A1 in Northumberland: Morpeth to Ellingham

Scheme Number: TR010041

6.2 Environmental Statement – Chapter 14 Climate

Part A

APFP Regulation 5(2)(a)

Planning Act 2008

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

June 2020

Infrastructure Planning

Planning Act 2008

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

The A1 in Northumberland: Morpeth to Ellingham

Development Consent Order 20[xx]

Environmental Statement

Regulation Reference:	APFP Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010041
Application Document Reference	TR010041/APP/6.2
Author:	A1 in Northumberland: Morpeth to Ellingham Project Team, Highways England

Version	Date	Status of Version
Rev 0	June 2020	Application Issue

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TABLES

FIGURES

14 CLIMATE

14.1 INTRODUCTION

14.1.1. This chapter presents the assessment of likely significant environmental effects as a result of Part A: Morpeth to Felton (Part A) on climate. This chapter presents the assessment of:

a. The potential effects of Part A on the magnitude and mitigation of Greenhouse Gases (GHGs) emitted during construction and operation.

b. The vulnerability of Part A to the potential impacts of climate change in particular impacts on Part A from extreme weather and long-term climate change during construction and operation.

14.1.2. The chapter also identifies, where appropriate, proposed mitigation measures to prevent, minimise or control the likely adverse climate effects arising from the construction and operation of Part A, and the subsequent residual effects.

14.1.3. This chapter should be read together with **Appendix 14.1: Vulnerability to Climate Change Baseline**, **Volume 7** of this Environmental Statement (ES) (**Application Document Reference: TR010041/APP/6.7**).

14.1.4. This chapter should be read together with the introductory chapters of this ES (**Chapters 1 to 4, Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**)) in particular **Chapter 2: The Scheme, Volume 1** of this ES. An assessment of combined effects of Part A is set out in **Chapter 15: Assessment of Combined Effects** of this ES and combined and cumulative effects of the Scheme are set out in **Chapter 16: Assessment of Cumulative Effects, Volume 4** of this ES (**Application Document Reference: TR010041/APP/6.4**).

14.1.5. **Section 4.3** of **Chapter 4: Environmental Assessment Methodology, Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**) identifies any differences in the assessment methodology employed for Part A and Part B: Alnwick to Ellingham (Part B). Further to this, there are other differences between the chapters for Part A and Part B. All key differences include:

a. There are differences between Part A and Part B that relate to the scoping process, for example elements that are scoped in and out of the assessment. Refer to the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**) and **Scoping Opinion** (**Application Document Reference: TR010041/APP/6.12**) for Part A, and the **Scoping Report** (**Application Document Reference: TR010041/APP/6.11**) and **Scoping Opinion** (**Application Document Reference: TR010041/APP/6.13**) for Part B.

b. Land use change is assessed for Part A but was scoped out of Part B. It is assessed for Part A as the proposed offline section of Part A has the potential to lead to a change in emissions associated with the loss of agricultural grassland, whereas the extent of Part B offline works are less extensive.

c. The terminology for sensitive receptors identified in Part A and Part B differ due to the absence of defined terminology for receptors in published guidance and to align with

terms used in the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**) for Part A and the **Scoping Report** (**Application Document Reference: TR010041/APP/6.11**) for Part B. The terminology used does not affect the outcomes of the assessment.

d. Both Part A and Part B have used Met Office published historical regional weather data to establish the current climate impacts, upon which the UKCP18 probabilistic projections are based. The future baseline projections for Part A, due to its scale and nature. have been supplemented by projections within a 25 km grid square. This reflects the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**) for Part A.

e. Slight differences in terminology exist between Part A and Part B. For Part A repair and refurbishment is used and for Part B replacement is used. This reflects the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**) for Part A and the **Scoping Report** (**Application Document Reference: TR010041/APP/6.11**) for Part B.

14.1.6. The future traffic levels for the assessment of Part A are based upon an opening year predicted to be in 2023. Since the assessments reported in this ES were completed, the Part A opening year has been put back to 2024. The assessment is based on traffic modelling for an opening year of 2023 and reported on that basis. However, as explained in **Section 4.1** in **Chapter 4: Environmental Assessment Methodology, Volume 1** of this ES (**Application Document Reference: TR010041/APP6.1**) it is considered that the assessments remain valid for an opening year of 2024.

14.2 COMPETENT EXPERT EVIDENCE

14.2.1. **Table 14-1** below demonstrates that the professionals contributing to the production of this chapter have sufficient expertise to ensure the completeness and quality of this assessment.

Table 14-1 – Relevant Experience

Name	Role	Qualifications and Professional Membership	Relevant Experience
Caroline Jones	Author	- BSc (Hons) Geography - Institute of Environmental Management and Assessment (IEMA) Practitioner	Senior Consultant 1 years' experience relevant to Environmental Impact Assessment (EIA). Other recent relevant experience includes: - Lead author of the climate chapter of the A27 East of Lewes Scoping Report and Environmental Assessment Report (EAR). - Author of the climate chapter of the Great

Name	Role	Qualifications and Professional Membership	Relevant Experience
			Yarmouth Third River Crossing Preliminary Environmental Information Report (PEIR) and ES. - Co-author of the climate chapter for the A27 Worthing to Lancing Scoping and EAR.
Tom Wood	Reviewer (GHGs)	- MSc Environmental Technology - Chartered Environmentalist (CEnv) - Society for the Environment - Member and Chartered member of Chartered Institution of Water and Environmental Management (M.CIWEM / C.WEM) Affiliate member of Institute of Environmental Management and Assessment (IEMA)	Associate 13 years' experience. Recent relevant experience includes: - Lead author of the (unpublished) Highways England Design Manual for Roads and Bridges (DMRB) Volume 10 and 11 Climate Change. - Contribution to the Highways England (2015) voluntary progress report on climate change adaptation. - Lead author or reviewer of climate chapters for multiple environmental assessments across sectors including highways, rail, energy, water and industry.
James Peet	Reviewer (GHGs)	- MSc Environment, Science and Society - Chartered Environmentalist (CEnv) - Full member of Institute of Environmental Management and Assessment (MIEMA)	Principal Consultant Eight years' experience in GHG assessments. GHG Topic Lead for the following schemes: - Southampton International Airport; - Banwell Bypass, Somerset County Council; - M4 Junction 15 improvements, Redrow Homes; and

