Planning Inspectorate (PINS) Scoping Opinion relevant to the Climate assessment. The full Scoping Opinion is provided in ES Appendix 4.2: EIA Scoping Opinion (Application Document 3.4).

7.5.2 Where assessment has been undertaken in accordance with the Scoping Opinion, the wording of each point raised, with a response and reference to the relevant ES section, is provided. Where further discussion and/or an alternative approach has been agreed with the relevant stakeholders and the Planning Inspectorate, an explanation is provided.

Table 7-3: Summary of scoping opinion and response

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
PINS	Vulnerability to climate change during construction: Although paragraph 8.9.11, Table 8-12 and footnote 99 seek to scope out vulnerability to climate change during construction, paragraph 8.6.6 of the Scoping Report explains that “climate change is expected to lead to changes in temperature and weather patterns which have the potential to impact on the construction of the Project...The construction period is currently proposed to take place between 2024 and 2029 and could be effected by both summer and winter related climate change impacts”. Whilst the Inspectorate acknowledges the relatively limited duration of the construction period, the Applicant also states that “extreme weather events are a feature of the baseline climate and projected climate at the time of construction”, and that “the EMP would be prepared by the appointed contractor and implemented during the construction period to address vulnerability to climate impacts”. As detail of the EMP is not yet defined by way of mitigating potential effects of vulnerability to climate change during construction, the Inspectorate does not agree that matter can be scoped out at this stage.	The purpose of the CCR assessment is to "identify whether anticipated changing climate conditions and weather events are likely to have significant adverse effects on the Project" (*DMRB LA 114*). The CCR assessment within the ES does not scope out the assessment of vulnerability from climate change during construction. However, the *UKCP18* climate projections for the 2020s (construction period) suggest that, whilst the climate will have changed by the construction period, it is not considered that climate change will significantly increase the vulnerability of the Project to climatic impacts during the construction period. Therefore, the detailed CCR assessment only covers the operational phase of the Project. Extreme events are a feature of the baseline climate, however, and the EMP sets out specific measures for the Project that the Principal Contractor(s) (PC) will employ in order to provide resilience to extreme weather during construction, which builds on existing	Section 7.4: Assessment methodology - Vulnerability of the Project to climate change (CCR assessment)

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
		National Highways standard construction processes.	
PINS	Baseline Conditions Table 8-5 provides baseline conditions of the climate characteristics for the north west and north east regions but does not specify which sections of the Proposed Development the east and west regions relate to. The ES should relate the described baseline conditions to the relevant sections of the Proposed Development. Additionally, the descriptions are more detailed for the north west region than for the north east. The baseline conditions should be sufficiently and consistently detailed across all the sections of the Proposed Development.	Section 7.8: Baseline conditions specifies which schemes of the Project the north east and north west climatologies relate to. The descriptions provided for each region are appropriately detailed. In some cases, the descriptions for the North West region appears to be more detailed because the North East region refers to North West description where relevant to avoid duplication of text.	Section 7.7: Baseline conditions - Vulnerability of the Project to climate change (CCR assessment)
PINS	Climate Change Projections The EA's climate change projections have been updated in July 2021. The appropriate and most up to date climate change projections should be applied to the assessments in the ES for the Proposed Development. The application of climate change projections should be justified, for example, flood risk projections should be applied using criteria set out by the Environment Agency (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances)	The Flood Risk Assessment (FRA), which is reported in ES Chapter 14: Road Drainage and the Water Environment, incorporates the updated Environment Agency climate change allowances for increases in rainfall intensity and peak river flow that were published in July 2021. The CCR assessment used the latest climate change projections (*UKCP18*, RCP8.5), over a 60-year appraisal period as required by *DMRB LA 114*.	Section 7.4: Assessment methodology - Vulnerability of the Project to climate change (CCR assessment) - Identification of climate hazards and risks FRA within ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)
PINS	Climate change delays Scoping Report paragraph 8.6.6 identifies that extreme weather events may result in a disruption of supply materials and potentially cause delays. This may have a	Extreme events are a feature of the baseline climate and could cause disruption to the supply of materials during construction.	Section 7.4: Assessment methodology - Vulnerability of the Project to climate change

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
	knock-on effect on the construction programme and should be considered when applying worst-case scenarios.	The EMP sets out the requirement of measures for the Project that the contractor will employ in order to provide resilience to extreme weather during construction, which builds on existing National Highways standard construction processes.	(CCR assessment) - Scope of the assessment
PINS	Scoping Report paragraphs 8.6.8 to 8.6.11 only describe some of the impacts set out in Table 8-10 but it is not made clear whether only some or all of the impacts set out in the Table will be assessed in the ES. The ES should provide an assessment of the impacts set out in Table 8-10 where significant effects are likely to occur.	The detailed CCR assessment is provided in this chapter and Appendix 7.2 CCR Assessment (Application Document 3.4).	Potential CCR impacts are presented in section 7.9: Potential impacts and section 7.11: Assessment of likely significant effects and in Appendix 7.2: CCR Assessment (Application Document 3.4)
Cumbria County Council	Assessment approach could be strengthened through to adoption of IEMA guidance for assessing the significance of greenhouse gas emissions.	The relevance of IEMA guidance on GHG assessment is set out in the Methodology section within section 7.4: Assessment methodology.	Section 7.11: Assessment of likely significant effects
Cumbria County Council	ES should include potential sources of GHG emissions using PAS 2080 lifecycle stages and provides justification for which lifecycle stages are scoped in or out for further assessment.	Typical emissions sources by lifecycle stage (using PAS 2080) are set out in *DMRB LA 114* and are reflected in Table 7-16: Potential sources of GHG emissions during construction and Table 7-17: Potential sources of GHG emissions during operation.	Table 7-16: Potential sources of GHG emissions during construction and Table 7-17: Potential sources of GHG emissions during operation.
East and West Layton and Carkin Parish Council Meeting	We note at paragraph 8.7.2 the quote “Projects shall seek to minimise GHG emissions in all cases to contribute to the UK’s target for net reduction in carbon emissions”. See our opening general comments. Whereas there is support for making the existing road safe, the current	The approach to design is set out in Case for the Project (Application Document 2.2), Project Design Principles (Application Document 2.3), Chapter 2: The Project and the traffic	Case for the Project (Application Document 2.2), Project Design Principles (Application Document 2.3) and Chapter 2: The Project.

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
	designs are over-engineered for the solution required and will encourage increase in traffic	model as explained in the Combined Modelling and Appraisal Report (Application Document 3.8).	
East and West Layton and Carkin Parish Council Meeting	We note at paragraph 8.9.1 that no assessment was taken at option selection which is a significant omission as the assessment would have been important to local views and their responses to consultation.	The information presented at statutory consultation in the Preliminary Environmental Information (PEI) Report has provided an opportunity for consultation to be sought from local stakeholders and where relevant and appropriate has been integrated into the Climate assessment.	Section 7.4: Assessment methodology
East and West Layton and Carkin Parish Council Meeting	The scoping report will need to take into account how the Project meets UK Government and local authority climate change plans and if it does not facilitate these, be designed in a way to minimise increase in emissions.	The assessment considers the impacts of the Project in the context of national carbon budgets (for GHG assessment) and in the context of local climate conditions (for the CCR assessment). The assessment also sets out mitigation that has been incorporated into the design and proposed for construction to minimise emissions.	Section 7.4: Assessment methodology
East and West Layton and Carkin Parish Council Meeting	The proposed development at Scotch Corner will have a consequential impact on local road use and this needs to be taken into account and mitigated.	The modelling used within the GHG assessment is the traffic model for the Project as a whole and incorporates changes in traffic levels on the surrounding road network as explained in the Combined Modelling and Appraisal Report (Application Document 3.8).	Already incorporated into the GHG assessment methodology (section 7.4: Assessment methodology).

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
East and West Layton and Carkin Parish Council Meeting	Hoping that electric cars will solve the problem is wishful thinking, given that proposals for phasing out petrol/diesel cars do not cover HGVs etc.	Assumptions on future uptake of electric vehicles are included in the assessment as specified in section 7.4: Assessment methodology.	Already incorporated into the GHG assessment methodology (section 7.4: Assessment methodology).
East and West Layton and Carkin Parish Council Meeting	Paragraphs 8.6.3 on in respect of emissions needs to take into account the above development.	The "development" referred to is unclear in the consultation submission. However, it should be noted that the GHG assessment incorporates (via use of the traffic model) other consented developments impacting upon the road network.	Already incorporated into the GHG assessment methodology (section 7.4: Assessment methodology).
East and West Layton and Carkin Parish Council Meeting	The options for mitigation do not sufficiently address road use: the suggestion at paragraph 8.7.7 is woefully insufficient.	Opportunities to mitigate emissions from road users by way of Project design, or implementation of specific measures, are limited. The primary approach to managing these emissions is through the wider work of National Highways (via the Net zero highways 2030 / 2040 / 2050 plan) and national Government (through the setting of carbon budgets and the Transport Decarbonisation Plan).	The climate assessment concludes that GHG emissions are not significant and, as explained above, the opportunity to deliver mitigation measures at a Project level is limited. The responsibilities and opportunities for delivering decarbonisation of road users is required at a policy scale greater than that at which the Project is being delivered, and is therefore addressed via UK Government and National Highways decarbonisation strategies/commitments.
East and West Layton and Carkin Parish	We note that Richmondshire District Council responded to offer files relating to flooding. They should also be asked to respond in terms of how the development at Scotch	The traffic modelling includes all relevant planned projects, including those which are not constructed but are	Combined Modelling and Appraisal Report

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
Council Meeting	Corner will impact climate policy and change and consequential impact on road use through this section, particularly given their recent approval of another extension to the retail park development at Scotch Corner to allow a large new garden centre.	consented. The Scotch Corner retail development is included.	
Durham County Council	Officers query what modelling has been done that includes the impact of electrification on traffic levels, especially over such routes. The Project raises concerns given the level of GHG emissions associated with its construction and operation, but no adverse comments on the scoping are raised.	Assumptions on future uptake of electric vehicles are included in the assessment as specified in section7.4: Assessment methodology. The aggregate levels of GHG emissions from construction and operation are addressed within the assessment.	Already incorporated into the GHG assessment methodology (section 7.4: Assessment methodology).
Cumbria County Council / Eden District Council	Recommended that the study area is extended (such as up to 1km beyond the draft DCO boundary) to encompass any potential climate risks which may impact on both the Project and the immediate wider environment	The study area has been specified in line with *DMRB LA 114* (paragraph 3.25) which states: *"The study area for assessing a project's vulnerability to climate change shall be based on the construction footprint/project boundary (including compounds and temporary land take)."*	Section 7.7: Study area
Cumbria County Council / Eden District Council	Should consider the potential for melting and/or deterioration of road surface as a result of increased temperatures and prolonged periods of hot weather. This is currently omitted from Table 8-10 of the Scoping Report.	This risk is assessed within the detailed CCR assessment provided in this ES.	Potential CCR impacts are presented in section 7.9: Potential impacts, section 7.11: Assessment of likely significant effects and in Appendix 7.2: CCR Assessment (Application Document 3.4).
Cumbria County	The potential impacts section of the Scoping Report does not identify any potential in-combination climate impacts (the extent to which climate exacerbates	In-combination impacts are assessed within the individual environmental topic chapters.	Addressed within individual topic chapters (Chapter 5: Air Quality, Chapter 6:

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
Council / Eden District Council	or ameliorates the effects of the Project on the environment).		Biodiversity, Chapter 8: Cultural Heritage to Chapter 14: Road Drainage and the Water Environment).
Cumbria County Council / Eden District Council	It is noted in the Scoping Report (8.1.4) that climate change has the potential to influence impacts considered under other discipline topics, and each discipline chapter will consider the potential for climate to influence the impacts identified. The discipline chapters listed do not at present provide such consideration. Therefore, to comply with the IEMA guidance and good practice the ES should consider in-combination climate impacts.	In-combination impacts, aligning with IEMA's Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation, are assessed within the individual environmental topic chapters.	Addressed within individual topic chapters (Chapter 5: Air Quality, Chapter 6: Biodiversity, Chapter 8: Cultural Heritage -Chapter 14: Road Drainage and the Water Environment).
Cumbria County Council / Eden District Council	It is noted that a detailed assessment of mitigation and enhancement measures, including resilience measures embedded within the design and additional to the design, was not undertaken within the Scoping Report and this should be included within the ES provided on the climate.	The mitigation measures embedded within the design have been identified and assessed as part of the detailed CCR assessment provided in this ES.	Section 7.10: Essential mitigation and enhancement measures, section 7.11: Assessment of likely significant effects and Appendix 7.2: CCR Assessment (Application Document 3.4).
Cumbria County Council / Eden District Council	No likely significant effects have been identified for the construction stage due to its duration. It is identified that an EMP will include adaptation measures in relation to extreme weather events during the construction stage. The assessment within the ES should provide details of such measures as a minimum and set out, with clarity on the measures themselves, as well as roles and responsibilities and a commentary on the status of the planned EMP.	The CCR assessment has not been taken forward for detailed assessment for construction stage as it is not considered likely that climate related risks will be significantly greater than those risks present for construction schemes in the current climate. The EMP includes a range of measures intended to address risks from weather events appropriate for the expected construction period.	Addressed within the EMP (Application Document 2.7).

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
Cumbria County Council / Eden District Council	The significance of impacts during the operation stage is outlined to be determined by a combination of likelihood and consequence as set out in DMRB LA114 Climate. It is concluded that there is potential for some receptors to be adversely affected by climate change however it is not clear how this conclusion has been reached as no assessment of likelihood and consequence is presented. The ES should clarify the likelihood and consequence of such impacts and as such, the conclusion of likely significant effects.	The detailed CCR assessment is provided in this ES.	Potential Impacts are presented in section 7.9: Potential impacts, section 7.11: Assessment of likely significant effects and in Appendix 7.2: CCR Assessment (Application Document 3.4).
Cumbria County Council / Eden District Council	We do not agree with the statement on their being limited guidance relating to undertaking climate change resilience assessments in EIA (paragraph 8.10.7). IEMA's EIA Guide to Climate Change Resilience and Adaptation in conjunction with *DMRB LA 114* should be followed to undertake the next stage of assessment in accordance with good practice.	It is acknowledged that the phrasing of this point was poor in the Scoping Report. The existence of guidance on the assessment approach is noted and has been relied upon in producing this CCR assessment, but the assertion remains that there is little public guidance on the assessment of likelihood and consequence of specific climate risks.	Section 7.4: Assessment methodology
Cumbria County Council / Eden District Council	The scoped in emissions sources are considered to be appropriate for the size and nature of the Project to determine overall emissions. Although reference is made to PAS 2080, Table 8-10 of the Environmental Scoping Report does not make reference to PAS 2080 when outlining emissions sources. It is recommended that the ES includes the potential sources of GHG emissions associated with the Project using the PAS 2080 lifecycle stages and provides justification for which lifecycle stages are scoped in or out for further assessment.	Typical emissions sources by lifecycle stage (using PAS 2080) are set out in *DMRB LA 114* and are reflected in Table 7-16: Potential sources of GHG emissions during construction and Table 7-17: Potential sources of GHG emissions during operation.	Table 7-16: Potential sources of GHG emissions during construction and Table 7-17: Potential sources of GHG emissions during operation.

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
Cumbria County Council / Eden District Council	The mitigation measures identified are considered appropriate for the scoping stage. It is recommended that specific mitigation measures are identified at the ES stage depending on the outcome of the assessment	Noted.	Mitigation measures are set out in section 7.10: Essential mitigation and enhancement measures.
Cumbria County Council / Eden District Council	There is no reference to the best practice guidance document, Institute of Environmental Management and Assessment (IEMA) EIA Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance. Although the Environmental Scoping Report states that emissions will be assessed in line with *DMRB LA 114*, it is requested that the ES should refer to the IEMA guidance, acknowledging that all GHG emissions are considered significant.	The relevance of IEMA guidance on GHG assessment is set out in the Methodology section within section 7.4: Assessment methodology.	Section 7.11: Assessment of likely significant effects
Cumbria County Council / Eden District Council	The assessment methodology is in line with *DMRB LA 114* and is considered acceptable. It is however, worth noting that since this report was published the sixth carbon budget has been released by the Climate Change Committee (CCC). The ES should therefore contextualise GHG emissions from the Project against the sixth carbon budget.	Noted, this Chapter assesses GHG emissions against all published carbon budgets including against the sixth carbon budget.	The Sixth Carbon Budget is reflected in section 7.3: Legislation and policy framework and in the assessment of significance within section 7.11: Assessment of likely significant effects.

Consultation

7.5.3 Consultation on the PEI Report resulted in a significant number of comments relating to the Climate Change assessment and the predicted climate change effects.

7.5.4 Table 7-4: Summary of key consultation comments received sets out the key themes to the responses received where they relate to the assessment methodology and approach, and how these have been addressed in the assessment presented in this ES. The full detail of all responses, and information regarding how the Project has responded to the consultation responses can be found in the Consultation Report (Application Document 4.4).

Table 7-4: Summary of key consultation comments received

Consultee/ respondent	Comment	Applicant response	Where addressed?
Cumbria County Council	Need for appropriate mitigation of GHG emissions and opportunity for engagement with Local Authorities to support development of this mitigation.	Mitigation embedded in the design is set out in the ES and additional mitigation for construction and operation will continue to be developed through subsequent project stages. This will include liaison with relevant stakeholders.	Section 7.10: Essential mitigation and enhancement measures
Cumbria County Council Eden District Council	ES should detail emissions sources in line with PAS 2080 lifecycle stages and provide clarity on any emissions scoped out of the assessment	Typical emissions sources by lifecycle stage (using PAS 2080) are set out in *DMRB LA 114* and are reflected in Table 7-16: Potential sources of GHG emissions during construction and Table 7-17: Potential sources of GHG emissions during operation.	Table 7-16: Potential sources of GHG emissions during construction and Table 7-17: Potential sources of GHG emissions during operation.
Cumbria County Council Eden District Council	CCR assessment should include local weather station data in the baseline	*DMRB LA 114* states "*The assessment of a project's vulnerability to climate change shall use published historical regional weather data to demonstrate the current climate impacts on a study area."* It is not considered that presenting finer detailed local weather station data within the climate assessment would enhance the assessment. This is as, although the information may provide additional background information, it is the future climate projections that are used in the methodology to make an assessment of climate change resilience.	Section 7.8: Baseline conditions

Consultee/ respondent	Comment	Applicant response	Where addressed?
Cumbria County Council Eden District Council	Use of IEMA Guidance for GHG Assessment and Evaluation of Significance	The relevance of IEMA guidance on GHG assessment is set out in the Methodology section within section 7.4: Assessment methodology.	Section 7.11: Assessment of likely significant effects
Eden District Council	Recognition of local declaration of Climate Emergency	The assessment is based on *DMRB LA 114* and considers the assessment of significance in the context of that methodology and the direction from the *NNPSNN*.	Section 7.11: Assessment of likely significant effects
Cumbria County Council Eden District Council	Use of IEMA Guidance for CCR Assessment	This guidance has been used to inform the CCR approach.	Section 7.11: Assessment of likely significant effects
Eden District Council	Provide breakdown of embodied GHG emissions for construction to facilitate design mitigation	Results are presented in the ES and appendices at the level of detail congruent with the assessment methodology.	Section 7.11: Assessment of likely significant effects and Appendix 7.1: GHG Assessment (Application Document 3.4)
Cumbria County Council	Propose extension of the CCR boundary beyond the DCO boundary	The study area has been specified in line with *DMRB LA 114*.	Section 7.7: Study area
Cumbria County Council	ES should capture topic mitigation measures that may impact the CCR and require additional climate mitigation.	The CCR resilience of mitigation measures from other topics have been reviewed and assessed as part of the ES.	Section 7.10: Essential mitigation and enhancement measures

Consultee/ respondent	Comment	Applicant response	Where addressed?
Cumbria County Council	Embedded and additional CCR mitigation should be reviewed to align with any changes to Project design	Mitigation measures have been reviewed to reflect the emerging design.	Section 7.10: Essential mitigation and enhancement measures
Eden District Council	The Applicant should engage with stakeholders where CCR risks (e.g. wildfires) are relevant	Mitigation embedded in the design is set out in the ES and additional mitigation for construction and operation will continue to be developed through subsequent project stages. This will include liaison with relevant stakeholders.	Section 7.10: Essential mitigation and enhancement measures
Cumbria County Council Eden District Council	GHG emissions associated with construction works should be minimised or seek to be carbon neutral	Mitigation measures have been identified to minimise GHG emissions and are set out in the ES.	Section 7.10: Essential mitigation and enhancement measures
Eden District Council Cumbria County Council	The Applicant should identify opportunities/areas of potential carbon offsetting including local projects	Opportunities for carbon offsetting have not been included in this ES but will form part of the ongoing Carbon Management Strategy for the Project.	None
Natural England	The risk of scour is noted from the PEI Report CCR assessment	The risks from climate change and appropriate mitigation are set out in this ES.	Section 7.9: Potential impacts, Section 7.10: Essential mitigation and enhancement measures, and Section 7.11: Assessment of likely significant effects

Consultee/ respondent	Comment	Applicant response	Where addressed?
Durham County Council Barningham Parish Council Mickleton Parish Council	Rationale for route selection does not align with outcome of GHG assessment	Chapter 3: Assessment of alternatives details the environmental effects of the different alternative alignments considered and how these were involved in the Project decision making. The Project Development Overview Report (Application Document 4.1) provides the full detail of the sifting process and reasons for all decisions taken.	Chapter 3: Assessment of alternatives Project Development Overview Report (Application Document 4.1)

Impact of the Project on climate (GHG emissions assessment)

Quantification of emissions

7.5.5 The assessment of the nature and magnitude of GHG emissions has been undertaken in line with the methodology of *DMRB LA 114* and in alignment with the framework presented in the Specification of infrastructure carbon management (PAS 2080: Carbon Management in Infrastructure) (British Standard Institute, 2016)[38].

7.5.6 PAS 2080 introduces a lifecycle assessment approach centred around a number of "Work Stages of Infrastructure Delivery". Those stages relevant to this assessment are:

- Construction and Commissioning[39]
- Operation (including periodic replacement of key elements, and use of the asset)

7.5.7 For the purpose of quantifying GHG emissions the study period of 60 years has been used to align with the Transport Appraisal Guidance methodology for end-user emissions calculation and aligned with the CCR assessment. In line with *DMRB LA 114*, 'end of life' impacts have been excluded from the assessment due to length of the assets' likely operational phase.

7.5.8 The assessment methodology for the ES is based upon the information available at the time of assessment. In some cases, conservative assumptions have been made to provide a reasonable worst-case scenario for the particular item or factor to seek to provide for a precautionary assessment. Further information on assessment assumptions and limitations is provided in section 7.6: Assessment Assumptions and limitations and in Appendix 7.1: GHG Emissions Assessment (Application Document 3.4).

7.5.9 The assessment carried out for the ES incorporates a change to the calculation approach used for the PEI Report (National Highways, 2021)[40] following a review of the underlying methodological assumptions. Within the PEI Report the assessment made a general allowance for the mass of excavated material that was likely to require stabilisation and assumed that this full quantity reflected the mass of lime required for stabilisation (i.e. the full quantity of material requiring stabilisation was converted into an equivalent quantify of lime). Due to the carbon-intensity of lime this error resulted in significant over-estimation of the construction emissions. The error has been corrected in the ES, and an updated assumption for ES is that the quantity of additional lime required for stabilisation is 8% of the proportion of excavation material identified as requiring stabilisation. A review has

[38] With the exception of setting project level carbon reduction targets as instructed by *DMRB LA 114* (paragraph 2.7). British Standard Institute (2016) PAS 2080:2016 Carbon Management in Infrastructure]
[39] Decommissioning is not in scope of the climate assessment.
[40] National Highways (2021) Preliminary Environmental Impact Report Climate Chapter.

been undertaken of the decisions made on alternatives within the Project where calculated construction GHG emissions were a factor in the decision-making, and it has been verified that this change to the assumptions would not have led to different decisions being taken. This is set out in more detail in the Project Development Overview Report (Application Document 4.1).

7.5.10 Table 7-5: Project lifecycle stages and potential sources of GHG emissions considered by the GHG emissions assessment presents the potential sources of GHG emissions during the Construction and Operation work stages of the Project and whether they have been included in the GHG emissions assessment.

Table 7-5: Project lifecycle stages and potential sources of GHG emissions considered by the GHG emissions assessment

Project Work Stage	PAS 2080 module	Description	Inclusion in the Assessment (and justification where excluded)	Source of Data Used in Assessment (where assessed)
Pre-construction	A0	Preliminary studies, consultations	No - Carbon emissions from preliminary studies and works are largely office-based and are assumed to be insignificant.	N/A
Construction	A1-3	Raw material supply	Yes	Material quantities from design teams Carbon assessments as part of the design optioneering to date
	A4	Transport to works site	Yes	Schedule of material delivery and assumed transportation distances
	A5	Construction / installation processes - fuel usage	Yes	Fuel usage during construction processes Electricity and water usage for site compounds
		Construction / installation processes - Business and employee travel	Yes	Number of construction staff and estimated commute frequency and distances
		Construction / installation processes - Waste and waste transport	Yes	Waste quantities and assumed distance to disposal facilities

Project Work Stage	PAS 2080 module	Description	Inclusion in the Assessment (and justification where excluded)	Source of Data Used in Assessment (where assessed)
	D[41]	Land use change	Yes	Type and area of land subject to change in usage taken from Chapter 6: Biodiversity
Operation	B1	Use	No - Carbon emitted directly from the fabric of products and materials once they have been installed as part of the Project and it is in normal use are assumed to be insignificant.	N/A
	B2	Maintenance	Yes	Typical replacement periods for key materials
	B3	Repair	Yes	
	B4	Replacement	Yes	
	B5	Refurbishment	Yes	
	B6	Operational energy use (i.e. street lighting)	No - The Project has been designed to reduce the requirement for energy consuming operational equipment such as street lighting wherever possible given the mostly rural setting. It is considered that there would be a negligible difference between the operational energy required for the Project compared with the existing A66, and therefore associated emissions are assumed to be not material to the wider operational carbon assessment[42].	N/A
	B7	Operational water use	No - Carbon emissions resulting from the consumption of water required by the Project to	

[41] PAS 2080 Stage D - supplementary information beyond the infrastructure life cycle
[42] For example, a four leg junction requiring lighting for 1km in each direction on both carriageways would require approximately 400 lighting columns, assuming a 20m distance between columns. Assuming a typical 200 Watts and 4,380 operating hours, this would result in approximately 350,000 kWh per year, equivalent to approximately 75tCO_2e per year at the current carbon intensity for grid electricity. This is marginal when compared to other operational emissions, and furthermore will reduce as the electricity grid continues to decarbonise.

Project Work Stage	PAS 2080 module	Description	Inclusion in the Assessment (and justification where excluded)	Source of Data Used in Assessment (where assessed)
			enable it to operate and deliver its service are assumed to be insignificant.	
	B8	Other operational processes	No - Other process carbon emissions arising from the Project to enable it to operate and deliver its service, such as management of operational waste, are assumed to be insignificant.	
	B9	User utilisation of infrastructure	Yes	Emissions from vehicles derived from the traffic model
	D	Ongoing land use emissions and sequestered carbon	Yes - Information relating to ongoing land use, including natural environment mitigation measures have been quantified as part of the assessment process[43].	Type and area of land subject to change in usage taken from Chapter 6: Biodiversity
End of life	C1	Deconstruction	No - In line with *DMRB LA 114*, 'end of life' impacts have been excluded from the assessment due to length of the assets' operational phase.	N/A
	C2	Transport		N/A
	C3	Waste processing for recovery		N/A
	C4	Disposal		N/A

7.5.11 The purpose of the GHG emissions assessment is to calculate and report the emissions anticipated to be generated or avoided by the Project for each of the Project work stages. The purpose of this is to:

- Enable consideration of magnitude against the relevant UK Carbon Budget(s)
- Enable identification of emissions hot spots to inform identification and prioritisation of mitigation measures to minimise GHG emissions from the Project.

7.5.12 *DMRB LA 114* requires use of an industry recognised carbon calculation tool(s) in accordance with the Overseeing Organisation requirements.

[43] For the evaluation of significance the positive impacts from sequestration have been excluded to provide a conservative assessment of aggregated operational impacts. However, the quantification of carbon sequestration during operation is included within the assessment results tables.

The *National* Highways *Carbon Emissions Calculation Tool* (National Highways, 2021)[44] has been used to calculate:

- All construction stage emissions, as identified in Table 7-5: Project lifecycle stages and potential sources of GHG emissions considered by the GHG emissions assessment, with the exception of land use change (the method for which is described separately in section 7.4: Assessment methodology)
- All operational stage emissions, as identified in Table 7-5: Project lifecycle stages and potential sources of GHG emissions considered by the GHG emissions assessment, with the exception of emissions from vehicles using the highways infrastructure (the method for which is also described separately in section 7.4: Assessment methodology).

7.5.13 Construction and operational emissions associated with land use change have been quantified by calculating the potential loss and/or gain of carbon stock after comparing the land use in each scheme before construction commences, and then after the construction period, reflecting new habitat and planting areas.

7.5.14 The change in land use within each scheme is based on the assessment of habitat types (biodiversity units), following assessment by suitably qualified ecologists using the methodology outlined in Chapter 6: Biodiversity. For each scheme the net change in the area of each habitat type within the Order Limits has been quantified. Where there is a decrease in the area of a habitat type, the carbon stock lost or damaged as result of the construction of the Project has been calculated based on the representative carbon storage for that habitat type, using carbon stock factors contained in guidance developed by Natural England (Natural England, 2012)[45] and (Natural England, 2021)[46]. Multiplication of these factors with the area of habitat type lost provides an estimate of carbon stock loss due to the construction phase of the Project. Similarly, where there is a net increase in the area of a habitat type, the potential carbon stock gained during the operation of the Project following the implementation of biodiversity mitigation is calculated in the same way, using the same Natural England carbon storage factors. The assessment approach takes a conservative approach by excluding the operational phase carbon sequestration from the evaluation of significance (i.e. excluding GHG benefits arising from new habitat creation when assessing the significance of changes in GHG emissions). However the quantification of these benefits (were all biodiversity units within the Order Limits to be delivered) are presented in the assessment results tables. Results of the assessment are presented in section 7.11: Assessment of likely significant effects

[44] National Highways (2021) Carbon emissions calculation tool.]
[45] Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources (NERR043).]
[46] Natural England (2021) Carbon Storage and Sequestration by Habitat 2021 (NERR094).]

expressed in tonnes of carbon dioxide[47] (tCO_2) and in Appendix 7.1: GHG Emissions Assessment (Application Document 3.4).

7.5.15 The assessment of operational phase emissions from vehicles using the highways infrastructure draws on existing traffic modelling information from earlier stages of the Project, as explained in the Combined Modelling and Appraisal Report (Application Document 3.8). This information is used to calculate emissions (using the Emissions Factors Toolkit, version 11 (Department for Environment, Food & Rural Affairs, 2021)[48]) associated with the Traffic Reliability Area[49] for the baseline, opening year (2029) and design (future) year (2044) under the following scenarios:

- 2019 Baseline scenario
- 2029 Do-Minimum (DM) scenario: the traffic scenario at the modelled
- opening year without the Project
- 2029 Do-Something (DS) scenario: the traffic scenario at the modelled opening year with the Project
- 2044 Do-Minimum (DM) scenario: the traffic scenario at the design year (15 years after the opening year) without the Project
- 2044 Do-Something (DS) scenario: the traffic scenario at the design year with the Project.

7.5.16 Emissions drawn from the traffic modelling are provided in carbon dioxide (CO_2) not carbon dioxide equivalents (CO_2e). To provide GHG emissions estimates as CO_2e, carbon emissions data has been converted to CO_2e by applying an additional 1% of the CO_2 emissions[50].

7.5.17 The assessment uses the traffic modelling information to calculate the additional GHG emissions associated with the Project (under the 'Do Something' scenario) above the existing anticipated increase in traffic emissions without the Project (the 'Do Minimum' scenario). The assessment calculation subtracts the modelled 'Do Minimum' emissions from the modelled 'Do Something' emissions to provide estimated additional GHG emissions associated with the Project from vehicles using the highways infrastructure.