Name	Role	Qualifications and Professional Membership	Relevant Experience
			- Drax Repower GHG expert witness. Other relevant experience includes: - Lead author or reviewer of GHG assessments and climate chapters for multiple environmental sectors including highways, transport, power waste and water sectors. - Expert witness on climate change. - Produced planning and climate change thought leadership.
Nikki van Dijk	Reviewer (Climate resilience)	- MSc Climate Change - BA (Cantab) Geography - Chartered member of the Chartered Institution of Water and Environmental Management (M.CIWEM / C.WEM) - Chartered Environmentalist (CEnv) Society for the Environment - Fellow of the Royal Geographical Society (FRGS)	Associate 12 years' experience. Climate Topic Lead for the following schemes: - A27 Arundel Bypass, Highways England; - Kurty-Kapshagi Road Improvement, (Kazakhstan), EBRD; - Banwell Bypass, Somerset County Council; and - M4 Junction 15 improvements, Redrow Homes. - Other recent relevant experience includes: - Lead author or reviewer of climate chapters for multiple environmental assessments across sectors including highways, rail, energy, water and industry. - Member of IEMA working group to update EIA Guide

Name	Role	Qualifications and Professional Membership	Relevant Experience
			to Climate Change Adaptation and Resilience.

14.3 LEGISLATIVE AND POLICY FRAMEWORK

INTERNATIONAL LEGISLATION

Directive 2014/52/EU on the Assessment of the Effects of Certain Public and Private Projects on the Environment (the EIA Directive)

14.3.1. Directive 2014/52/EU on the assessment of the effects of certain public and private projects on the environment (the EIA Directive) (**Ref. 14.1**) provides the overarching legislative framework for assessing the significance of impacts and effects from schemes on the environment.

14.3.2. The Directive requires EIAs to identify, describe and assess the direct and indirect significant effects of a project on climate (Article 3). It also stipulates that the information to be included within the ES should include "*the impact of the project on climate (for example the nature and magnitude of GHG emissions) and the vulnerability of the project to climate change*" (Annex IV).

14.3.3. Under an amendment to the EIA Directive (2014/52) the requirement to consider a project's effects in relation to climate has resulted from the 2014 amendment to the EIA Directive (2014/52). The Directive has been fully transposed into UK law in the Infrastructure Planning (Environmental Impact Assessment) Regulations (**Ref. 14.2**) and came into force in the UK on the 16 May 2017. The Directive requires: "*A description of the likely significant effects of the project on climate (for example the nature and magnitude of GHG emissions) and the vulnerability of the project to climate change*."

NATIONAL LEGISLATION

UK Climate Change Act

14.3.4. The Climate Change Act 2008 (**Ref. 14.3**) established a legal requirement for an 80% reduction in the GHG emissions of the UK economy by 2050 in comparison to a 1990 baseline. The Act also created the Committee on Climate Change, with a responsibility for:

a. Setting five-year carbon budgets, covering successive periods of emissions reduction to 2050
b. Advising and scrutinising the UK Government's associated climate change adaptation programmes
c. Producing a national adaptation plan for the UK Government to implement

14.3.5. In 2019, the target was revised to achieve 100% reduction (net zero) GHG emissions by 2050. However, the UK Carbon budgets were not updated as part of this revision.

PLANNING POLICY

National Policy

14.3.6. National policy relevant to climate and the significance of Part A on the policy objectives is outlined in **Table 14-2**.

Local Policy

14.3.7. Local policy relevant to climate and the significance of Part A on the policy objectives is outlined in **Table 14-3**.

Table 14-2 - National Planning Policy Relevant to Climate

Policy	Relevant Policy Objectives	Significance of Part A on Policy Objective
National Policy Statement for National Networks 2014 (NPS NN) (**Ref. 14.4**)	The emissions section of Chapter 3: Wider Government Policy on National Networks identifies that the transport sector will play an important part in meeting the Government's carbon targets. It is acknowledged that technologies, fuels and promoting lower carbon transport choices will make the biggest reductions and that (comparatively) the likely impact from road development is "*very small*." Chapter 5: Generic Impacts paragraph 5.17 states that "*it is very unlikely that the impact of a road project will, in isolation, affect the ability of Government to meet its carbon reduction plan targets*." The Climate Change Adaptation section of Chapter 4: Assessment Principles sets out how the policy statement shall put policy into practice with regards to climate change mitigation and adaptation when developing and consenting infrastructure. It sets out the key considerations for infrastructure projects that are proposed on or near the coast. Developments in these areas are required to "*undertake an assessment of the vulnerability of the proposed development to coastal change, taking account of climate change, during the project's operational life*." With regards to the decision-making process, paragraph 5.78 of the policy states that "*the applicant must demonstrate that a full account has been taken of the policy on assessment and mitigation…taking account of the potential effects of climate change on these risks*." The Flood Risk section under Chapter 4: Assessment Principles paragraph 5.90 acknowledges that climate change will likely lead to an "*increased flood risk in areas susceptible to flooding, and to an increased risk of flooding in some areas which are not currently thought of as being at risk.*" Paragraph 5.93 and 5.94 also states that an applicant's assessment should "*identify and assess the risks of all forms of flooding to and from the project and demonstrate how these flood risks will be managed, taking climate change into account*" by taking "*the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made*" when preparing the flood risk assessment.	The design of Part A is in accordance with the objectives of the policy set out in the NPS NN. The design process has sought to avoid significant effects and identify appropriate mitigation and adaptation measures to align with the policy objectives (refer to **Section 14.9** of this chapter), reducing potentially significant effects where they are anticipated to arise. In relation to Chapter 3 of the NPS NN, Part A does not contribute positively to government carbon targets albeit the impacts of construction and operation are not concluded to be significant and land use change results in a reduction in emissions due to an increase in forest area. In relation to Chapter 4 of the NPS NN, the assessment of climate resilience (including flood risk) and the identification and incorporation of adaptation measures aligns Part A with these objectives. In relation to Chapter 5 of the NPS NN, Part A in isolation would not affect the ability of Government to meet its carbon reduction plan targets. The GHG assessment identifies emissions associated with Part A (refer to **Section 14.10** of this chapter). Mitigation and adaptation measures that have been integrated into Part A in order to improve the resilience of Part A to climate change and reduce GHG emissions are detailed in **Section 14.9** of this chapter. The Flood Risk Assessment (FRA) (refer to Appendix 10.1, Volume 7 of this ES (Application Document Reference: TR010041/APP/6.7) and Chapter 10: Road Drainage and the Water Environment of this ES) takes into account an allowance for climate change.
National Planning Policy Framework (NPPF) 2019 (**Ref. 14.5**)	The National Planning Policy Framework sets out the core planning principle of "*moving to a low carbon economy*": Chapter 9: Promoting Sustainable Transport, encourages the pursuit of "…opportunities to promote walking, cycling and public transport…and offer a choice of genuine transportation modes" In accordance with NPPF 2019 Chapter 14: Meeting the challenge of climate change, flooding and coastal change; 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 GHG 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.	The design of Part A is in accordance with the objectives of the policy set out in the NPPF. The design process for Part A has sought to avoid significant effects and identify appropriate mitigation and adaptation measures (refer to **Section 14.9** of this chapter) to reduce potentially significant effects where they are anticipated to arise.