7.5.18 In line with *DMRB LA 114*, the assessment presents the estimated net GHG emissions associated with end-users for the modelled design

[47] The quantification of land use change GHG impacts produces results expressed as mass of carbon alone. In order to align with the wider GHG quantification it is assumed that all carbon is released in the form of CO_2. Conversion of mass of carbon to an equivalent mass of CO_2 is calculated based on the ratio (by mass) of the molecular weight of CO_2 to the atomic mass of carbon. This ratio is 44/12. Therefore calculated carbon mass has been multiplied by 44/12 to provide an equivalent mass of CO_2.
[48] Department for Environment, Food & Rural Affairs (2021) Emissions Factors Toolkit
[49] DMRB LA 105 defines the Traffic reliability area as "the area covered by the traffic model, that the competent expert for traffic has identified as reliable for inclusion in an environmental assessment".
[50] Assumption of 1.01 conversion factor, assumes petrol and diesel fuels are used in vehicles using the highway infrastructure and is based upon analysis of the BEIS Conversion factors for Fuels, comparing the difference of CO_2 and CO_2e emissions factors on 'Fuels'. This gives an approximate 1% difference in the factors. This uplift of 1% has then been used to convert CO_2 to CO_2e for emissions from vehicles using the highways infrastructure.

(future) year (2044) ('Do Something' scenario minus the 'Do Minimum' scenario).

Evaluation of significance

7.5.19 In line with *DMRB LA 114*, to evaluate the significance of project GHG emissions, project GHG emissions will be reported against the legislated UK Carbon Budgets as set out in Carbon Budget Orders (Department for Business Energy and Industrial Strategy, 2021)[51] (shown in Table 7-6: UK Carbon Budgets) considered relevant to the stage of the Project under consideration.

7.5.20 The Climate Change Act (2050 Target Amendment) Order 2019 sets legally binding targets for reducing the UK's carbon emissions to net zero by 2050. A key provision of the UK Climate Change Act (2050 Target Amendment) Order 2019 is a requirement for the government to set legally binding carbon budgets limiting the amount of carbon emitted in the UK over a five-year period. At time of writing, budgets have not yet been adopted for the period beyond 2038.

7.5.21 Total estimated GHG emissions from the construction stage of the Project will be considered against the Fourth Carbon Budget (2023-2027) and Fifth Carbon Budget (2028-2032) respectively, as construction works are expected to take place between 2024 and 2029.

7.5.22 Total estimated GHG emissions from the operational stage of the Project will be considered against the Sixth Carbon Budget (2033-2037) as this is the Carbon Budget set furthest into the future able to represent the operational phase, to provide a reasonable worst case assessment using information currently available on carbon budgets.

7.5.23 For the end-user assessment, the estimated additional GHG emissions associated with the Project from vehicles using the highways infrastructure will be combined with the total estimated emissions relating to maintenance and refurbishment for the Project, to provide a total estimated GHG emissions for the Project in the operational phase (for the assumed 60-year lifetime). This is then reported against the Sixth Carbon Budget to consider significance, to provide a reasonable worst case assessment using information currently available on carbon budgets.

[51] Department for Business Energy and Industrial Strategy (2021) UK Carbon Budgets.

Table 7-6: UK Carbon Budgets

Carbon Budget	Years	Carbon Budget Limit ($MtCO_2e$)	Reduction below 1990 levels	Project Appraisal Period
Third	2018-2022	2,544	37% by 2020	2024 to 2089 (Construction period and an assumed operational project lifetime used for assessment of 60 years)
Fourth	2023-2027	1,950	50% by 2025	
Fifth	2028-2032	1,725	68% by 2030*	
Sixth	2033-2037	965	70% by 2035	
*Originally 57% when fifth carbon budget was enshrined in law, has recently been increased to 68% as the UK's Nationally Determined Contribution ahead of the UN's COP26 in November 2021				

7.5.24 In line with *DMRB LA 114*, the GHG emissions performance of the Project have been benchmarked against other recent road scheme projects within the Strategic Road Network. The following list of road scheme projects has been provided by National Highways for the benchmarking exercise:

- A303 Stonehenge (Amesbury to Berwick Down)
- A428 Black Cat to Caxton Gibbet improvements
- A417 missing link.

Vulnerability of the Project to climate change (CCR assessment)

7.5.25 In line with *DMRB LA 114*, the CCR assessment is a qualitative assessment to identify whether anticipated changing climate conditions and weather events are likely to have significant adverse effects on the Project. It considers the potential impacts and risks of climate change on the Project based on professional expertise and judgement. This expertise is provided by structural, geotechnical and drainage engineers under the guidance of the climate change specialists.

Scope of the assessment

7.5.26 The CCR assessment is comprised of these main steps:

- Researching the historic baseline of the Project location
- the analysis of climate change projections to identify future climate conditions
- the identification and assessment of relevant climate hazards and disruptive weather conditions, based on climate trends, which could impact the Project, and the identification of potential risks from these climate hazards to the infrastructure and operations of the Project
- the assessment of the resilience of the Project to each identified risk within the context of any embedded mitigation measures, considering the likelihood of impacts occurring and consequence of impacts should they occur
- the evaluation of any significant risks and the need for any further adaptation (mitigation) measures.

7.5.27 A detailed CCR assessment for the construction phase of the Project has not been taken forward. Extreme weather events are a feature of the current climate (i.e. the baseline) and these effects will be mitigated against through measures outlined in the draft of the Environmental Management Plan (EMP) that is provided as part of the DCO application. The purpose of the CCR assessment, however, is to "identify whether anticipated changing climate conditions and weather events are likely to have significant adverse effects on the Project" (*DMRB LA 114*). The *UKCP18* climate projections for the 2020s (construction period) suggest that, whilst the climate will have changed by the construction period, it is not considered that climate change will significantly increase the vulnerability of the Project during the construction period. Therefore, the CCR assessment only covers the operational phase of the Project.

7.5.28 The EMP (Application Document 2.7) sets out specific measures for the Project that the Principal Contractor (PC) will employ in order to provide resilience to extreme weather, which builds on existing National Highways standard construction processes. The EMP defines the outcome that the mitigation will need to achieve (i.e. protection of construction site to prevent environmental impact in the event of extreme weather events) and examples of mitigation that could be employed. The mitigation will then be developed further by the PC to achieve those outcomes, and defined in detail in the next iteration of the EMP produced at construction stage. The types of measures to be implemented include climate resilience measures, such as ensuring construction materials are covered when stored, and pro-active construction planning that accounts for the possibility of extreme weather events, including the use of extreme weather alert systems and site-level management mitigation measures provided by the contractor, e.g. those relating to construction methods and site management methods. It will be a requirement of the DCO that the EMP is implemented during construction in full accordance with the draft EMP (which will be a certified document under the DCO) and therefore the CCR assessment assumes that the measures set out in the draft EMP to address the climatic changes and risks outlined in this chapter are implemented fully and effectively, such that it addresses climate resilience risk in full.

7.5.29 The topic of 'Major Events (Major Accidents and Disasters)' has also been scoped out of the wider EIA assessment, with no further consideration of the vulnerability of the project to major accidents and disasters (man-made and natural) being included as part of the EIA. However, the wider EIA assessment methodology (as set out in the Scoping Report (A66 Northern Trans-Pennine PCF Stage 3 Environmental Scoping Report (National Highways, 2021b)[52]) states that *"Where further design mitigation is unable to remove the potential interaction between a major event and a particular topic, the relevant ES chapter would be required to identify the potential consequence for*

[52] National Highways (2021b) A66 Northern Trans-Pennine PCF Stage 3 Environmental Scoping Report

receptors covered by the topic and give a qualitative evaluation of the potential for the significance of the reported effect to be increased as a result of a major event." The CCR assessment considers the potential for major events to result in climate change risk and the need for mitigation across the Project.

Climate change projections

7.5.30 *UK Climate Projections 2018 (UKCP18)* (Met Office, 2018)[53] have been used to provide quantitative estimates of future climatic conditions for the Project. In accordance with *DMRB LA 114*, all *UKCP18* projections used in the assessment reflect the high emissions scenario, representative concentration pathway 8.5 (RCP8.5) against a baseline period of 1981-2010. The CCR assessment uses the *UKCP18* probabilistic projections for climate change and the *UKCP18* regional projections for climate change to identify the future baseline. For the *UKCP18* probabilistic projections, the 50th percentile (median) projections are used to inform the assessment.

7.5.31 The assessment of climatic effects on the Project is assessed over an assumed 60-year operational life cycle, in line with *DMRB LA 114*.

Identification of climate hazards and risks

7.5.32 The following climate hazards have been considered in the CCR assessment:

- High temperatures
- High precipitation
- Low precipitation
- High humidity
- Extreme winds.

7.5.33 Climate projections indicate that temperatures will increase throughout the period of operation and so the likelihood of the Project being impacted by low temperatures will decrease. Similarly, the incidence of fog is projected to decrease throughout the period of operation (Met Office, 2010)[54]. Consequently, the potential impacts arising from low temperatures and fog have not been considered in the assessment.

7.5.34 A Flood Risk Assessment (FRA) for the Project has been undertaken and is reported in Chapter 14: Road Drainage and the Water Environment (Application Document 3.2). The FRA, which has informed the design, incorporates Environment Agency allowances for increases in rainfall intensity and peak river flow (Environment Agency, 2021)[55] in a future changed climate. The design standards upon which the Project has been designed take conservative assumptions on flood risks.

7.5.35 A qualitative assessment of the climate change resilience of the mitigation measures proposed by other environmental topics that may

[53] Met Office (2018) UK Climate Projections (UKCP)
[54] Met Office (2010) Future changes in fog frequency from the *UKCP09* ensemble of regional climate model projections.
[55] Environment Agency (2021) Flood risk assessments: climate change allowances

be vulnerable to climate change has been conducted. This is presented in section 7.10: Essential mitigation and enhancement measures.

Assessment of likelihood and consequence

7.5.36 As part of the CCR assessment, the potential likelihood of climate change impacts occurring, and the potential consequence should they occur, are scored using professional judgement and using a qualitative five-point scale, as set out in *DMRB LA 114*. The qualitative five-point scales for likelihood and consequence are presented in Table 7-7: Likelihood categories - A qualitative five-point scale for assessing likelihood of climate change impacts occurring (*DMRB LA 114, 2021*) and Table 7-8: Measure of consequence - A qualitative five-point scale for assessing the consequence of climate change impacts if they were to occur (*DMRB LA 114, 2021*) below.

Table 7-7: Likelihood categories - A qualitative five-point scale for assessing likelihood of climate change impacts occurring (*DMRB LA 114, 2021*)

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

Table 7-8: Measure of consequence - A qualitative five-point scale for assessing the consequence of climate change impacts if they were to occur (*DMRB LA 114, 2021*)

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

7.3.40 The potential likelihood and consequence of each climate change risk has been determined based upon the professional judgement of climate change experts in the EIA team, designers, structural engineers, drainage

engineers and geotechnical experts from the wider design team delivering the Project.

7.5.37 The CCR assessment assesses the proposed design, including any embedded mitigation measures at the time of assessment.

7.5.38 Climate change risks have been identified and assessed based on the climate *UKCP18* RCP 8.5 projection for each climate change parameter and across the spatial extent of the Project (referred to from hereon in as the 'project-wide assessment').

7.5.39 Where there are risks that apply only to specific schemes, or which differ from the project-wide CCR assessment, these are identified. Conversely, where project-wide risks are not applicable to a specific scheme, these have also been identified.

7.5.40 Additionally, *DMRB LA 114* (Section 3.30), requires that H++ (which are typically extreme) climate scenarios are used to test the sensitivity of vulnerable safety critical features, to ensure that such features would not be affected by more radical changes to the climate beyond that which is projected in *UKCP18* RCP8.5. The safety critical features that are vulnerable to climate change within the Project are:

- Drainage assets
- Earthworks
- Multi-span bridges at Kirkby Thore (Temple Sowerby to Appleby scheme) and Warcop (Appleby to Brough scheme) for which the design includes piers positioned within the floodplain.

7.5.41 A high-level sensitivity test using H++ climate scenarios (outlined in section 7.7: Baseline conditions) for these vulnerable safety critical features has been undertaken and is presented in section 7.11: Assessment of likely significant effects.

Evaluation of significance

7.5.42 To evaluate the significance of each risk, the likelihood and consequence of each risk is combined to provide a significance conclusion using the significance matrix, as set out in Table 7-9: Significance matrix. Note: NS = Not significant; S = Significant (*DMRB LA 114*, 2021)

Table 7-9: Significance matrix. Note: NS = Not significant; S = Significant (*DMRB LA 114*, 2021)

		Measure of Likelihood				
		Very low	Low	Medium	High	Very High
Measure of Consequence	Very large	NS	S	S	S	S
	Large	NS	NS	S	S	S
	Moderate	NS	NS	S	S	S
	Minor	NS	NS	NS	NS	NS
	Negligible	NS	NS	NS	NS	NS

7.5.43 In accordance with *DMRB LA 114*, where any climate change risk is concluded to be significant, additional mitigation measures (i.e.

resilience measures to protect against the impacts of climate change) are identified and proposed, which if implemented would seek to reduce the identified risk to "an acceptable level" (i.e. not significant).

7.5.44 The likelihood and consequence of each significant risk is then reassessed based on the assumption that the additional proposed mitigation will be implemented successfully, effectively and in full as proposed, to reassess for significance.

7.5.45 Any residual significant effects will be presented in the conclusion of the assessment.

7.6 Assumptions and limitations

Impact of the Project on climate (GHG emissions assessment)

7.6.1 The assessment of GHG emissions is based on relevant design and construction information provided by design teams and buildability contractors, e.g. construction material quantities, transport and plant emissions, as set out in Chapter 2: The Project. The assessment presented in this ES chapter is based on the information available at the time of assessment.

7.6.2 Conservative assumptions have been made in some cases where data is missing or incomplete in order to provide a reasonable worst-case scenario for the particular item or factor to inform a precautionary assessment. Professional judgement has been used where required to adopt appropriate benchmark data (in line with good practice as set out in PAS 2080).

7.6.3 Assumptions have been made using:

- Emerging design detail
- Engineering specialist knowledge
- Environmental specialist knowledge
- Climate change and carbon specialist knowledge
- Proxy engineering data from previous comparable projects.

7.6.4 ES Appendix 7.1: GHG Emissions Assessment (Application Document 3.4) sets out the detailed assumptions and limitations associated with the GHG emissions assessment.

7.6.5 The assessment of road user emissions is based on considering traffic volumes for the traffic reliability area (TRA). The TRA was determined based on the regional screening criteria set out in *DMRB LA 105*. Emissions were calculated using the *Emissions Factors Toolkit* version 11 (Department for Environment, Food & Rural Affairs, 2021)[56] and presented as tonnes of carbon dioxide (tCO_2). A 1% uplift was then applied to convert CO_2 to CO_2e.

7.6.6 A proportionate approach to the quantification of land use emissions has been undertaken. A range of assumptions are incorporated into the

[56] Department for Environment, Food & Rural Affairs (2021) Emissions Factors Toolkit

consideration of carbon in habitats which are set out in detail in ES Appendix 7.1: GHG Emissions Assessment (Application Document 3.4).

Vulnerability of the Project to climate change (CCR assessment)

7.6.7 The climate projections used in this assessment are based on simulations of potential future climate scenarios, under a range of hypothetical emissions scenarios and assumptions, and should not be viewed as predictions or forecasts.

7.6.8 Global projections are generally able to reflect large-scale change with more confidence when compared with projections for regional scale changes, and temperature projections are more certain than those for precipitation. Furthermore, the degree of uncertainty associated with all climate change projections increases for projections further into the future.

7.6.9 The CCR assessment has been informed by the following principal assumptions. The assessment has:

- assumed that identified embedded mitigation measures relevant to different assets would be implemented successfully and are effective at addressing the risk, including having effective monitoring and site safety procedures in place to manage climate risk throughout the operation of the Project
- assumed that any additional mitigation measures identified to mitigate those climate impacts and risks that are assessed as significant will be implemented successfully
- been based upon, and therefore influenced by, the assumptions associated with climate modelling and climate change projections of the *UKCP18*.
- assumed that disruption to the Project resulting from any climate risk would cause, at worst, a regional level disruption (on the basis that alternative highway routes exist and such disruption would not be considered 'national' in scale). Therefore, no risk is assessed to have greater than a 'large adverse' consequence in line with the rating approach specified in *DMRB LA 114*.

7.6.10 The CCR assessment is considered to have the following limitations:

- the assessment is predominantly qualitative and is based on the professional judgement of climate experts, structural engineers, drainage engineers and geotechnical experts
- although there is guidance provided on the assessment methodology (IEMA (The Institute of Environmental Management and Assessment, 2020)[57] and *DMRB LA 114*), the guidance and publicly available case studies on the assessment of individual climate risks and impacts on different aspects of the Project are limited
- as climate projections represent an uncertain future, there are inherent uncertainties in the climate change projections that will have

[57] The Institute of Environmental Management and Assessment (2020) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation

been used to inform the CCR assessment. This study has been informed using *UKCP18*, the latest available set of probabilistic climate projections for the UK at the time of assessment. However, projections are regularly updated and superseded based on updated and developing scientific understanding

- there is often uncertainty in the relationship between changes in climate hazards and the respective response in terms of infrastructure asset performance. This creates uncertainty when assessing the likelihood and consequence of climate risks on assets within the Project

Limits of Deviation

7.6.11 This assessment has been conducted within the Limits of Deviation (LoD) as outlined within Chapter 2: The Project. It is considered that the development of the design at detailed design stage will lead to changes in the quantities and types of material used for the construction phase. However, the approach in this ES has sought to adopt a conservative approach where estimates are required in order to avoid under-reporting of GHG emissions, and any change would be expected to remain within these broad assumptions. On this basis it is not considered likely that the conclusions of the assessment would be affected or changed.

7.7 Study area

Impact of the Project on climate (GHG emissions assessment)

Construction

7.7.1 The study area for construction GHG emissions aligns with the Order Limits, which covers all direct GHG emissions arising from activities and land use change where the excavation and engineering works take place within the Order Limits. It also includes indirect emissions embedded within the construction materials arising as a result of the energy used for their extraction and production as well as emissions arising from the transportation of materials and waste to and from the site.

7.7.2 These activities are defined in terms of lifecycle stages, detailed in Section 7 of PAS 2080: Carbon Management in Infrastructure as follows:

- Products and materials (A1-3) - use of materials for temporary and permanent construction activities
- Transport to works site (A4) - the transportation of materials to the Project site, e.g. by HGV
- Construction and installation processes (A5) - construction plant use, business and employee travel, waste and waste disposal (including site preparation and demolition).

7.7.3 The assessment is based on the Project as it is described in Chapter 2: The Project, including embedded mitigation inherent in the design that is

presented. The assessment also takes into account the baseline assessment of habitat types (biodiversity units) within the Order Limits as outlined in Chapter 6: Biodiversity. These are used to calculate the GHG emissions associated with the loss of carbon stock due to the construction of the Project.

Operation

7.7.4 The study area for operational GHG emissions arising from maintenance and refurbishment activities aligns with the Order Limits.

7.7.5 The study area for end user GHG emissions from vehicles using the highways infrastructure is consistent with the TRA (Traffic Reliability Area), as defined in section 7.6: Assumptions and limitations, which reflects the widest road network over this traffic modelling is considered verified and reliable.

7.7.6 These operational elements are also defined in terms of life cycle stages, as detailed in Section 7 of *PAS 2080* as follows:

- Maintenance (B2), Replacement (B4) and Refurbishment (B6) activities - e.g. the embodied carbon emissions associated with the materials used for resurfacing, replacement etc
- Operational energy use (B6) - operational lighting emissions
- User utilisation of infrastructure (B9) - end user traffic emissions.

7.7.7 The assessment is based on the Project as it is described in Chapter 2: The Project includes embedded mitigation inherent in the design that is presented. The assessment also considers mitigation measures within the Order Limits associated with changes to biodiversity units as outlined in Chapter 6: Biodiversity. It is noted that these would be expected to have a positive impact on net GHG emissions through the sequestration of carbon in the operational phase of the project, following habitat creation in construction phase. However, the assessment takes a conservative approach by excluding this benefit from the evaluation of significance, although the quantification of these benefits are presented in the assessment results tables.

Vulnerability of the Project to climate change (CCR assessment)

Operation

7.7.8 The study area for the CCR assessment includes potential climate hazards during the operational phase of the Project (over 60 years in line with *DMRB LA 114*) to infrastructure and assets that constitute the Project within the Order Limits. The assessment also considers the climate change resilience of the mitigation measures implemented to address impacts from other EIA topics.

7.8 Baseline conditions

Impact of the Project on climate (GHG Assessment)

Current and future baseline

7.8.1 This section identifies the GHG emissions without implementing the Project 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.

7.8.2 The operation and management of the existing A66 assets likely requires a small number or volume of specialist components (for example, signage) as well as some bulk material (cement, concrete, sand and gravel) for minor maintenance and refurbishment works and repairs of the highway and ancillary infrastructure. This use of materials in the baseline scenario would have embodied emissions associated with them. However, due to the small quantities of materials required, emissions are considered to be minimal and as such have been excluded from further assessment.

7.8.3 The estimated baseline GHG emissions for the 'Do-minimum' scenario in the 2019 baseline year, future baseline years (2029 and 2044) and over the study period (60 years) are summarised in Table 7-10: Estimated baseline operational GHG emissions for the study area.

Table 7-10: Estimated baseline operational GHG emissions for the study area

Project Work Stage	Definition	Emissions (tCO_2e)			
		2019 baseline scenario (historic)	2029 modelled opening year	2044 modelled future year	Total (over the 60-year appraisal period)
Operation	User utilisation of infrastructure (B9)	1,577,127	1,506,832	1,209,944	74,971,735

Vulnerability of the Project to climate change (CCR assessment)

Existing baseline

7.8.4 The Met Office generates climatologies for different areas of the UK (known as climate districts) which include historical regional climate information. The A66 crosses between the North East England and North West England regional climate zones (Met Office, 2016)[58]. As a result, the historical observed weather differs because of topography and atmospheric conditions. Table 7-11: Synopsis of historical climate observations for the North West and North East England regional

[58] The Met Office generates climatologies based on standard areas (UK climate districts) of the UK. The Project spans across the North West and North East districts as shown on the UK climate districts map. Met Office (2016) UK regional climates

climate zones describes the historical observed weather for the two regional climate zones associated with the Project.

7.8.5 The historical weather observations for the North West Region are relevant to the M6 Junction 40 to Kemplay Bank, Penrith to Temple Sowerby, Temple Sowerby to Appleby, and Appleby to Brough schemes. The historical weather observations for the North East Region are relevant to the Bowes Bypass, Cross Lanes to Rokeby, Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner schemes.

Table 7-11: Synopsis of historical climate observations for the North West and North East England regional climate zones

Climate Parameter	North West Region – Historical Weather Observations	North East Region – Historical Weather Observations
Temperature	Temperature depends heavily on altitude. Over low lying areas, mean annual temperatures vary between 9°C and 10.5°C.	The North East region of the UK is surrounded by the coldest waters and contains extensive areas of upland (higher altitude), meaning that temperatures are generally cool throughout the year (relative to elsewhere in the UK). Mean annual temperatures vary between 8.5°C and 10°C.
Precipitation	Annual precipitation varies significantly in the region between 3200mm per year in the Lake District and 800mm per year in the Eden. The driest season is in spring, whilst the wettest season is in autumn and winter when the Atlantic depressions are at their most vigorous.	Annual precipitation in the region varies between 1500mm in the Pennines and 600mm towards the East Coast. Seasonal patterns are similar to those for the North West region.
Wind	The region is among the most exposed parts of the UK as it is close to the Atlantic and contains large upland areas. The region experiences five to ten gales per year. Gales are defined as days that the wind reaches a mean speed greater than 34 knots over ten consecutive minutes.	Over the highest Pennines there are about 15 gales per year while along the coast gales occur on five to ten days and low-lying places inland experience less than five gales per year.
Sunshine	Sunshine duration is controlled by the length of day and cloudiness. It decreases with increasing altitude, latitude and distance from the coast. Average annual sunshine ranges from 1200hrs to 1500hrs per year.	Average annual sunshine ranges from 1500hrs per year near the coast to 1250hrs further inland.
Ground frost	Ground frost occurs on average between 75 and 150 days per year	Ground frost occurs on average between 80 and 135 days per year, depending on altitude.

Climate Parameter	North West Region – Historical Weather Observations	North East Region – Historical Weather Observations
	Ground frost refers to a temperature below 0°C measured on a grass surface	
Snowfall	The occurrence of snow is closely linked to temperature. The region experiences, on average, between 20 and 50 days of snowfall per year depending on altitude, with an additional five days of snowfall for every 100m of elevation gain. Depths of undrifted snow can occasionally reach up to 60cm. When depths of over 15cm occur in association with strong winds, serious drifting can occur and can cause widespread travel disruption where this occurs on transport routes.	The region experiences between 20 and 50 days of snowfall per year depending on altitude. Snow depths are similar to those described for the North West region.

7.8.6 National Highways provided a record of previous flood events that have occurred on the existing A66 between 2005 and 2021 from the Highway's Agency Drainage Data Management System (HADDMS). This record contains information on the location of each flood event and, where available, the severity and impact of the event. Flood events are labelled by National Highways as 'closed', 'historic' or 'open' events where 'open' events refer to those that are currently being monitored. Table 7-12: Number of recorded previous flood events that have occurred on the existing A66 within the Order Limits of each scheme since 2005. Open flood events refer to those which are currently being monitored. outlines the number of open and closed flood events that have occurred within the Order Limits of each scheme on the Project.

Table 7-12: Number of recorded previous flood events that have occurred on the existing A66 within the Order Limits of each scheme since 2005. Open flood events refer to those which are currently being monitored.

Scheme	Number of closed/historic flood events	Number of open flood events
M6 Junction 40 to Kemplay Bank	5	0
Penrith to Temple Sowerby	7	0
Temple Sowerby to Appleby	9	0
Appleby to Brough	10	0
Bowes Bypass	16	16
Cross Lanes to Rokeby	6	2
Stephen Bank to Carkin Moor	7	19
A1(M) Junction 53 Scotch Corner	4	0

7.8.7 The historic flooding records suggest that the Bowes Bypass and Stephen Bank to Carkin Moor schemes are the most susceptible to

flooding, particularly since June 2017. The most severe event in the Bowes Bypass scheme resulted in total road closure, whilst four other events resulted in partial road closure. Two events on the Stephen Bank to Carkin Moor scheme, both in November 2012, resulted in total road closure, whilst a further two events resulted in partial road closure.

7.8.8 In addition, three previous events on the M6 Junction 40 to Kemplay Bank scheme, three events on the Temple Sowerby to Appleby scheme, four events on the Appleby to Brough scheme, and one event on the Cross Lanes to Rokeby scheme resulted in partial road closure. The other events recorded in Table 7-12: Number of recorded previous flood events that have occurred on the existing A66 within the Order Limits of each scheme since 2005. Open flood events refer to those which are currently being monitored. had more minor impacts, such as congestion or closure of the hard shoulder, or do not have a recorded impact.

Future baseline

7.8.9 The *UKCP18* projections provide the future baseline of how global climate change is likely to affect the study area, relative to the existing (historic) baseline conditions from 1981-2010.

7.8.10 All future climate projections for the UK indicate an increased likelihood of warmer, wetter winters and hotter, drier summers, in addition to an increase in the frequency of extreme weather. Climate projections for wind metrics have the highest level of uncertainty and interannual variability and therefore quantitative projections have not been used. Instead, climate change risks associated with wind have been assessed based on the *UKCP18* general trends for the UK. This shows an increase in near surface wind speeds over the UK for the second half of the 21st century for the winter season when more significant impacts of wind are experienced. This is accompanied by an increase in the frequency of winter storms (Met Office, 2019)[59].

7.8.11 Two sources of information are used to describe the future climate within which the Project will operate and to determine the likely climate hazards and their significance within the CCR assessment:

- *UKCP18* probabilistic projections of climate change - the median (50th percentile) change in average climate conditions for the RCP8.5 scenario. These are presented in Table 7-13: *UKCP18* climate change projections for average climate variables for the four 25km grid squares intersected by the Project. Projections reflect the RCP 8.5 high emissions scenario for the period of operation (2080s) (shown in Plate 7-1: *UKCP18* probabilistic data is provided in 25km grid squares. This map shows the grid squares that are intersected by the A66 route.).
- *UKCP18* regional projections of climate change[60] which show changes in extreme weather events, such as the number of heavy

[59] Met Office (2019) *UKCP18* Factsheet: Wind
[60] Met Office (2018) UK Climate Projections (UKCP)

rain days, for the 2060s[61]. These projections also represent the RCP 8.5 high emissions scenario and are presented in Table 7-14: *UKCP18* climate change projections for extreme weather events for the local area (12km grid square) surrounding each scheme within the Project.

UKCP18 probabilistic projections

7.8.12 Both summer and winter temperatures in the area surrounding the Project are projected to increase due to climate change. The largest increases in temperature are projected to be in the mean daily maximum summer temperatures, which are projected to increase by between 4.5°C and 4.7°C in the 2080s across the extent of the Project, relative to the 1981-2010 baseline, for the high (RCP 8.5) emissions scenario.

7.8.13 Mean precipitation rates in the area surrounding the Project are anticipated to change significantly throughout the next century. Winter precipitation rates are projected to increase by between 8% and 16% for the 2080s. Summer precipitation rates are projected to decrease by between 22% and 27% for the 2080s, relative to the 1981-2010 baseline, for the high (RCP 8.5) emissions scenario.

UKCP18 regional projections

7.8.14 The mean number of hot days per year, taken to be when the maximum temperature exceeds 25°C, is anticipated to increase by between 15 and 33 days compared to the existing (historic) baseline, up to a maximum of 85 days (for the M6 Junction 40 Penrith to Kemplay Bank, and Penrith to Temple Sowerby schemes). The mean number of cold days per year, when the mean daily temperature falls below 0°C is anticipated to decrease by between 39 and 60 days when compared to the baseline.

7.8.15 In the case of extreme precipitation, the mean number of days with heavy rainfall (defined by the Met Office as precipitation greater than 25mm/day) in a given year is expected to increase by between 0.1 and 2.3 days, up to a maximum of 6.3 days (seen on the grid squares 2 and 3 in Plate 7-1: *UKCP18* probabilistic data is provided in 25km grid squares. This map shows the grid squares that are intersected by the A66 route., covering the Appleby to Brough scheme). Similarly, the mean number of dry spells in a given year, defined as periods of at least ten consecutive days with no precipitation, is anticipated to increase by between 0.4 and 0.7 days, to a maximum of 3.5 days per year (for the grid square 4, covering the Stephen Bank to Carkin Moor scheme).

[61] These projections reflect the period for 2060-2079 as the Met Office do not currently provide data beyond 2079 for these parameters.

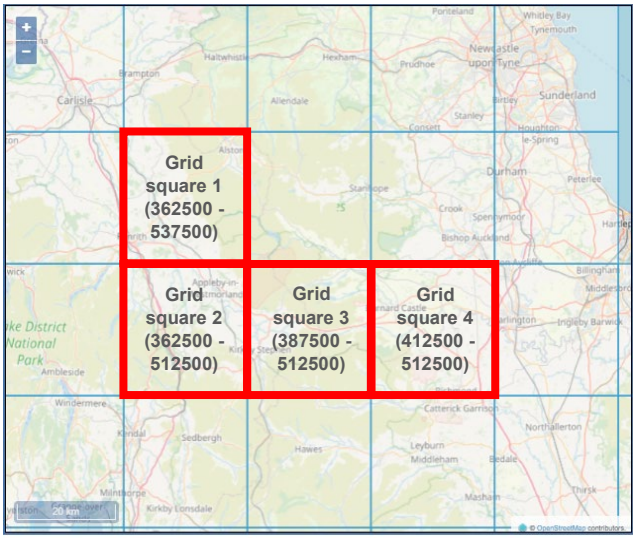

Plate 7-1: *UKCP18* probabilistic data is provided in 25km grid squares. This map shows the grid squares that are intersected by the A66 route.