Policy	Relevant Policy Objectives	Significance of Part A on Policy Objective
Highways England Climate Change Adaptation Strategy and Framework (**Ref. 14.6**)	Highways England's Climate Change Adaptation Strategy and Framework (2009) has led to modifications in existing standards on the national network. In 2011, Highways England was required to complete a climate change adaptation report and submit it to UK government to inform the national adaptation plan. This report set out the risks from climate change to Highways England and adaptation measures to improve resilience. In 2015, Highways England submitted a voluntary report on progress following the climate change adaptation report.	Many of the risks identified are relevant to Part A. An assessment of the vulnerability of Part A to anticipated changes in climate has been undertaken (refer to **Section 14.10** of this chapter). Mitigation and adaptation measures that have been integrated into Part A in order to improve the resilience of Part A to climate change are detailed in **Section 14.9** of this chapter. Part A would not negatively impact upon the policy objective.
Infrastructure Carbon Review (**Ref. 14.7**)	In 2013, the UK government published the Infrastructure Carbon Review aiming to "*release the value of lower carbon solutions and to make carbon reduction part of the DNA of infrastructure in the UK*" (page 5). Major infrastructure owners, operators and developers, including Highways England, were invited to endorse, become signatories and make commitments under the review. The review provided increased emphasis on 'capital carbon' (GHG emissions associated with raw materials, activities and transport for construction, repairs, replacement, refurbishment and de-construction of infrastructure) while acknowledging that 'operational carbon' (associated with energy consumption for the operation and use of infrastructure) will continue to dominate overall emissions to 2050 and beyond. The Infrastructure Carbon Review highlighted the importance of assessing GHG emissions early in the lifecycle of an infrastructure scheme when there is the greatest carbon reduction potential. The Infrastructure Carbon Review also led to the publication of a Publicly Available Specification on infrastructure carbon management; PAS2080:2016 (**Ref. 14.8**).	The assessment identifies GHG emissions associated with the construction and operation of Part A (refer to **Section 14.10** of this chapter) and outlines measures to be included within Part A design to reduce emissions where possible (refer to **Section 14.9** of this chapter). The 'carbon footprint' of Part A would continue to be assessed and targeted throughout detailed design, refer to **Section 14.9** of this chapter.

Table 14-3 - Local Planning Policy Relevant to Climate

Policy	Relevant Policy Objectives	Significance of Part A on Policy Objective
Alnwick District Wide Local Plan (1997) (**Ref. 14.9**)	Section 18.3 of the Local Plan considers 'Energy Conservation and Global Warming'. Given that the Local Plan was produced in 1997, policies in relation to climate change are limited. The Local Plan includes the following policy of relevance to the assessment. Policy CD33 Planning permission will not be granted for development where there is an unacceptable risk of flooding, or where the development would be likely to increase the risk of flooding elsewhere.	The **FRA** (refer to **Appendix 10.1**, **Volume 7** of this ES (**Application Document Reference: TR010041/APP/6.7**)) takes into account an allowance for climate change.
Alnwick Core Strategy (October 2007) (**Ref. 14.10**)	The Alnwick Core Strategy notes the importance of considering climate change, particularly in relation to the effects of global warming resulting in sea level rise, coastal erosion and flooding. In relation to transport, the Strategy seeks to reduce	The design process for Part A has sought to avoid significant effects and identify appropriate mitigation and adaptation measures to reduce potentially significant impacts where they are anticipated to arise (refer to **Section 14.9** of this chapter).The inclusion of footways, cycleway and bus stops (as described in

Policy	Relevant Policy Objectives	Significance of Part A on Policy Objective
(Northumberland Consolidated Planning Policy Framework, 2018) (**Ref. 14.11**)	the environmental impact of transport while meeting the needs of people and firms for access. Objective 6 of the Core Strategy sets out a goal to assist in the delivery of a sustainable integrated transport system and enhance accessibility for all.	**Chapter 2: The Scheme**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**) align Part A to sustainable and integrated transport objectives.
Morpeth Neighbourhood Plan (May 2016) (**Ref. 14.12**)	The Morpeth Neighbourhood Plan states that tackling climate change is a key role for the planning system, although a need for a distinctive local objective and policies specificity to the plan have not been identified within the Plan. The Plan will however align with the principles of the Northumberland Core Strategy and National Planning Policy.	No specific climate objectives are set out in policy document, however the consideration of climate change has been undertaken as part of this assessment aligning Part A with the Neighbourhood Plan.
Northumberland Local Plan: Draft Plan for Consultation (January 2019) (**Ref. 14.13**)	The draft local plan includes Policy STP 4 which provides principles for how the local plan and development proposals should contribute to climate change mitigation and adaptation. The key principles of the policy relevant to Part A are summarised below: Development proposals should mitigate climate change and contribute to meeting targets to reduce GHG emissions through: - Reducing the need for travel for both people and goods, and encourages sustainable modes of transport - Include the re-use of existing materials Development proposal should support adaptation to climate change through: - Incorporating design features to provide resilience to climate change - Take account of the risk for flooding - Incorporate the use of sustainable drainage systems	Mitigation and adaptation measures to reduce GHG emissions are detailed in **Section 14.9** of this chapter. Measures that have been integrated into Part A in order to improve the resilience of Part A to climate change are also detailed in **Section 14.9** of this chapter.
Northumberland County Council Transport Plan 2011 – 2026 (**Ref. 14.14**)	Chapter 7 of the Transport Plan sets out the strategy for reducing carbon emissions. The main goal and objective is to minimise the environmental impact of transport by reducing carbon emissions and addressing the challenge of climate change and deliver sustainable low carbon travel choices. The actions in place to achieve the goal and objective include: - Continue to implement the Council's own travel plan as an integral part of the Carbon Management Plan - Promote sustainable travel choices such as walking, cycling and public transport - Improve and enhance the traffic free rights of way network around urban areas to increase the use of sustainable transport for accessing work, schools and services	The assessment identifies GHG emissions associated with the construction and operation of Part A and outlines measures to be included within the design of Part A to reduce emissions where possible (refer to **Section 14.9** of this chapter). The inclusion of footways, cycleway and bus stops (as described in **Chapter 2: The Scheme**, **Volume 1** of this ES (A**pplication Document Reference: TR010041/APP/6.1**)) align Part A to sustainable and integrated transport objectives.