Table 7-13: *UKCP18* climate change projections for average climate variables for the four 25km grid squares intersected by the Project. Projections reflect the RCP 8.5 high emissions scenario for the period of operation (2080s)[62],[63]

Parameter		Grid Square 1		Grid Square 2		Grid Square 3		Grid Square 4	
		Baseline (1981-2010)	2080s (2070-2099)	Baseline (1981-2010)	2080s (2070-2099)	Baseline (1981-2010)	2080s (2070-2099)	Baseline (1981-2010)	2080s (2070-2099)
Temperature (°C)	Mean winter daily temperature	2.4	5.4	2.9	6.0	2.1	5.2	3.2	6.2
	Mean summer daily temperature	12.8	16.9	13.3	17.5	12.6	16.7	13.8	18.1
	Mean daily winter minimum temperature	-0.5	2.4	0.1	3.0	-0.5	2.5	0.1	2.9
	Mean daily summer maximum temperature	16.8	21.4	17.4	21.9	16.3	20.9	18.5	23.2
Precipitation rate (mm/ day)	Winter mean precipitation rate	4.0	4.3	5.2	5.7	4.5	4.8	2.5	2.9
	Summer mean precipitation rate	2.9	2.3	3.0	2.2	2.8	2.2	2.1	1.5

[62] Met Office (2018) UK Climate Projections (UKCP)
[63] *UKCP18* probabilistic projection data is provided in 25km grid squares. The Project intersects four of these grid squares:
Grid square 1 projections cover the M6 Junction 40 to Kemplay Bank scheme; Penrith to Temple Sowerby scheme; and, the western part of the Temple Sowerby to Appleby scheme
Grid square 2 projections cover the eastern part of the Temple Sowerby to Appleby scheme and the Appleby to Brough scheme
Grid square 3 projections cover the Bowes Bypass scheme
Grid square 4 projections cover the Cross Lanes to Rokeby, Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner schemes

Table 7-14: *UKCP18* climate change projections for extreme weather events for the local area (12km grid square) surrounding each scheme within the Project[64]

Parameter		Temperature			Precipitation	
		Number of frost days (daily minimum temperature equal or lower than 0°C)	Heatwaves (2 days with maximum temperature higher than 29°C and minimum temperature higher than 15°C)	Number of hot days (daily maximum temperature higher than 25°C)	Dry spells (10 days or more with no precipitation)	Heavy rain (number of days per year when precipitation is greater than 25mm per day (Met Office definition of 'heavy rain')
M6 Junction 40 to Kemplay Bank & Penrith to Temple Sowerby	Baseline (1981-2010)	66.5	3.4	66.5	2.8	5.6
	2060s (2050-2079)	21.7	5.6	84.6	3.3	5.9
Temple Sowerby to Appleby	Baseline (1981-2010)	66.1	2.7	26.9	2.5	2.2
	2060s (2050-2079)	18.5	4.5	43.5	2.9	4.0
Appleby to Brough	Baseline (1981-2010)	60.9	2.7	25.1	2.7	4.0
	2060s (2050-2079)	11.4	4.1	39.6	3.1	6.3
Bowes Bypass & Cross Lanes to Rokeby	Baseline (1981-2010)	82.0	2.0	22.2	2.0	3.5
	2060s (2050-2079)	32.4	3.7	40.5	2.5	4.2
Stephen Bank to Carkin Moor	Baseline (1981-2010)	70.9	4.5	38.8	2.9	1.8
	2060s (2050-2079)	26.3	7.2	65.4	3.5	2.2
A1(M) Junction 53 Scotch Corner	Baseline (1981-2010)	56.6	5.9	46.3	2.8	1.4
	2060s (2050-2079)	17.4	9.5	79.6	3.5	1.5

[64] All projections reflect the RCP8.5 high emissions scenario for the 2060s (this reflects the period for 2060-2079 as the Met Office do not currently provide data beyond 2079 for these parameters).

H++ Scenarios

7.8.16 *DMRB LA 114*, Section 3.30, requires that H++ climate scenarios are used to test the sensitivity of the vulnerable safety critical features, to ensure such features would not be affected by more radical changes to the climate beyond that projected in *UKCP18* RCP8.5. These are typically high impact, low likelihood events.

7.8.17 H++ scenarios are a set of plausible 'high-end' climate change scenarios which are typically extreme climate change scenarios on the margins or outside of the 10th to 90th percentile range presented in the UK Climate Projections 2009 (*UKCP09*). The *UKCP18* projections do not include an updated H++ scenario and so the H++ scenario developed from *UKCP09* remains current and applicable. The H++ scenarios are shown in Table 7-15: A summary of the H++ scenarios (extract from Table S1 from the Met Office 2015 report on developing climate change scenarios). and cover the following climate hazards: heat waves, cold snaps, low and high rainfall, droughts, floods and windstorms.

Table 7-15: A summary of the H++ scenarios (extract from Table S1 from the Met Office 2015 report[65] on developing climate change scenarios).

Hazard	Scenario	Scenario Description
Heat waves	H++	Annual average summer maximum temperatures exceeding 30°C over most of the UK and 34°C over much of central and southern England. Hottest days would exceed 40°C in some locations, with 48°C being reached in extreme cases.
Low rainfall	H++	A 6 month duration summer drought with rainfall deficits of up to 60% below the long-term average (1900-1999). Longer dry periods spanning several years with rainfall deficits of up to 20% below the long-term average (1900-1999) across all of England and Wales, similar to the most severe and extensive long droughts in the historical record.
Low river flows	H++	A 30-60% reduction in 'low flows' (Q95) in Scotland and Northern Ireland in a single summer. For multi-season droughts, including 2 summers, a 20 to 50% reduction in low flows in Scotland and Northern Ireland. For longer droughts (2 years or more), a 45% reduction in low flows in Scotland and Northern Ireland.
High rainfall	H++	A 70%-100% increase in winter rainfall (Dec to Feb) in a single winter (from a 1961-1990 baseline). An up to five-fold increase in frequency and 60% to 80% increase in heavy daily and sub-daily rainfall depths, for both summer and winter events (all year round).
High river flows	H++	A 55% to 125% increase in peak flows at the 'lower end' of the H++ scenarios for some regions in Scotland and Northern Ireland. The upper limit for any region is a 290% increase in peak flows (1961-1990 baseline). The scenarios are based on the average response of

[65] Met Office (2015) Developing H++ climate change scenarios for heat waves, droughts, floods, windstorms and cold snaps

Hazard	Scenario	Scenario Description
		"Enhanced-high" catchments, which are particularly sensitive to increases in rainfall.
Windstorms	H++	A 50-80% increase in the number of days per year with strong winds over the UK (1975-2005 baseline). A strong wind day is defined as one where the daily mean wind speed at 850 hPa, averaged over the UK (8W-2E, 50N-60N), is greater than the 99th percentile of the historical simulations.
Cold snaps	L--*	In the 2020s, UK average winter temperatures (December, January and February) of 0.3°C and for the 2080s, UK average winter temperatures would be around -4°C. In the 2020s, UK average temperatures on the coldest day would be -7°C in some locations. UK average temperature of the coldest day would be around -11°C.
*Note the term L-- is used specifically for the 'cold snap' scenario to emphasise that it is at the opposite end of the scale to the extreme warm summer temperatures in H++.		

7.9 Potential impacts

Impact of the Project on climate (GHG emissions assessment)

7.9.1 Based on the Project design and associated construction activities as set out in Chapter 2: The Project, the Project has the potential to impact upon Climate during both construction and operation.

7.9.2 Potential impacts of the Project are described in this section prior to the implementation of the mitigation described in section 7.10: Essential mitigation and enhancement measures. The residual effects of the Project, taking into account this mitigation, are then described in section 7.11: Assessment of likely significant effects.

Construction

7.9.3 As set out in Chapter 2: The Project, section 2.8: Construction, operation and long-term management, construction works are expected to commence in 2024, with all schemes targeted for a 2029 completion or sooner depending on traffic management interface challenges.

7.9.4 The potential sources of GHG emissions during the construction work phase of the Project are listed in Table 7-16: Potential sources of GHG emissions during construction.

Table 7-16: Potential sources of GHG emissions during construction

Sub-stage of Life Cycle	Potential Sources of GHG Emissions
Product stage; including raw material supply, transport and manufacture (A1-A3)	Embodied GHG emissions associated with the required raw materials. Vehicle emissions for transportation prior to factory gate. Industrial and energy emissions in the manufacture of materials.

Sub-stage of Life Cycle	Potential Sources of GHG Emissions
Construction process stage: including transport to and from works site as well as construction and installation processes (A4-A5)	Vehicle emissions for transportation of materials to site. Energy use in construction processes.
Land use change (D)	GHG emissions mobilised from vegetation or soil loss/degradation during construction phase.

Operation

7.9.5 The appraisal period of the Project is 60 years for the purpose of quantifying emissions for this assessment, in line with *DMRB LA 114* and consistent with the CCR assessment. The assumed opening year is 2029 and design year is 2044 (15 years after opening).

7.9.6 The potential sources of GHG emissions and carbon sequestration during the operational phase are listed in Table 7-17: Potential sources of GHG emissions during operation.

Table 7-17: Potential sources of GHG emissions during operation

Sub-stage of Life Cycle	Potential Sources of GHG Emissions
Use of the infrastructure by the end-user (road users) (B9)	Emissions from vehicles using highway infrastructure
Operation and maintenance (including repair, replacement and refurbishment) (B2- B5)	Energy consumption for infrastructure operation and activities of organisations conducting routine maintenance including extraction, manufacture, transportation and installation energy use.
Land use and forestry (D)	The potential aggregate carbon stock sequestered in new habitats created as part of the Project over the course of the study period of the assessment[66].

Vulnerability of the Project to climate change (CCR assessment)

7.9.7 During the operational phase of the Project, there is potential for the anticipated changes to the climate and extreme weather events to impact on the Project in the medium to longer-term.

7.9.8 A summary of the potential impacts on the Project from weather events that may affect the study area is presented in Table 7-18: Summary of weather events and the potential impacts on the Project. Details of the climate change risk (CCR) assessment, including the potential impacts assessed for the Project can be found in Appendix 7.2: CCR Assessment (Application Document 3.4).

[66] As noted, the potential benefits from carbon sequestration during operation are excluded from the evaluation of significance but are presented within the assessment results tables.

Table 7-18: Summary of weather events and the potential impacts on the Project

Primary Weather Event	Potential Impacts
Heavy rain and flooding	Water scour causing structural damage Weakening or wash out of structural soils Changes in ground water level and soil moisture impacting earthwork stability Raised river levels, flooded drains, collapsed culverts Road closures Danger to road users from reduced grip on the road surface Contaminated water Fallen trees
High winds and gales	Damage to structures from wind borne debris and power cuts Additional or uneven loading of structures Fallen trees and damage to landscaping Disruption and potential danger to crossing users Road closures Danger to road users from wind borne debris
Increased temperatures and prolonged periods of hot weather	Health impacts from breathing problems and sunstroke Grass and forest fires Stress on structures and technology Challenges from maintenance regimes Danger to road users (e.g. from vehicle breakdown associated with hot weather)
Increased frequency of extreme weather events	Increased requirement for maintenance and repair Increased costs (e.g. associated with increased frequency of maintenance and repair)
Lightning	Structural damage Danger to road users (e.g. from fallen trees blocking the road) Power surge and tripping electricity breakers. Fires Health impacts from direct strikes
Snow and ice	Road closures Danger to road users from reduced grip on the road surface Damage to roads Health impacts from slipping on ice and chest illnesses
Fog	Danger to road users due to reduced visibility

7.10 Essential mitigation and enhancement measures

Impact of the Project on climate (GHG emissions assessment)

7.10.1 DMRB LA 114 requires that *"Projects shall seek to minimise GHG emissions in all cases to contribute to the UK's target for net reduction in carbon emissions"* (paragraph 3.22).

7.10.2 Minimising GHG emissions through design and construction is a core principle of the UK Government's Infrastructure Carbon Review (H.M. Treasury, 2013)[67], PAS 2080, and National Highway's Net Zero Highways: 2030/2040/2050 plan (National Highways, 2021)[68] and the Transport Decarbonisation Plan (Department for Transport, 2021b)[69].

7.10.3 The Transport Decarbonisation Plan provides a system level strategy for decarbonisation, setting out key steps to be taken to deliver emissions reductions and associated benefits, including plans to decarbonise motor transport. The National Highways Net Zero Highways Plan supports the Transport Decarbonisation Plan and also sets out targets to cut emissions from maintenance and construction.

7.10.4 The *NPSNN* requires that the Project design should provide *"evidence of appropriate mitigation measures (incorporating engineering plans on configuration and layout, and use of materials) in both design and construction. The Secretary of State will consider the effectiveness of such mitigation measures in order to ensure that, in relation to design and construction, the carbon footprint is not unnecessarily high. The Secretary of State's view of the adequacy of the mitigation measures relating to design and construction will be a material factor in the decision-making process"*[7] (paragraph 5.19).

7.10.5 As outlined in Chapter 3: Assessment of alternatives, alternative options have been considered and assessed at each stage of the Project in order to come to a decision on the most appropriate route. A sifting matrix approach was used to assess the alternatives across several criteria, including likely impact on construction and operational carbon. Alternative route options were assessed from a qualitative point of view, based on professional judgment of the climate specialists, to provide input on the likely relative merits of different design options in GHG and CCR terms. Due to the wide range of factors influencing design options not all sifts resulted in the lowest carbon option being preferred, although this did occur for a number of alternatives, where lower carbon was a factor in favour of the selected option e.g. for the Winderwath Estate access it was determined that, on balance, an underpass would be the preferred option in comparison to an overbridge at the location. From a climate perspective it was considered that choosing the underpass would require lower volumes of materials, and associated

[67] H.M. Treasury (2013) Infrastructure Carbon Review.
[68] National Highways (2021) Net Zero Highways: our 2030 / 2040 / 2050 plan
[69] Department for Transport (2021b) Decarbonising transport: a better, greener Britain

energy use for transportation and construction energy, likely resulting in lower total GHG emissions compared to alternatives.

Additionally:

7.10.6 The M6/M40 junction was downgraded from a major infrastructure solution to a resurfacing and slip road widening solution, providing carbon benefits as well as delivering cost and construction disruption benefits; and the A1(M) intervention has also been minimised through design progression; and

- The underpass at Kemplay Bank has been retained for access to avoid the need for construction of a new structure.

7.10.7 As the Project has progressed through design, GHG mitigation measures have been considered and implemented where appropriate. GHG mitigation is considered in the context of the PAS 2080 carbon emissions reduction hierarchy:

- Build nothing: evaluate the basic need for the asset and explore alternative approaches
- Build less: evaluate the potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required
- Build clever: consider the use of low carbon solutions (including technologies, materials and products) to minimise resource consumption during construction, operation and user's use stages of the asset
- Build efficiently: use techniques that reduce resource consumption during construction and operational phase of the asset.

7.10.8 Design stage estimates of GHG emissions associated with structures options were developed (covering PAS 2080 Modules A1-A3) during the Project optioneering process to provide a relative guide when comparing between options, and to ensure embodied GHG impacts could inform decision making on each preferred option.

7.10.9 Examples of where design decisions have been made using the hierarchy are presented in Table 7-19: Mitigation measures.

Table 7-19: Mitigation measures

Mitigation hierarchy	Mitigation measure
Build nothing	The amount of lighting throughout the Project has been minimised. Lighting around the existing Center Parcs junction will be removed as the upgrade of the junction will result in an improvement to safety, removing the need for lighting. Lighting elsewhere in the Project will be limited to only locations identified by road safety audits and traffic assessments where it is required for safety purposes. This removes potential GHG required for manufacture of lighting, and also reduced operational energy use for lighting
Build less	Utilising existing carriageway for the majority of the Penrith to Temple Sowerby scheme
Build less	Reprofiling of embankments to reduce the volumes of stabilisation or import of materials leads to a reduction in embodied carbon for materials, and also reduce transport emissions for materials

Mitigation hierarchy	Mitigation measure
Build less / Build clever	Masonry arches were rejected as an option for culverts on a number of schemes due to their higher embodied carbon and likely higher maintenance requirements
Build less	A two span bridge option with a pier support outside the northern verge was considered on the Cross Lanes to Rokeby scheme. This option was discounted due to the increased costs and carbon emissions associated with the introduction of a second span and pier support
Build less / Build clever	Steel bowstring, tied arch or cable-stayed structures were considered for viaducts on the Appleby to Brough scheme. These options were discounted as it was anticipated that there would be substantially higher carbon emissions associated with materials and inspection / maintenance
Build less	The least carbon intensive option was chosen as the preferred option for 24 structures assessed as part of the optioneering process. Five structures did not choose the lowest carbon option as the preferred option. For these five structures the reasons for not selecting the least carbon intensive option generally relate to the design and appearance of the structures and to greater weighting being given to ecological benefits associated with alternative options. Further information on the approach is set out in the Project Development Overview Report (Application Document Number 4.1)
Build clever	Carbon steel has been discounted from use on overbridges on a number of schemes in order to minimise durability concerns associated with corrosion and to eliminate the need for repainting. Thus, having a beneficial impact on operational GHG emissions (B2-B5)
Build efficiently	The majority of these opportunities will be determined in subsequent project stages as there is increased input from the Principal Contractor(s) (PC) selected to construct the Project. The PC will develop a carbon strategy which will systematically seek to identify and implement opportunities to reduce carbon from existing proposals or compared to business-as-usual approaches.

7.10.10 The hierarchy will continue to be followed throughout the construction phase through the implementation of a measures to reduce carbon emissions during construction. As per the EMP, these measures will be implemented by the PC. Opportunities for carbon reduction during construction include:

- Efficient methods of transport, logistics tracking, geofencing for efficient construction site operations, tailored delivery scheduling, and digital-twin traffic modelling
- Maximising efficient plant usage; Hydrogen lighting, battery powered lighting, and hybrid lighting
- Maximising use of land to install renewable energy sources (permanent and/or temporary)
- Consider echelon paving technique to increase longevity of surfaces.
- Hydrophobic concrete (negates need for waterproofing of structures) reducing maintenance and associated emissions
- Use recycled asphalt, and graphene asphalt (Gipave) which can increase longevity of surfaces
- H Pile use providing a reduction in materials required and providing better material longevity

- Cemfree concrete which can provide up to 80% saving on associated GHG emissions compared to typical materials
- Electrical Vehicles onsite - charge points in compounds to facilitate a reduction in fossil fuel powered vehicles
- Mains connected compound provided via a Green Tariff to provide lower carbon intensive electricity for site operation and construction
- Local procurement, local labour and training - reducing reliance on transportation of workforce and provision of accommodation.

Vulnerability of the Project to climate change (CCR assessment)

7.10.11 The potential CCR risks are expected to be largely mitigated through the use of appropriate design standards, delivered through quality construction, as well as appropriate asset management procedures during operation.

7.10.12 Many general mitigation and adaptation measures to address CCR risks have been considered within the Project to date and embedded into the current design. Many of these measures relate to impacts associated with other topic chapters and so have been identified within the relevant topic chapters of the ES. For example, water management and addressing drainage issues relating to flooding are considered in Chapter 14: Road Drainage and the Water Environment, as well as through the Project design process, led by the design teams.

7.10.13 The CCR assessment identifies and takes into account existing resilience measures (embedded mitigation) for each climate variable where these are either already in place or identified as being included within the design development by the design teams.

7.10.14 The Project will be designed to be resilient to impacts arising from weather events and climatic conditions in accordance with current planning, design and engineering practice, standards and codes. The climate assessment assumes that design and engineering practice standards and codes incorporate conservative assumptions of future climatic conditions, as guided by *UKCP18*, and that these are being used in the design process, particularly for safety critical assets[70].

7.10.15 Most weather and climate-related resilience effects during operation are expected to be mitigated through measures embedded in the design of the Project as a result of meeting current planning, design and engineering practice and codes. It is expected that these practices and codes will provide effective resilience throughout the operational phase of the Project (for the study period of a 60-year project lifetime).

7.10.16 To provide mitigation for increases in peak rainfall events and peak flows in watercourses as a result of climate change, and which might

[70] For example, CG 501 Design of highway drainage systems: Section 4 makes reference to climate change; and DMRB CD 622 Managing Geotechnical Risk specifies that degradation of material parameters with respect to climate change is accounted for during design, and that the Geotechnical Design Report accounts for future climate change scenarios for drainage and flooding.

result in higher risk of flooding, the design takes into account the results of a FRA for the Project which is presented in Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4). The FRA incorporates Environment Agency allowances (Environment Agency, 2021)[71] for increases in rainfall intensity and peak river flow in a future changed climate and considers the increased future risk from both pluvial and fluvial flooding.

7.10.17 A summary of the key climate resilience and adaptation measures embedded in the design are summarised in Table 7-20: Examples of embedded mitigation in the Project design, considered within the CCR assessment.

Table 7-20: Examples of embedded mitigation in the Project design, considered within the CCR assessment.

Climate Hazard	Example of Embedded Mitigation
Heavy rain and flooding	FRA and modelling informs design mitigation and includes climate change allowance defined by Environment Agency allowances for increases in rainfall intensity and peak river flow (Environment Agency, 2021)[72] in a future changed climate. The climate change allowances considered in the drainage design throughout the Project are Q100+94% for peak river flow, Q100+40% for drainage ponds, and Q5+40% for road drainage. Where low spots and sags are identified in the vertical geometry of the road, the capacity of drainage outlets will be doubled to reduce the risk of water ponding on the road surface. Maintenance regimes will monitor sediment build up in drainage systems and remove debris causing blockages. In the Bowes Bypass scheme, it is anticipated that the redesign of the road drainage system and existing culverts may reduce the existing flood risk that was identified through analysis of the Highway's Agency Drainage Data Management System (Table 7-12: Number of recorded previous flood events that have occurred on the existing A66 within the Order Limits of each scheme since 2005. Open flood events refer to those which are currently being monitored.). An existing flood risk at Stephen Bank to Carkin Moor scheme was identified through analysis of the Highway's Agency Drainage Data Management System (Table 7-12: Number of recorded previous flood events that have occurred on the existing A66 within the Order Limits of each scheme since 2005. Open flood events refer to those which are currently being monitored.). However, the new highway for this scheme is offline and so a new drainage system associated with the new highway is being implemented. Geotechnical design of slopes considers long-term stability and risk from surface water scouring, groundwater and pore water pressure. Where

[71] Environment Agency (2021) Flood risk assessments: climate change allowances
[72] Environment Agency (2021) Flood risk assessments: climate change allowances

Climate Hazard	Example of Embedded Mitigation
	possible, slopes have been designed to no greater than a 1 in 3 gradient to improve stability. For steeper slopes, earth retention systems or reinforcement will be used to improve stability. The risk of earthwork destabilisation at Warcop (within the Appleby to Brough scheme) due to the topography channelling large volumes of runoff across the scheme has been mitigated by enhancing the surface water drainage on the upslope of cuttings. Risks from subsidence and sink hole formation following storm events have been considered in route selection. In particular, the route selection for the Temple Sowerby to Appleby scheme has avoided areas of former mine working where there is a known risk of sink hole formation. It is expected that the pavement design, material specification and maintenance regime will mitigate against surface deterioration and associated risks to road users.
High winds and gales	Structures are designed to accommodate wind loading criteria as specified in design standard *BS EN 1991-1-4* (The European Union, 2005)[73] and NA *BS EN 1991-1-4* (Rees et al., 2011)[74]
Increased temperatures and prolonged periods of hot weather	Structures are designed to accommodate the range of worst case high and low temperatures specified in the standards which differ depending on geographical locations. There are specified in *BS EN 1991-1-5* (The European Union, 2003)[75] and NA *BS EN 1991-1-5*. It is expected that the pavement design, material specification and maintenance regime will mitigate against surface deterioration and the impacts of hot weather.

7.10.18 The assessment of the likely significant effects identifies five significant risks. It has then considered how implementing additional proposed future mitigation could reduce the likelihood and consequence of the significant risks identified, such that they are not significant.

7.10.19 The CCR assessment has also identified additional proposed mitigation measures through the sensitivity test of the safety critical features against H++ scenarios which are set out in Sensitivity test of the Project's vulnerable safety critical features against the H++ climate scenarios of section 7.11: Assessment of likely significant effects.

[73] The European Union (2005) EN 1991-1-4(English): Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]
[74] Rees, J., Harris, T., Smith, B., Denton, S. and Ko, R., (2011) The UK National Annex to BS EN 1991-1-4, BS EN 1991-1-5, and PD 6688-1-4. In Bridge Design to Eurocodes: UK Implementation (pp. 123-147). ICE Publishing.
[75] The European Union (2003) EN 1991-1-5 (English): Eurocode 1: Actions on structures - Part 1-5: General actions - Thermal actions [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

7.10.20 The qualitative assessment of the climate change resilience of mitigation measures outlined by other EIA topics has identified several classes of mitigation measures that may be vulnerable to climate change. These classes are listed below. The implementation of these mitigation measures should ensure their resilience to climate change resilience is considered.

- The restoration and creation of habitats and landscaping measures should consider the resilience of the vegetation used to ensure the mitigation remains effective throughout operation in light of changes to temperatures and precipitation. The Landscape Environmental Management Plan (LEMP) (Annex B.1 of EMP (Application Document 2.7)) specifies the use of mixed woodlands for planting to maximise resilience.
- The appropriate timing of maintenance works which affect habitats to avoid breeding seasons should be monitored and adapted throughout operation to reflect changes in the timing of the breeding season as a result of climate change, as outlined in the LEMP.
- The implementation of mitigation measures which involve earthworks and soft-engineered slopes will include a design principal to ensure they are resilient to the projected increase in precipitation intensity and the associated risks to earthwork stability, including erosion from surface runoff and potential impacts from increases in groundwater flow and porewater pressure.
- The design of drainage-related mitigation measures should incorporate the Environment Agency climate change allowances for rainfall intensity[34]. Drainage outflows should be designed to account for climate change allowances and the sensitivity of the receptive environment and biodiversity receptors, including newly created habitats, as outlined in the EMP.

7.11 Assessment of likely significant effects

7.11.1 This section presents an assessment of the likely significant effects of the Project on Climate. Likely effects not predicted to be significant are presented in Appendix 7.1: GHG Emissions Assessment (Application Document 3.4) Appendix 7.2: CCR Assessment (Application Document 3.4).

Impact of the Project on climate (GHG emissions assessment)

7.11.2 *DMRB LA 114* guides that the assessment of projects on climate shall only report significant effects where increases in GHG emissions will have a material impact on the ability of Government to meet its carbon reduction targets. However, it does not provide further clarity on the definition of "material impact".

7.11.3 The *NPSNN* also states that “It is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets”.

7.11.4 This assessment presents a breakdown of the emissions calculated for the Project, and a comparison against UK Government carbon budgets, to determine the significance of emissions. The assessment is based upon information available at the time of the assessment, including information from design teams and the buildability contractor, and results of traffic modelling for the road network in operation.

7.11.5 The assumptions and limitations associated with the assessment are listed in section 7.6: Assumptions and limitations and in Appendix 7.1: GHG Emissions Assessment (Application Document 3.4).

Construction

7.11.6 The total, and broken down, construction phase emissions are displayed in Table 7-21: Emissions associated with construction by scheme including land use change impacts. Emissions from the construction phase are predicted to total 518,562 tCO_2e including emissions associated with land use change during the construction period.

7.11.7 The approach taken to estimating GHG emissions associated with Land Use Change has been to model the loss of all carbon in soils and vegetation within the Order Limits during construction where land is changing from one habitat to another. In many cases habitats are changing as part of ecological improvements and will provide a greater biodiversity value, and greater potential for GHG sequestration as a result. However, these are modelled as a total loss of carbon stock during construction, followed by ongoing carbon sequestration year-on-year during the operational phase. In many schemes the main area of GHG release during construction will be focused on the construction of the new route, with areas outside this either remaining similar in habitat or being improved. For the purposes of the evaluation of significance for GHG emissions a pessimistic approach has been adopted which assumes construction impacts (i.e. loss of stored carbon) across the full Order Limits, and no benefits accruing from new habitat creation during the operational phase (although, in practice, new habitats will provide a benefit). By omitting the operational benefits from the evaluation of significance it is considered that a highly precautionary approach has been adopted. The assessment quantification results for construction are presented in Table 7-21: Emissions associated with construction by scheme including land use change impacts.

Table 7-21: Emissions associated with construction by scheme including land use change impacts

Scheme	PAS 2080 module						Total (tCO_2e)
	A1-A3	A4	A5			D	
	Materials Embedded (tCO_2e)	Transport to works site (tCO_2e)	Energy Use (tCO_2e)	Business & Employee Transport (tCO_2e)	Waste & Waste Transport (tCO_2e)	Land Use Change (tCO_2)	
M6 Junction 40 to Kemplay Bank	17,423	914	829	564	1,808	10,125	31,663
Penrith to Temple Sowerby	25,061	4,816	1,543	329	200	23,805	55,754
Temple Sowerby to Appleby	59,792	2,230	4,759	1,178	6,512	67,551	142,022
Appleby to Brough (Warcop)	63,835	3,970	4,100	703	10,501	60,512	143,621
Bowes Bypass	12,694	1,937	691	170	1,328	9,332	26,152
Cross Lanes to Rokeby	18,381	3,043	1,102	261	1,852	22,679	47,318
Stephen Bank to Carkin Moor	33,021	1,501	2,221	361	5,319	29,139	71,562
A1 (M) Junction 53 Scotch Corner	69	12	245	0	7	137	470
Total for module category	230,276	18,423	15,490	3,566	27,527	223,280	518,562
Construction stage total (tCO_2e)							518,562

7.11.8 The largest source of emissions during the construction phase of the Project is expected to arise from construction materials, including sourcing, processing and manufacture (PAS 2080 module: A1-A3). A1-A3 emissions account for 44% of total construction emissions.

7.11.9 Emissions associated with the loss of carbon stock from habitats lost during construction equate to 43% of total construction stage emissions, although as noted above, in practice the planting of new habitats leads to sequestration benefit during operational phase.

7.11.10 As noted in section 7.4: Assessment methodology, an important assumption on the quantity of excavated material requiring lime stabilisation has been updated in the assessment methodology for ES. The assessment at PEI Report assumed that 100% of excavated material requiring stabilisation was replaced with lime. This was an error in application of the assumptions, as in practice the quantity would be much lower. An updated assumption for ES is that the quantity of additional lime required for stabilisation is 8% of the proportion of excavation material identified as requiring stabilisation[76]. This is a conservative estimate, and the percentage of lime addition in practice is expected to be lower than this figure.

Operation

7.11.11 The assessment of operational emissions includes the use of the road (i.e. emissions from vehicles); the need to maintain/replace certain elements of the Project periodically; and land use change benefits arising from planting.

7.11.12 As noted in section 7.4: Assessment methodology, there are likely minimal direct emissions associated with operating the Project since the lighting of most schemes is minimal or not implemented (given the rural nature of much of the Project). In some cases where lighting is being provided, this is replacing existing lighting. This would provide some operational benefit albeit due to the overall scale of other user emissions this benefit is likely to be marginal in terms of the overall GHG assessment. Similarly in the limited areas where new lighting is provided then this is similarly expected to be marginal in terms of overall operational emissions. On this basis power consumption has been assumed as negligible in the context of the Project and therefore has not been taken forward as part of the GHG emissions assessment.

[76] An exercise was carried out to understand the impact of the methodology change whereby material requiring stabilisation was treated with the addition of lime. At PEI Report this was assumed at 100% and at ES a more appropriate assumption of 8% has been used. If this assumption had been made at PEI Report then the overall construction stage emissions (A1-5) reported in PEI Report would have been reduced by between 72% and 75% depending on the combination of route options being assessed. The worst performing combination would be reduced from 1,250 $ktCO_2e$ to 309$ktCO_2e$. It is important to note that this change in the calculated emissions from PEI Report reflect only the assumption on the use of lime for ground stabilisation, and do not reflect any other design or technical changes between PEI Report and ES. The review exercise has also confirmed that the change in methodology, while reducing estimated GHG emissions across all schemes and options, would not have resulted in the selection of different preferred scheme options.

7.11.13 Operational phase emissions for the baseline, modelled opening and design years are presented in Table 7-22 Routewide emissions associated with operation. Also included are the total operational emissions over the modelled 60-year study period.

7.11.14 Emissions from the operational phase are predicted to total 77,015,521 tCO_2e over the 60-year study period as presented in Table 7-22 Routewide emissions associated with operation, however, as noted in section 7.4: Assessment methodology, benefits associated with carbon sequestration from land use change in operation is excluded from the evaluation of significance. Emissions from the operational phase excluding benefits from land use change (to be included in the evaluation of significance) are predicted to total 77,162,187 tCO_2e over the 60-year study period as presented in Table 7-23: 'Do-Something' and 'Do-Minimum' operation (‘use stage’) emissions

Table 7-22 Routewide emissions associated with operation

PAS 2080 module	Emissions (tCO_2e)		
	2029 modelled opening year	2044 modelled design year	Total over modelled 60-year appraisal period (2029 – 2089)
Maintenance and refurbishment (B2-B5) [77]	2,027	2,027	121,608
Vehicles using the highways infrastructure (B9)	1,546,036	1,243,698	77,040,579
Land use and forestry (D): future ability to sequester carbon from habitats gained (over the 60-year assessment period)[78]	- 2,444	- 2,444	- 146,666
Total for module category	1,545,618	1,243,280	77,015,521
Operation stage total (tCO_2e)			77,015,521

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

7.11.15 The GHG emissions associated with construction do not occur in the ‘Do-Minimum’ scenario. On this basis it can be considered that the construction stage of the Project would have the effect of releasing

[77] In order to provide an annual estimate of maintenance and refurbishment emissions the total A1-3 for the 60-year study period have been portioned across each year of the study period.
[78] Figures are based on 60-year carbon sequestration then apportioned to each year on an average basis. In practice the rate of sequestration will be non-linear. This leads to the same value being present for both 2029 modelled opening year and 2044 modelled design year. Negative values represent the capture of carbon in the soil arising from land use and forestry (i.e. negative GHG emissions). These values have been quantified for the operational stage but are excluded from the main assessment and evaluation of significance.

approximately 502,219 tCO_2e into the atmosphere in the ‘Do-Something’ scenario when compared to the 'Do-Minimum' scenario[79].