14.3.8. Compliance with planning policy is addressed further in the **Case for the Scheme** (**Application Document Reference: TR010041/APP/7.1**) and **NPS NN Accordance Table** (**Application Document Reference: TR010041/APP/7.2**).

14.4 ASSESSMENT METHODOLOGY

EFFECTS OF PART A ON CLIMATE (GHG EMISSIONS)

Scope of the Assessment

14.4.1. This section sets out the scope of the assessment which has been determined via the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**) and **Scoping Opinion** (**Application Document Reference: TR010041/APP/6.12**). **Appendix 4.1: Scoping Opinion Response Tracker**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**) provides a summary of the Scoping Opinion for Part A comments received from the Planning Inspectorate, along with the responses which have informed the scope, methodology and assessment in this chapter.

14.4.2. **Table 14-4** outlines the potential GHG emissions sources scoped into the assessment.

Table 14-4 – Construction and Operation Phase GHG Emissions Sources included in the Assessment

Lifecycle Stage	Potential Sources of GHG Emissions	Examples of GHG Emissions Generated during Construction and Operation
Construction		
Product stage; including raw material supply, transport and manufacture	Emissions from construction materials typically form the greatest proportion of a scheme's emissions. Main works include: - Online widening 6.1 km carriageway (single to dual carriageway) - Offline construction of 6.6 km new dual carriageway - 3 new grade-separated junctions (Highlaws, Fenrother, West Moor) - New bridge over River Coquet	Available information for construction materials required for Part A include: - Bulk materials for earthworks - Road paving materials, including sub-base and asphalt - Steel – for structures, reinforcement and road safety barrier - Concrete including pre-cast

Lifecycle Stage	Potential Sources of GHG Emissions	Examples of GHG Emissions Generated during Construction and Operation
	- 16 new detention basins, a storage swale, 17 additional or modified culverts and wildlife culverts	or prefabricated elements - Aggregate - Timber for fencing and formwork - Plastics for drainage pipes - Other general construction materials
Construction process stage; including transport to/from works site and construction/installation processes.	Activities of organisations conducting construction work, including demolition activities and emissions sources such as fuel or energy consumption by delivery vehicles and construction plant.	Transportation of materials from point of purchase to site, mode and distance. Fuel or electricity consumption and construction activity type and duration.
Operation		
Use of the infrastructure by the end-user	Change in end-user emissions from the surrounding network (increase or decrease).	Traffic count / speed / % Heavy Delivery Vehicle (HDV) for highway links in the network.
Repair and refurbishment	Part A's resurfacing schedule provides for renewal of surface course commencing in year 12 of Part A and in years 20, 30, 40, 45 and 57.	Number of replacements / repairs to assets over design life.
Land Use Change	Reduced or improved capacity of the landscape to sequester carbon due to Part A	Reduction or increase in forested area

14.4.3. The proposed scope of assessment for the effects of Part A on climate are as presented in the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**).

Emissions sources that are scoped out of the assessment are as reported in the **Scoping Report** for Part A and are summarised below:

a. Operation and maintenance: As detailed in **Chapter 2: The Scheme**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**) roadside technology provided for Part A would be minimal, with GHG emission impacts considered to be negligible. No lighting would be provided for Part A. End user emissions are within scope and considered in the assessment.

b. Replacement (duplication with repair which is scoped in).

c. End of life elements: Decommissioning would happen several decades into the future and well beyond the period for which the UK Government has set agreed carbon budgets. The uncertainty about the future decommissioning process and associated emissions is sufficient to scope this lifecycle stage out of the emissions assessment.

Methods of Baseline Data Collection

14.4.4. The baseline data collected and presented in this chapter were sourced through desktop research.

Methodology

14.4.5. The assessment approach considers the likely magnitude of GHG emissions (or avoided GHG emissions) relative to the baseline scenario with no Part A (the 'do minimum' scenario). Comparison of GHG emissions to UK National Carbon Budget periods are also considered to aid the assessment of the magnitude of change. This is in line with paragraph 5.17 of the NPS NN (**Ref. 14.4**). The assessment considers GHG emissions throughout the lifecycle of Part A including:

a. Construction phase e.g. embodied GHG emissions associated with materials, transportation of materials to site and waste arisings from Part A, and the construction process.

b. Operation e.g. GHG emissions (or avoided GHG emissions) from end-user vehicles and repair.

14.4.6. To quantify GHG emissions for the construction and operation lifecycle stages and sub-stages (as described in **Table 14-4**) of Part A, the assessment includes the following steps:

a. Collection of available data/information on the scale of GHG emitting activities for the baseline scenario and for Part A e.g. tonnes of concrete, litres of diesel, average daily traffic flows. For each of these items, the data collected covers the whole study period (lifecycle of the assets). The whole lifecycle of Part A is considered to be from 2021-2083 (Construction phase of 2021-2024 and operation phase 2024-2083).

b. Calculation of the GHG emissions using best practice approaches to quantifying GHG emissions depending on the emissions source being calculated. In simplest terms, this involves applying the most suitable emissions factor (e.g. kgCO_2e per tonne of concrete).