7.11.16 The calculated annualised operational stage emissions for the modelled 2029 and 2044 ‘Do-Minimum’ and ‘Do-Something’ scenarios and the total net operation stage emissions over the 60-year study period for the ‘Do-Minimum’ and ‘Do-Something’ scenarios are compared in Table 7-23: 'Do-Something' and 'Do-Minimum' operation (‘use stage’) emissions.

7.11.17 The total 'net' operational emissions (i.e. 'Do-something' scenario minus 'Do-minimum' scenario) are predicted to total 2,043,786 tCO_2e over the 60-year study period including benefits associated with land use change during operation, and 2,190,452 tCO_2e over the 60-year study period when excluding benefits from land use change during operation. As noted, the evaluation of significance uses the more conservative estimate of total 'net' GHG emissions when benefits from operational land use change are excluded.

[79] It is noted that under the 'Do minimum' scenario there will still be a need to provide maintenance for the existing A66. However, this is considered marginal and has not been quantified for the assessment. This has the effect of increasing net GHG emissions for the 'Do something' assessment in line with the conservative approach taken to quantification of emissions arising from the Project.

Table 7-23: 'Do-Something' and 'Do-Minimum' operation ('use stage') emissions

Project stage / PAS 2080 Module	Emissions (tCO_2e)								
	Modelled opening (future) year (2029)			Modelled design (future) year (2044)			Total over modelled 60-year operation (2029 – 2089)		
	'Do-minimum' scenario	'Do-something' scenario	Difference [80]	'Do-minimum' scenario	'Do-something' scenario	Difference	'Do-minimum' scenario	'Do-something' scenario	Difference
Maintenance and replacement (B2-B5)	N/A	2,027	2,027	N/A	2,027	2,027	N/A	121,608	121,608
Vehicles using the highways infrastructure (B9)	1,506,832	1,546,036	39,204	1,209,944	1,243,698	33,754	74,971,735	77,040,579	2,068,844
Land use and forestry (D)*	0	-2,444	-2,444	0	-2,444	-2,444	0	-146,666	-146,666
Total operational 'use stage' emissions excluding operational land use benefits	1,506,832	1,548,063	41,231	1,209,944	1,245,725	35,772	74,971,735	77,162,187	2,190,452
Total operational 'use stage' emissions including operational land use benefits	1,506,832	1,545,618	38,786	1,209,944	1,243,280	33,337	74,971,735	77,015,521	2,043,786
*These results are tCO_2 only									

[80] 'Do something' scenario minus the 'Do-minimum' scenario

Evaluation of significance

7.11.18 The construction phase of the Project is planned to start in 2024 with all schemes targeted for completion in 2029 and therefore the opening year is 2029 for the operational phase of the Project.

7.11.19 Construction phase GHG emissions have therefore been assessed against the UK's Fourth (2023-2027) and Fifth (2028-2032) Carbon Budgets. The assessment took the total construction emissions and compared this to the total Fourth carbon budget and total Fifth carbon budget as a worst-case assessment where schedule changes might lead to full construction falling within a single budget period.

7.11.20 The total estimated construction phase GHG emissions would represent 0.027% of the Fourth Carbon Budget and 0.030% of the Fifth Carbon Budget, respectively.

7.11.21 Operational phase emissions have been assessed against the Sixth Carbon Budget (2033-37) (as the Carbon Budget set furthest into the operational phase) by taking an annual operational emissions figure (i.e. net emissions for the future modelled year of 2044 plus one sixtieth of estimated maintenance emissions) and comparing it to an annual figure for the Sixth Carbon Budget (i.e. one fifth of the Sixth Carbon Budget). Land-use benefits during the operational phase have been excluded from the evaluation of significance to provide a pessimistic assessment.

7.11.22 The estimated operational phase GHG emissions would represent 0.019% of the Sixth Carbon Budget.

7.11.23 Table 7-24: Comparison of emissions against UK Carbon Budgets shows the GHG emissions of each project stage against the relevant UK Carbon Budgets.

Table 7-24: Comparison of emissions against UK Carbon Budgets

Project stage	Estimated total GHG emissions over carbon budget (tCO_2e) ('Do-something' Scenario)[81]	Net CO_2 project GHG emissions (tCO_2e) (Do something minus Do-minimum)[82]	Relevant carbon budget[83]		
			4th (2023-27)	5th (2028-32)	6th (2033-37)
Construction[84]	518,562	518,562	0.027%	0.03%	N/A

[81] Figures presented are the total GHG emissions for construction of the Project and the operation of the Project over the assumed 60-year lifetime.
[82] Figures presented are the total net GHG emissions the operation of the Project over the assumed 60-year lifetime.
[83] Figures presented compare the total GHG emissions for construction of the Project and the operation of the Project over the assumed 60-year lifetime, against the relevant carbon budget(s).
[84] It should be noted that the construction phase is forecast to fall across 4 years within the 5-year Fourth carbon budget period, and 2 years within the 5-year Fifth carbon budget.

Project stage	Estimated total GHG emissions over carbon budget (tCO_2e) ('Do-something' Scenario)[81]	Net CO_2 project GHG emissions (tCO_2e) (Do something minus Do-minimum)[82]	Relevant carbon budget[83]		
			4th (2023-27)	5th (2028-32)	6th (2033-37)
Operation[85]	77,162,187	2,190,452	N/A	N/A	0.019%
Total	77,680,749	2,709,014	0.027%	0.03%	0.019%

7.11.24 The analysis following *DMRB LA 114* shows that emissions from the Project to be low when compared against the relevant carbon budgets. As set out by *DMRB LA 114* and in line with the *NPSNN*, the assessment concludes that the Project's GHG emissions, in isolation, will not have a significant effect on climate or a material impact on the ability of the Government to meet its carbon reduction plan targets and Carbon Budgets.

7.11.25 In line with *DMRB LA 114*, the GHG emissions performance of the Project have been benchmarked against other recent road scheme projects within the Strategic Road Network. Benchmarking has been carried out by dividing the reported construction emissions (A1-5) for each project by the estimated capital cost of construction to provide a tCO_2/£1k benchmarking parameter. The benchmarking comparison is shown in Plate 7-2: Benchmarking of construction emissions against other road schemes within the SRN.

[85] The operational emissions for the 5-year budget period include the modelled yearly emissions for each year, plus an allowance for average annual maintenance/replacement emissions over the 60-year study period.

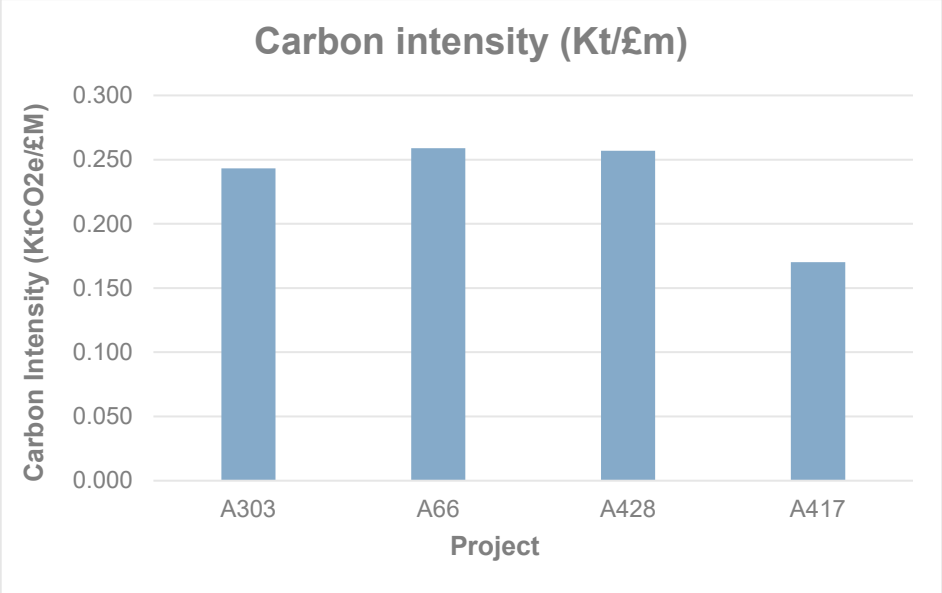

Plate 7-2: Benchmarking of construction emissions against other road schemes within the SRN

7.11.26 The benchmarking exercise demonstrates that the GHG emissions associated with construction of the Project are comparable to other road schemes. On this basis it is considered reasonable to conclude that the carbon footprint of the Project is not unnecessarily high.

Vulnerability of the Project to climate change (CCR assessment)

Project-wide assessment

7.11.27 Risks associated with climate change for the operational phase of the Project have been identified and assessed for their likelihood and consequence to evaluate the significance, utilising information on the future baseline (drawn from the *UKCP18* probabilistic projections of climate change and the *UKCP18* regional projections of climate change).

7.11.28 Risks have been assessed on a project-wide basis, highlighting the schemes to which they are relevant further to the specific conditions that apply.

7.11.29 Appendix 7.2: CCR Assessment (Application Document 3.4) sets out further details on the risks identified, the schemes they are relevant to, the likelihood and consequence assigned to each risk, and the embedded mitigation relevant to each risk which formed the assessment.

Analysis of CCR risks

7.11.30 The preliminary assessment has found that most climate change risks during the operational phase of the Project are ‘not significant’ due to effective embedded mitigation measures in the existing project design, or which will be delivered through monitoring and maintenance regimes assumed to be in place throughout operation (Appendix 7.2: CCR Assessment (Application Document 3.4)).

7.11.31 Five climate change risks have been assessed as significant:

- **Increased surface rainfall run-off** resulting in scouring of embankments and cuttings, leading to earthworks failure. The risk of scouring of embankments and cuttings from surface run-off was identified as a potential significant risk by the geotechnical team. This will be mitigated further during detailed design by identifying specific areas of high risk and by implementing run-off defences such as masonry gullies. Future monitoring of embankments and cuttings during/following storm events will also help to identify any area for which additional run-off defences are required.
- **Extended periods of hot dry weather** leading to a risk of spontaneous grassland fires in the vicinity of the route, affecting safety on the road in operation. Wildfires typically occur at the urban-rural interface (Philosophical Transactions of the Royal Society B: Biological Sciences, 2016)[86]. The national climate change risk assessment (Department for Environment, Food & Rural Affairs, 2021)[87] identified an increased frequency of wildfires as a key risk from climate change. The risk should be closely monitored throughout the operation of the road and an increased frequency of wildfires in the vicinity of the road should prompt an active collaboration between National Highways, landowners and land managers to install proactive, preventative measures to reduce the likelihood of wildfires occurring.
- **Flooding of the road surface** within the Kemplay Bank Underpass. The M6 Junction 40 to Kemplay Bank scheme consists largely of an underpass, taking the main carriageway of the Project underneath the existing Kemplay Bank roundabout. The vertical geometry of the road within the underpass has the potential to create low spots or sags in the road surface where water could pond during storm events. If this underpass was to flood it has the potential to cause short-term regional disruption through closure of the road (A66). Kemplay Bank also represents an important access/egress route for nearby emergency services, including Penrith Hospital, Penrith community fire and ambulance station and a Cumbria Constabulary police station. The necessity of this section of the route for these emergency services would increase the consequence of any road closure. The road drainage within the underpass has been designed to the requirements of CG 501 (National Highways (previously Highways England), 2020b)[88] and CD 521 (National Highways (previously Highways England), 2020c)[89] to provide a design to ensure no flooding for a 1 in 5 year rainfall event. However, when considering the *UKCP18* projects for the RCP 8.5 high emissions scenario, short-term operational disruption of the route due to exceedance of this drainage capacity is considered a potential significant risk. This risk

[86] Philosophical Transactions of the Royal Society B: Biological Sciences (2016) Wildfire policy and management in England: an evolving response from Fire and Rescue Services, forestry and cross-sector groups.]
[87] Department for Environment, Food & Rural Affairs (2012) UK Climate Change Risk Assessment: Government Report.

will be mitigated at detailed design through the addition of additional drainage capacity, if required, based on detailed flood modelling.

- **Structural failure of multi-span bridges** due to the erosion and scouring of piers located within floodplains. The Temple Sowerby to Appleby and Appleby to Brough schemes both include multi-span bridge structures which will require piers to be placed within a floodplain. As climate change increases the frequency and magnitude of large flood events, the risk of structural failure due to scouring and erosion of these piers is considered to be a potential significant risk. This risk will be mitigated during detailed design following the completion of a ground investigation. Mitigation will include the use of appropriate foundations in pier design which reduce the risk of scour damage and, if required, the implementation of concrete aprons to protect piers that are deemed to be particularly vulnerable.
- **Increased risk to high-sided vehicles due to high wind speeds**. During ongoing engagement, stakeholders shared their previous experience of high wind speeds at specific locations along the A66. Stakeholders highlighted locations in the temple Sowerby to Appleby, Appleby to Brough, and Cross Lanes to Rokeby schemes. Wind speeds are projected to increase throughout the study period due to climate change and could exacerbate the effect of wind in these locations. Therefore, the potential impact of high winds in these locations on the safety of road users, particularly high-sided vehicles, has been assessed as having the potential to give rise to a significant risk. The potential effect of wind on structures has been taken account of in the preliminary design across the Project in line with design standards, however further investigation is required at detailed design to better understand the severity of the risk to road users from high winds at these locations. This investigation should consider the potential impacts of future increased wind speeds due to climate change. If this further investigation confirms that high-wind speeds in these locations may cause dangerous conditions to road users, then further mitigation will be implemented at detailed design to reduce the risk. Further mitigation could include the use of wind baffles, signage in high-risk locations warning road users of the potential risks, and the monitoring of observed and forecast wind speeds to allow for dynamic communications of the potential risks to road users (for example via social media channels). Ultimately, in extreme circumstances, sections of the road could be temporarily closed to vehicles where there may be a risk of overturning.

7.11.32 Table 7-25: Significant risks identified within the CCR assessment outlines the four risks identified as significant in the preliminary assessment. It also shows: the embedded mitigation considered in the assessment; the likelihood and consequence of each risk; and the schemes for which the risk is applicable.

Table 7-25: Significant risks identified within the CCR assessment

Potential Climate Change Risk to the Project	Existing or Embedded Mitigation Measure	Likelihood	Consequence	Schemes for Which Risk is Significant
Increased surface run-off resulting in scouring of embankments and cuttings, leading to earthworks failure	Attenuation ponds are designed for a Q100 event +40% allowance for climate change. Road drainage design is designed to accommodate a Q5 storm event +40% allowance for climate change. All cuttings and embankments will be drained in accordance with the DMRB to intercept overland flows and minimise surface water scouring earthworks.	Medium	Large adverse	All schemes
Extended periods of hot dry weathers leading to a risk of spontaneous grassland fires in the vicinity of the route, affecting safety on the road	National Highways standard emergency procedures for wildfires on or around the Strategic Road Network. The road will also act as a firebreak, providing a gap in combustible material that will act as a barrier to slow or prevent the progress of a wildfire.	High	Moderate adverse	• Penrith to Temple Sowerby • Temple Sowerby to Appleby • Appleby to Brough • Bowes Bypass • Cross Lanes to Rokeby • Stephen Bank to Carkin Moor
Flooding of the road surface within the Kemplay Bank Underpass	In line with drainage design standards, run-off drainage systems will be designed to take into account a 40% increase in peak rainfall intensity by the 2080s. The underpass will be designed to the requirements of CG 501 (National Highways,	Medium	Large adverse	• M6 Junction 40 to Kemplay Bank

Potential Climate Change Risk to the Project	Existing or Embedded Mitigation Measure	Likelihood	Consequence	Schemes for Which Risk is Significant
	2020b)[88] and CD 521 (National Highways, 2020c)[89] to provide a design to ensure no flooding for a 1:5-year rainfall event plus a 40% climate change allowance.			
Structural failure of multi-span bridges due to the erosion and scouring of piers located within floodplains.	No piers will be located within the river channel itself, meaning the risk from scour and erosion is isolated to flood events (although it is possible that the channel may migrate to encompass one or more piers in future).	Medium	Large adverse	• Temple Sowerby to Appleby • Appleby to Brough (Warcop)
Increased risk to high-sided vehicles due to high wind speeds	No embedded mitigation identified.	Medium	Moderate adverse	• Temple Sowerby to Appleby • Appleby to Brough (Warcop) • Cross Lanes to Rokeby

7.11.33 The assessment has considered how proposed and future mitigation could reduce the likelihood and consequence of the significant risks identified.