Emissions Calculations

14.4.7. Construction and repair emissions calculations have been completed using Highways England's (the Applicant's) carbon tool (**Ref. 14.15**) which is an industry recognised carbon calculation tool that quantifies carbon emissions for operational, construction and maintenance activities (throughout a project lifestyle) from highways' schemes. The tool uses design information in the form of materials' quantities and scheme assets. It utilises carbon emissions and conversion factors and material density factors to determine the associated emissions. This tool has been used as it is specifically designed for assessing highways' schemes and is therefore the most appropriate.

14.4.8. The material and waste types and quantities have been obtained from **Chapter 13: Material Resources** of this ES from data provided by the Buildability Advisor including estimated distances to the likely source of materials and location of waste sites. Values have been reported as tonnes of carbon dioxide equivalents (tCO2e). Professional judgement based on similar road schemes has been applied when completing the carbon calculation tool in relation to the assigning of material types (where not already known).

14.4.9. The total operational phase end-user GHG emissions from traffic have been modelled using traffic data for Part A. Emissions were quantified using WebTAG data tables (**Ref. 14.16**) and data from the Department of Transport (**Ref. 14.17**). This takes into account the proportions of the vehicle types, fuel type, forecast fuel consumption parameters and emission factors over the Part A reference lifespan. An operational period of 60 years has been assumed for the assessment of GHG emissions. From this, emissions were quantified for each year over a 60 year lifetime of Part A (up to 2083). This quantitative assessment forms the basis of the assessment of this emissions source by providing emissions magnitude. This then enables the significance of emissions to be determined and is considered to be a suitable approach to identify and assess likely significant effects from Part A.

14.4.10. The calculation of land use change emissions has used data on the change in land cover types between the 'do minimum' and 'do something' scenarios, as presented in **Appendix 9.20: Biodiversity No Net Loss Assessment**, **Volume 7** of this ES (**Application Document Reference: TR010041/APP/6.7**). For each land cover category, the change in land cover due to Part A is 'do something' minus 'do minimum'. Each land cover type releases or sequesters carbon at different rates. As such carbon emissions are quantified based on the change in land cover due to Part A.

14.4.11. The rate that carbon sequesters also depends on soil type. As such, the soil type data for Part A presented in **Chapter 11: Geology and Soils** of this ES was used to inform the assessment.

14.4.12. The quantification of emissions from land use change is inherently uncertain, and different methodologies exist for calculation emissions from land use change. As such, two methods have been used to quantify emissions from Part A: the International Panel on Climate

Change (IPCC) 2006 method (**Ref. 14.18**) and the Woodland Carbon Code (WCC) (**Ref. 14.19**) method. Both methods apply emissions factors to quantify the amount of carbon emitted or sequestered by different land cover types. In the case of this assessment the emissions factors are applied to the change in land cover types to quantify emissions due to Part A.

14.4.13. The results of both methods are presented in **Section 14.10** to provide transparency. However, the most conservative result[1] has also been presented in **Section 14.10** and has been used to conclude on significance.

14.4.14. All GHG emissions have been reported as tonnes of carbon dioxide equivalents (tCO_2e).

Significance of Effects

14.4.15. In line with the NPS NN (2014) (**Ref. 14.4**), significance of effects has been assessed by comparing estimated GHG emissions arising from Part A with UK carbon budgets, and the associated reduction targets.

14.4.16. The NPS NN (2014) (**Ref. 14.4**) also sets out 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" (paragraph 5.17, page 50, NPS NN). As such it is unlikely that Part A would constitute a significant portion of the UK carbon budgets.

14.4.17. There are currently no agreed thresholds for what level of GHG emissions is considered significant in an EIA. As such the significance of emissions is assessed with reference to:

a. The magnitude of GHG emissions anticipated to be generated by Part A
b. Comparison of the anticipated Part A emissions in relation to their regional and national context
c. Comparison of the anticipated Part A emissions with the UK carbon budgets
d. Guidance from IEMA (IEMA EIA Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance (**Ref. 14.20**)
e. Comparisons to GHG emissions of schemes of a similar size and nature

14.4.18. Based on the above criteria and in the absence of agreed thresholds, significance is determined using professional judgement, based upon schemes of a similar size and nature, where it is deemed that increases in GHG emissions would have a material impact.

Sensitive Receptors

14.4.19. The local, regional, national and global environment within which GHG emissions are emitted is considered the sensitive receptor within the assessment.

[1] Largest adverse impact of Part A / Smallest beneficial impact of Part A

Data Sources

14.4.20. The Part A traffic model has been used to calculate total operational phase end-user GHG emissions.

14.4.21. Material and waste types and quantities have been obtained from **Chapter 13: Material Resources** of this ES and the Buildability Advisor.

Consultation

14.4.22. No consultation has been undertaken for the completion of this chapter, as it was not required in order to obtain the necessary data and information for this assessment.

Guidance

14.4.23. The following guidance documents have been used to inform the methodology for this assessment:

a. IEMA EIA Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2017) (**Ref. 14.20**)
b. NPS NN (2014) (**Ref. 14.4**)
c. TAG Unit A3 Environmental Impact Appraisal, Chapter 4 Greenhouse Gases (**Ref. 14.16**)
d. PAS 2080:2016 Carbon management in infrastructure (**Ref. 14.8**)

VULNERABILITY OF PART A TO CLIMATE CHANGE

Scope of the Assessment

14.4.24. This section sets out the scope of the assessment which has been determined via the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**) and **Scoping Opinion** (**Application Document Reference: TR010041/APP/6.12**). **Appendix 4.1: Scoping Opinion Response Tracker**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**) provides a summary of the Scoping Opinion for Part A comments received from the Planning Inspectorate, along with the responses which have informed the scope, methodology and assessment in this chapter.

14.4.25. The scope of the vulnerability assessment covers the construction and operational phases of Part A as detailed within the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**). The decommissioning phase was previously scoped out and therefore is not assessed in this chapter.

14.4.26. Drainage aspects (such as surface water drainage systems; cross-culverts; road-edge drainage; attenuation; outfalls; and drainage ditches) are not assessed within this chapter but have been assessed in **Chapter 10: Road Drainage and the Water Environment** of this ES.

14.4.27. This ES uses data from the UK Climate Projections (2018) (UKCP18), which was released after the publication of the **Scoping Report** (**Application Document Reference: TR010041/APP/6.10**).

14.4.28. Incident management does not form part of the climate vulnerability assessment. Major accidents are dealt with separately within **Chapter 4: Environmental Assessment Methodology**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**). The management of other incidents, such as breakdowns, road use incidents / accidents and third party incidents are referred to in the **Construction Traffic Management Plan** (**Application Document Reference: TR010041/APP/7.4**).

14.4.29. **Table 14-5** lists the climate variables, including extreme weather events which have been considered in this assessment (indicated with a tick in the table). Blank cells indicate variables that have not been considered further in this assessment due to geography and/or the context of Part A. Australian guidance (Standards Australia (2013) Climate Change Adaptation for settlements and infrastructure – a risk-based approach (**Ref. 14.21**) is used in lieu of any UK guidance to assess the vulnerability of the elements of Part A, along with professional judgement.

14.4.30. Part A is not in a coastal or estuarine location and is not at risk of tidal flooding as the tidal limits for the River Coquet and River Wansbeck are downstream of Part A, however there is a potential for salinity variation. Other variables associated with, sea level rise do not require further inclusion in this chapter but are included in **Chapter 10: Road Drainage and the Water Environment** of this ES.

14.4.31. Evaporation is not expected to have a direct effect on the road, bridge or pedestrian and cycle way elements of Part A. Bridges are not considered to be highly sensitive to long term changes in average precipitation, however they are expected to be sensitive to extreme rainfall, which is included in the assessment. The effects of soil moisture on bridges are assessed under the soil stability variable. The bridge elements are not considered to be sensitive to changes in soil runoff.

Table 14-5 – Climate Variables and Climate Related Hazards

Elements of Part A	Climate variables and Hazards																			
	Sea				**Precipitation**				**Temperature**			**Wind**		**Relative Humidity**		**Water Quality and Soils**				
	Sea level rise	Storm surge and tide	Surface temperature	Currents and waves	Changes in seasonal average	Drought	Extreme precipitation events	Snow	Changes in seasonal average	Extreme temperature events	Solar radiation	Gales and extreme wind events	Storms (lightning, hail)	Changes in annual average	Evaporation	Soil moisture	Salinity/pH	Runoff	Soil stability
Road					P	P	P	P	P	P	P	P	P	P		P	P	P	
Bridges						P	P	P	P	P	P	P	P	P	P		P		P
Pedestrian and cycle					P	P	P	P	P	P	P	P	P	P		P	P	P	P

Methods of baseline data collection

14.4.32. The baseline data collected and presented in this chapter were sourced through desktop research.

Methodology

14.4.33. The climate vulnerability assessment focusses on identifying the impacts and effects of climate change, including extreme weather events on receptors. The steps below have been followed:

a. **Step 1** – Identify receptors (refer to **paragraph 14.4.39** below).
b. **Step 2** – Identify potential impacts of changes in scoped in climate variables on receptors (refer to **Table 14-5**). **Table 14-6** shows typical climate change impacts affecting road schemes.
c. **Step 3** – Identify the significance of effects on receptors by considering the likelihood and consequence of their occurrence, taking into account embedded mitigation measures incorporated in the design of Part A which contribute to the resilience of the development to changes in climate and the reduction of GHG emissions.

14.4.34. In **Step 1,** receptors for each of the broad elements of Part A considered at the scoping stage (road, bridge, pedestrian and cycle) are identified. These are the receptors that could be affected by the potential impacts of climate change.

14.4.35. In **Step 2**, for each of the receptors, potential hazards associated with changes in the climate variables scoped in for assessment are identified. **Table 14-6** shows typical climate change impacts affecting a road scheme.

Table 14-6 – Climate Variables and Potential Impacts

Climate Variable	Potential Impacts
Average (air) temperature change (annual, seasonal, monthly)	Prolonged warm periods, drought, change in growing season, sea level rise (plus local land movements), storm surge/tide Reduction in ice and snow
Extreme (air) temperature (frequency and magnitude)	Heatwaves, water availability / drought
Average precipitation (annual, seasonal, monthly)	Water availability / drought, flooding (pluvial and fluvial), soil moisture deficit, erosion, snow, ice and hail
Extreme rainfall (frequency and magnitude)	Flooding (fluvial and pluvial), subsidence and reduced ground stability, erosion
Average wind speed change (annual, seasonal, monthly)	Increased wind loading on structures, erosion

Climate Variable	Potential Impacts
Gales and extreme winds (frequency and magnitude)	Storms, lightning strike
Humidity	Fog
Solar radiation	Increased UV radiation

14.4.36. In **Step 3**, the significance of effects depends on the likelihood of potential impacts occurring and the consequence if they do occur. The assessment of likelihood and consequence includes consideration of mitigation identified in **Section 14.9.**

Assessment Criteria

14.4.37. The significance of the effects of climate change on receptors is determined by combining the likelihood and consequence ratings, as shown in **Table 14-9**. Consequence and Likelihood have been qualitatively assessed using the descriptions in **Table 14-7** and **Table 14-8,** based on professional judgement and emerging best practice as identified in **Section 14.3**. Likelihood takes account of the rate of climate change (and is informed by information on current and projected climate). Consequence considers both the potential extent and severity of disruption associated with the identified risks.

14.4.38. Mitigation measures are identified for 'significant' climate impacts using expert opinion.

Table 14-7 – Qualitative Description of Consequence

Consequence of Impact	Description
Negligible	Disruption to an isolated section of a strategic route lasting less than one day.
Minor adverse	Regional level disruption to strategic route(s) lasting less than one day.
Moderate adverse	Regional level disruption to strategic route(s) lasting more than one day but less than one week.
Large adverse	National level disruption to strategic route(s) lasting more than one day but less than one week OR regional level disruption to strategic route(s) lasting more than one week.
Very large adverse	National level (or greater) disruption to strategic route(s) lasting more than one week.

Table 14-8 – Qualitative Description of Likelihood

Likelihood Category	Description (Probability and Frequency of Occurrence)
Very high	The event occurs multiple times during the lifetime of a scheme (60 years) e.g. approximately annually, typically 60 events.
High	The event occurs several times during the lifetime of a scheme (60 years) e.g. approximately once every five years, typically 12 events.
Medium	The event occurs limited times during the lifetime of a scheme (60 years) e.g. approximately once every 15 years, typically 4 events.
Low	The event occurs during the lifetime of a scheme (60 years) e.g. once in 60 years.
Very low	The event may occur once during the lifetime of a scheme (60 years).