7.11.34 Table 7-26: Proposed future mitigation to mitigate the impact of significant risks to the Project presents the proposed and future mitigation against each of the significant risks.

Table 7-26: Proposed future mitigation to mitigate the impact of significant risks to the Project

Potential Climate Change Risk to the Project	Schemes for Which Risk is Significant	Proposed Future Mitigation
Increased surface run-off resulting in scouring of embankments and cuttings, leading to earthworks failure	All schemes	Areas of high risk will be identified and run-off defences (e.g. masonry gullies) will be built into detailed design by the design teams. Embankments and cuttings will need to be monitored by National Highways to identify any

[88] National Highways (2020b) CG 501 Design of highway drainage systems.]
[89] National Highways (2020c) CG 521 Hydraulic design of road edge surface water channels and outlets.

Potential Climate Change Risk to the Project	Schemes for Which Risk is Significant	Proposed Future Mitigation
		areas where additional run-off defences are required.
Extended periods of hot dry weathers leading to a risk of spontaneous grassland fires in the vicinity of the route, affecting safety on the road	• Penrith to Temple Sowerby (Center Parcs) • Temple Sowerby to Appleby • Appleby to Brough (Warcop) • Bowes Bypass • Cross Lanes to Rokeby • Stephen Bank to Carkin Moor	The occurrence of wildfires in the vicinity of the route will be monitored. If the frequency of wildfire events starts to increase, it is proposed that National Highways should engage landowners/land managers to discuss adaptive management techniques to reduce wildfire risk.
Flooding of the road surface within the Kemplay Bank Underpass	M6 Junction 40 to Kemplay Bank	The design will incorporate an exceedance test in the underpass area during detailed flood modelling. Extra storage will be installed to hold exceedance flows if required based on the flood modelling. Detailed modelling results will be incorporated into detailed design and will take into account the run-off from the cuttings in the underpass. Additional drainage mechanisms will be incorporated into the design for steep sections of the road surface where there is a danger of high velocity flow bypassing drainage outlets during storm events. If required, larger/more gullies, larger/more pipes to the attenuation pond, and increased maintenance frequency could be considered as additional mitigation at detailed design.
Structural failure of multi-span bridges due to the erosion and scouring of piers located within floodplains.	• Temple Sowerby to Appleby • Appleby to Brough (Warcop)	The risk will be mitigated at detailed design, following the completion of ground investigations. The pier foundations will be designed to be resilient from scour and erosion, and concrete aprons will be added to the design to protect any piers that are considered to be particularly vulnerable to scour during flood events and to ensure operational resilience if river channel migration results in the piers being situated within the river channel in future.

Potential Climate Change Risk to the Project	Schemes for Which Risk is Significant	Proposed Future Mitigation
Increased risk to high-sided vehicles due to high wind speeds	• Temple Sowerby to Appleby • Appleby to Brough (Warcop) • Cross Lanes to Rokeby	A further investigation will be undertaken at detailed design to better understand the severity of the risk from high winds at the locations highlighted by Stakeholders based on their previous experience. If this further investigation confirms that high-wind speeds in these locations may cause dangerous conditions to road users, then further mitigation will be implemented at detailed design, for example wind baffles, signage in high-risk locations and the monitoring of observed and forecast wind speeds to allow for dynamic communications (for example via social media channels). In extreme circumstances, sections of the road will be temporarily closed to vehicles where there may be a risk of overturning.

7.11.35 Table 7-27: Reassessment of significant climate change resilience risks during operation assuming the successful implementation of the proposed future mitigation outlined in Table 7 reassesses each of the significant risks, considering the proposed and future mitigation, based upon the assumption that the proposed future mitigation would be incorporated during further design and would be fully implemented successfully.

Table 7-27: Reassessment of significant climate change resilience risks during operation assuming the successful implementation of the proposed future mitigation outlined in Table 7

Potential Climate Change Risk to the Project	Likelihood of Occurrence Following Implementation of Proposed Future Mitigation	Consequence Following Implementation of Proposed Future Mitigation	Re-assessment of Significance Following Implementation of Proposed Mitigation
Increased surface run-off resulting in scouring of embankments and cuttings, leading to earthworks failure	Low	Large adverse	Not significant
Extended periods of hot dry weathers leading to a risk of spontaneous grassland fires in the vicinity of the route, affecting safety on the road	Low	Moderate Adverse	Not significant
Flooding of the road surface within the	Low	Large Adverse	Not significant

Potential Climate Change Risk to the Project	Likelihood of Occurrence Following Implementation of Proposed Future Mitigation	Consequence Following Implementation of Proposed Future Mitigation	Re-assessment of Significance Following Implementation of Proposed Mitigation
Kemplay Bank Underpass			
Structural failure of multi-span bridges due to the erosion and scouring of piers located within floodplains.	Low	Large Adverse	Not significant
Increased risk to high-sided vehicles due to high wind speeds	Low	Moderate adverse	Not significant

7.11.36 Following the inclusion of the additional mitigation measures, the likelihood and consequence of all climate change risks on the Project are considered to be sufficiently reduced to be assessed as not significant.

Analysis of H++ scenarios

7.11.37 The assessment has identified three categories of vulnerable safety critical features which have undergone a sensitivity test against the H++ climate scenarios to assess the extent to which they could be affected by more radical changes to the climate beyond the *UKCP18* projections. The vulnerable safety critical features identified were:

- Drainage assets
- Earthworks
- Multi-span bridges at Kirkby Thore (Temple Sowerby to Appleby scheme) and Warcop (Appleby to Brough scheme) for which the design includes piers positioned within the floodplain

7.11.38 Other safety critical features have been scoped out of the sensitivity test due to their limited vulnerability to climate change (e.g. road restraint systems), or their embedded resilience due to the use of appropriate design standards, including the relevant Eurocodes and British Standards (e.g. other bridges and structures).

7.11.39 This high level appraisal (shown in Sensitivity test of the Project's vulnerable safety critical features against the H++ climate scenarios) represents a sensitivity test for an extreme climate change scenario and so is additional to the CCR assessment detailed in Appendix 7.2: CCR Assessment (Application Document 3.4).

7.11.40 The purpose of the appraisal is to identify any adaptive management measures potentially required over and above those already identified in the CCR assessment should any of the low likelihood extreme climate scenarios develop over the assumed 60-year study period for the Project.

Table 7-28: Sensitivity test of the Project's vulnerable safety critical features against the H++ climate scenarios

Hazard (and scenario)	Scenario Description	A66 vulnerable safety critical features		
		Drainage	Earthworks	Multi-span bridges at Kirby Thore and Warcop
Heat waves (H++)	Annual average summer maximum temperatures exceeding 30°C over most of the UK and 34°C over much of central and southern England. Hottest days would exceed 40°C in some locations, with 48°C being reached in extreme cases.	**Risks/consequences:** N/A - No vulnerable features identified **Adaptation measures:** N/A	**Risks/consequences:** N/A - No vulnerable features identified. The risk of soil desiccation on the Project is considered minimal. **Adaptation measures:** N/A	**Risks/consequences:** N/A - No vulnerable features identified **Adaptation measures:** N/A
Low rainfall (H++)	A 6-month duration summer drought with rainfall deficits of up to 60% below the long-term average (1900-1999). Longer dry periods spanning several years with rainfall deficits of up to 20% below the long-term average (1900-1999) across all of England and Wales, similar to the most severe and extensive long droughts in the historical record.	**Risks/consequences:** N/A - No vulnerable features identified **Adaptation measures:** N/A	**Risks/consequences:** N/A - No vulnerable features identified. **Adaptation measures:** N/A	**Risks/consequences:** N/A - No vulnerable features identified. **Adaptation measures:** N/A

Hazard (and scenario)	Scenario Description	A66 vulnerable safety critical features		
		Drainage	Earthworks	Multi-span bridges at Kirby Thore and Warcop
Low river flows (H++)	A 40-70% reduction in 'low flows' (Q95) in a single summer. For multi-season droughts, including 2 summers, a 20 to 60% reduction in low flows. For longer droughts (2 years or more), a 50% reduction in low flows.	**Risks/consequences:** Pollution - with a reduction in river flows, drainage dilution levels would be more concentrated due to receiving water courses carrying less water. **Adaptation measures:** Drainage and attenuation ponds will allow settlement and removal of pollutants before water enters the receiving water courses. Swales will be implemented to provide a level of removal of metals present in the water.	**Risks/consequences:** N/A - No vulnerable features identified. **Adaptation measures:** N/A	**Risks/consequences:** N/A - No vulnerable features identified. **Adaptation measures:** N/A
High rainfall (H++)	A 70%-100% increase in winter rainfall (Dec to Feb) in a single winter (from a 1961-1990 baseline). An up to five-fold increase in frequency and 60% to 80% increase in heavy daily and sub-daily rainfall depths, for both summer and winter events (all year round).	**Risks/consequences:** An increase in the flooding of the highway would impact the performance of the network itself, including congestion and impacting user safety. Deterioration of the performance of other assets, for example the road pavement due to standing water. **Adaptation measures:** The drainage systems within the designs take into account a climate change allowance for high rainfall, beyond that required by the DMRB	**Risks/consequences:** An increase in winter precipitation could adversely impact the stability of earthworks, including cutting slopes and embankments, through increased groundwater levels, porewater pressures and the erosion of the toe of earthworks. Increased rainfall would also result in increased groundwater flows emerging from springs which could results in internal erosion of earthwork embankments.	**Risks/consequences:** N/A - No vulnerable features identified. **Adaptation measures:** N/A

Hazard (and scenario)	Scenario Description	A66 vulnerable safety critical features		
		Drainage	Earthworks	Multi-span bridges at Kirby Thore and Warcop
		standards. However, H++ scenarios have not informed the Project design. Carriageway collection systems and water levels in drainage systems are designed for a Q5 storm event +40% allowance for climate change, whilst attenuation ponds are designed to accommodate a Q100 storm event +40% climate change allowance. However, if the +70% climate change factor is applied, then interruptions to the operation of the Project could become more frequent than the designed level of service for operations. To accommodate the H++ scenario, changes to the physical infrastructure would be required. This includes larger channels and pipes and more outlets. A precautionary approach could be implemented to increase the climate change allowance within the design, or the operational performance of the drainage on the Project could be monitored during operation and the drainage capacity increased in any areas where frequent flooding is observed.	Adaptation measures: Risks to earthworks' stability from increased rainfall, surface runoff and internal erosion will need to be considered at detailed design stage. Adaptation measures could include the implementation of masonry gullies or additional earth retention or reinforcement.	

Hazard (and scenario)	Scenario Description	A66 vulnerable safety critical features		
		Drainage	Earthworks	Multi-span bridges at Kirby Thore and Warcop
		The impact of blockages to drainage systems would increase under this scenario. Potential adaptations could include enhanced monitoring, maintenance and inspection regimes (perhaps utilising smart technology) so that operational disruption due to blockages are minimised.		
High river flows (H++)	A 60% to 120% increase in peak flows at the 'lower end' of the H++ scenarios. The upper limit is a 290% increase in peak flows (1961-1990 baseline). The scenarios are based on the average response of "Enhanced-high" catchments, which are particularly sensitive to increases in rainfall.	**Risks/consequences:** The Project interacts with floodplain areas in several locations. An increase to peak river flows could cause flooding of the road surface and therefore operational disruption, safety concerns and the deterioration of pavement assets in these locations. **Adaptation measures:** The Project is already designed to accommodate a Q100 storm event with a +94% climate change allowance. The road has been designed to be 600mm above the floodplain to ensure the road does not flood for the Q100+94% fluvial event and can be drained. However, a more extreme increase in peak river flows could result in	**Risks/consequences:** Increased river flows, resulting in flooding, could lead to the erosion of earthworks. **Adaptation measures:** Mitigation for earthworks that are vulnerable to increased peak river flows will need to be considered as part of the detailed design.	**Risks/consequences:** An increase in peak river flows would increase the risk of scour and erosion of piers that are located within the floodplain. Larger flood events would be associated with a higher velocity of water within the floodplain which could accelerate the erosion and scour of vulnerable piers. There may also be a risk of scour and erosion to abutments in particularly large flood events. **Adaptation measures:** Adaptation measures to minimise the risk of scour and erosion to these structures

Hazard (and scenario)	Scenario Description	A66 vulnerable safety critical features		
		Drainage	Earthworks	Multi-span bridges at Kirby Thore and Warcop
		increased operational disruption in areas that are vulnerable to fluvial flooding. A precautionary approach could be taken to increase the elevation of the road surface above the floodplain in vulnerable locations during initial construction. Alternatively, adaptation pathways could be defined and incorporated into the design to allow the elevation of the road surface to be increased in the future if required based on observed impacts.		will need to be considered at detailed design. Adaptation measures could include the use of scour protection such as concrete aprons around the piers and the introduction of rock armour to protect the abutments.
Windstorms (H++)	A 50-80% increase in the number of days per year with strong winds over the UK (1975-2005 baseline). A strong wind day is defined as one where the daily mean wind speed at 850 hPa, averaged over the UK (8W-2E, 50N-60N), is greater than the 99th percentile of the historical simulations.	**Risks/consequences:** N/A - No vulnerable features identified **Adaptation measures:** N/A	**Risks/consequences:** N/A - No vulnerable features identified **Adaptation measures:** N/A	**Risks/consequences**: N/A - No vulnerable features identified **Adaptation measures:** N/A
Cold snaps (L--)	In the 2020s, UK average winter temperatures (December, January and February) of 0.3°C and for the 2080s, UK average	**Risks/consequences:** N/A - No vulnerable features identified **Adaptation measures:** N/A	**Risks/consequences:** N/A - No vulnerable features identified **Adaptation measures:**	**Risks/consequences:** N/A - No vulnerable features identified **Adaptation measures:**

Hazard (and scenario)	Scenario Description	A66 vulnerable safety critical features		
		Drainage	Earthworks	Multi-span bridges at Kirby Thore and Warcop
	winter temperatures would be around -4°C. In the 2020s, UK average temperatures on the coldest day would be -7°C in some locations. UK average temperature of the coldest day would be around -11°C.		N/A	N/A

7.11.41 The sensitivity test of the vulnerable safety critical features against the H++ climate scenarios at this stage in the design indicates that these features could be significantly affected by more radical changes to the climate beyond that projected in *UKCP18*. As such, these climate scenarios should continue to be taken into account through detailed design and maintenance to ensure the scheme is designed with resilience to climate change as a key consideration. These climate scenarios represent extreme stress tests and so adapting the design at the point of construction to accommodate these scenarios would be considered precautionary. An alternative approach would be to define adaptation pathways for these vulnerable assets to ensure that the design accommodates increases in resilience at a later data if operational monitoring suggests this is necessary.

7.11.42 Therefore, the assessment concludes no residual significant climate change risks for the Project, assuming the identified mitigation is incorporated into the design and operation of the Project effectively and adaptation pathways are identified to improve operational resilience if observed climate change is more extreme than the *UKCP18* RCP 8.5 projections.

7.12 Monitoring

Impact of the Project on climate (GHG emissions assessment)

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

7.12.2 In line with the monitoring requirements set out in *DMRB LA 114*, and to be secured through the EMP, quarterly GHG emission returns during construction and operation shall be reported in accordance with National Highways 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.

7.12.3 The EMP (Application Document 2.7) includes a requirement that the mitigation outlined in section 7.10: Essential mitigation and enhancement measures and ES Appendix 7.1: GHG Assessment (Application Document 3.4) is monitored to ensure its effective application throughout construction.

Vulnerability of the Project to climate change (CCR assessment)

7.12.4 Although a detailed CCR assessment has not been taken forward for construction, it is important that the adequacy of resilience measures set out in the EMP are monitored throughout the construction period.

7.12.5 In accordance with the monitoring requirements set out in DMRB LA 114, operational asset data will be managed, maintained and monitored to ensure the Project is operating as intended with regards to climate

resilience. Monitoring and maintenance regimes should be frequently reviewed to respond to actual or predicted climatic changes.

7.12.6 Where a design issue is identified, an assessment will be made to determine whether corrective action is appropriate.

7.12.7 Where corrective action is deemed appropriate, adaptive management measures will be used to improve the resilience of the asset. The additional resilience measures should be monitored after implementation to ensure they have successfully mitigated the risk.

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