Table 14-9 – Significance Rating Matrix

Likelihood	Consequence				
	Negligible	**Minor Adverse**	**Moderate Adverse**	**Large Adverse**	**Very large Adverse**
Very high	Not Significant	**Significant**	**Significant**	**Significant**	**Significant**
High	Not Significant	**Significant**	**Significant**	**Significant**	**Significant**
Medium	Not Significant	Not Significant	**Significant**	**Significant**	**Significant**
Low	Not Significant	Not Significant	Not Significant	**Significant**	**Significant**
Very Low	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant

Sensitive Receptors

14.4.39. The sensitive receptors in relation to the Part A assets identified in **Table 14-5** (road, bridges and Walkers, Cyclists and Horse riders (WCH)) have been detailed into the following components and been considered within the assessment:

a. Construction and Operation

i. Structures (including built structures such as over and under bridges, site compounds, geotechnics (including earthworks, embankments and foundations), hard surfaces (including pavements and the road surface))
ii. Soft estate (including vegetation)
iii. Ancillary equipment (including machinery and plant, roadside infrastructure such as signs and traffic signals)
iv. Materials (including topsoil which has been stripped and stored)
v. Site contents and business continuity
vi. Users (construction staff, operators and customers)

Data Sources

14.4.40. The following data sources have been used in this assessment:

a. UK Climate Projections (2018) (UKCP18) (**Ref. 14.22**) – UK climate change projections used to define the future baseline against which vulnerability of Part A to climate change is assessed.
b. UK Climate Projections (2009) (UKCP09) (**Ref. 14.23**) –previous UK climate projections used where data from UKCP18 is unavailable.
c. Centre for Environmental Data Analysis (CEDA) (**Ref. 14.24**) – for observed climate data.
d. Met Office regional climate profile for the North East of England – for observed climate data (**Ref. 14.25**).

Consultation

14.4.41. No consultation has been undertaken for the completion of this chapter, as it was not required in order to obtain the necessary data and information for this assessment.

Guidance

14.4.42. The following guidance documents have been used to inform the methodology for this assessment:

a. IEMA EIA Guide to Climate Change Resilience and Adaptation (IEMA, 2015) (**Ref. 14.26**)
b. European Commission (2013) Guidance on Integrating Climate Change and Biodiversity into EIA (**Ref. 14.27**)
c. European Commission (2016) Climate change and major projects (**Ref. 14.28**)
d. European Commission Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient (2013) (**Ref. 14.29**)
e. Highways England (2016) Climate adaptation risk assessment progress update (**Ref. 14.30**)

f. Australian guidance (Standards Australia (2013) Climate Change Adaptation for settlements and infrastructure – a risk-based approach (**Ref. 14.21**))

UPDATED DMRB GUIDANCE

14.4.43. This section applies to both effects of Part A on climate change (GHG Emissions) and vulnerability of Part A to climate change.

14.4.44. Since initial preparations of this ES, a new DMRB guidance document for Climate has been published – DMRB LA 114 Climate (**Ref. 14.31**).

14.4.45. In order to determine the implications of the updated guidance to the conclusions of the ES, a sensitivity test has been undertaken to identify key changes in the assessment methodology and determine whether there would be changes to the significant effects reported in this ES if the updated guidance had been used for the assessment.

14.4.46. The findings of the sensitivity test are presented in **Appendix 4.5: DMRB Sensitivity Test**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**) and are summarised in **Section 14.10**, below.

14.5 ASSESSMENT ASSUMPTIONS AND LIMITATIONS

EFFECTS OF PART A ON CLIMATE (GHG EMISSIONS)

14.5.1. The assumptions and limitations which apply to this assessment are outlined in **Table 14-10**. For each assumption or limitation, an explanation of the possible effect of the assumption has been provided as well as a description of any corrective actions that have been taken to adjust for any limitations. These assumptions are considered reasonable and are not likely to impact on the outcome of the assessment.

Table 14-10 – GHG Assessment Assumptions and Limitations

Assumption or Limitation	Effect	Solution
There is currently no specific guidance or carbon emissions threshold, which, if exceeded, is considered significant.	The assessment has not been undertaken in line with specific guidelines or standards.	Professional judgement based on experience and knowledge of similar schemes and current guidance as identified in **Section 14.3** have been used to make the assessment.
Type and quantities of material and waste provided at this stage are indicative and will be refined as the design of Part A progresses.	Data has been provided by the Buildability Advisor, based on the current design for Part A.	The data included the anticipated source of construction materials, anticipated waste generated and their waste disposal method and anticipated waste management facilities. The data also included an estimation of fuel usage. The

Assumption or Limitation	Effect	Solution
		data comprises estimates of bulk quantities of anticipated construction materials.
Data on the anticipated transportation distance for materials brought to site and wastes taken from site have been provided by the Buildability Advisor (as outlined in **Chapter 13: Material Resources** of this ES), based on the current design for Part A and anticipated location of material resources and waste disposal sites.	The transportation distances have been used to complete the Highways England Carbon Tool to calculate construction phase GHG emissions.	The transportation distances are considered reasonable based on the Buildability Advisor's professional judgement. Any changes to the distances are not considered to materially affect the chapter outcomes.
Highways England Carbon Tool (**Ref. 14.15**) required units different to those provided by the main contractor.	Errors in calculations within the Carbon Tool.	The Waste and Resources Action Programme (WRAP) conversion factors have been applied (**Ref. 14.32**) to convert volumes to weight based on density of typical construction materials. Professional judgement based on similar road infrastructure schemes has been applied when completing the Highways England carbon tool (**Ref. 14.15**). Alterations to the conversion factors are not considered to materially affect the chapter outcomes.
Method for traffic data modelling for end-user traffic emissions	Ensuring consistency across end-user traffic data calculations	The change in vehicle km has been determined using data from demand forecasting modelling. This modelling predicted future use of Part A and thereby a modal shift of road users as derived from a number of factors. Emissions were quantified using WebTAG book and data from the Department of Transport. This takes account the proportions of the vehicle types, fuel type,

Assumption or Limitation	Effect	Solution
		forecast fuel consumption parameters and emission factors – and how they change over time.
The assessment of land use change emissions accounts for the change in emissions sequestration between the 'do minimum' and 'do something' scenarios.	The assessment does not account for emissions from the disposal of biomass waste generated from site clearance.	Emissions from the disposal of biomass waste generated from site clearance are not considered to be significant.
The best available match between the land cover types in **Appendix 9.20: Biodiversity No Net Loss Assessment**, **Volume 7** of this ES (**Application Document Reference: TR010041/APP/6.7**), and the land cover types used in the IPCC 2006 (**Ref. 14.18**) and WCC (**Ref. 14.19**) methodologies. The same process was also used to map the soil types in **Chapter 11: Geology and Soils** of this ES to the soil types used in the IPCC 2006 (**Ref. 14.18**) and WCC (**Ref. 14.19**) methodologies.	The land cover types and soil types have been used to calculate GHG emissions from land use change.	Professional judgement has been used best match the land cover and soil types based on the available data and experience from similar schemes.
The future traffic levels for the assessment of Part A are based upon an opening year predicted to be in 2023. Since the assessments reported in this ES were completed, the Part A opening year has been put back to 2024. The assessment is based on traffic modelling for an opening year of 2023 and reported on that basis. However, as explained in **Section 4.1** in	The construction date for Part A moved forward to 2024, however the traffic data opening year remains as 2023 for Part A.	To model the GHG emissions, WebTAG data tables (**Ref. 14.16**) and data from the Department of Transport which take into account the proportions of the vehicle types, fuel type, forecast fuel consumption parameters and emission factors were used for the new opening date 2024 and design year 2039. As the Part A opening year is programmed for 2024 (refer to **Chapter 4: Environmental**

Assumption or Limitation	Effect	Solution
Chapter 4: Environmental Assessment Methodology, Volume 1 of this ES (**Application Document Reference: TR010041/APP6.1**) it is considered that the assessments remain valid for an opening year of 2024. As the traffic data for Part A reports on the opening year as 2023, the future year is 2038 and lifecycle year is 2082.		**Assessment Methodology**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**) for further details), the assessment has applied the revised date and associated lifecycle year of 2083.
An operational period of 60 years has been assumed for the assessment of GHG emissions.		

VULNERABILITY OF PART A TO CLIMATE CHANGE

14.5.2. The assumptions and limitations which apply to this assessment are outlined in **Table 14-11**. For each assumption or limitation, an explanation of the possible effect of the assumption has been provided as well as a description of any corrective actions that have been taken to adjust for any limitations. These assumptions are considered reasonable and are not likely to impact on the outcome of the assessment.

Table 14-11 - Climate Vulnerability Assessment Assumptions and Limitations

Assumption or Limitation	Effect	Solution
The assessment undertaken provides a broad indication of the potential impacts of climate change on Part A.	The assessment is based on a qualitative assessment and professional judgement.	An approach has been developed and applied in this assessment based on existing best practice.
There is currently no agreed methodology that should be applied for assessing the vulnerability of major schemes, including road	The assessment has not been undertaken in line with specific standards.	An approach has been developed and applied in this assessment based on existing best practice as identified in **Section 14.4**.

Assumption or Limitation	Effect	Solution
infrastructure, under the EIA regulations.		
The UKCP18 projections have been used to infer future changes in a range of climate variables that may affect the vulnerability of Part A to climate change. At the time of writing, these represent the most up-to-date representation of future climate in the UK.	The UKCP18 data currently available does not provide data from extreme precipitation, drought, snow and ice, extreme temperature, solar radiation, wind or relative humidity. Data for these aspects has been taken from UKCP09 (**Ref. 14.23**). There are inherent uncertainties associated with climate projections and they are not predictions of the future. It is possible that future climate will differ from the baseline climate against which the resilience of Part A has been assessed depending on global emissions over the next century.	A 'high' emissions scenario (Representative Concentration Pathways (RCP) 8.5) using the 2080s timeslice (2070-2099 – the longest temporal scale available through UKCP18) has been used to develop the baseline against which resilience has been assessed. This is consistent with the precautionary principle (i.e. 'worst case' scenario).
Analysis of climate projections is based on selected observational data.	the results of climate model ensembles and a selected range of existing climate change research and literature available at the time of assessment.	Any future decision-making based on this analysis should consider the range of literature, evidence and research available at that time and any changes to this.
The determination of resilience has been undertaken under the assumption that industry design standards will be adhered to where detailed information is unavailable.	Industry design standards may not have been updated to account for climate resilience.	To be applied, as applicable, as the design, construction and operation of Part A develops.

14.6 STUDY AREA

EFFECT OF PART A ON CLIMATE (GHG EMISSIONS)

14.6.1. The GHG emissions assessment is not restricted by geographical area but instead includes any increase or decrease in emissions as a result of Part A.

14.6.2. The Study Area, therefore, comprises:

a. Primary:

i. Emissions relating to onsite construction activities (such as plant use on site).
ii. Operational emissions from site maintenance activities related to repair and refurbishment (such as plant use on site).

b. Secondary:

i. Operational end user traffic – a comparison has been made between GHG emissions between the do-minimum (Without Part A) and do-something (With Part A) scenarios provided by a GHG assessment based on data from the traffic model for Part A, and Transport Analysis Guidance: Unit A3 Environmental Impact Appraisal.

c. Tertiary:

i. Construction emissions relating to the manufacturing, transport and disposal of materials, which may be some distance from the location of Part A (for example, emissions associated with the manufacture of cement and steel).
ii. Operational emissions from the manufacturing, transport and disposal of repair and refurbishment materials, which may be some distance from the location of Part A (for example, emissions associated with the manufacture of cement and steel).

VULNERABILITY OF PART A TO CLIMATE CHANGE

14.6.3. The Study Area for the climate change vulnerability assessment is related to the impact of climate on Part A (rather than the impact of Part A on the environment). The climate vulnerability assessment has used Met Office published historical regional weather data to establish the current climate impacts on the Study Area for which the UKCP18 probabilistic projections are based.

14.6.4. The projections that are used to define the future baseline (against which resilience of Part A is assessed) are UKCP18 projections for the 2080s for the 25 km^2 UKCP18 grid square (412500.00, 587500.00) (for a high emissions scenario (Representative Concentration Pathway (RCP) 8.5) which encompasses Part A (**Figure 14-1** below), and supplemented by the 25 km^2 UKCP09 grid square (ID: 965) where data under UKCP18 is not available (**Figure 14-2** below).

14.6.5. In addition, it is likely that changes in climate and extreme weather events may be influenced by regional characteristics, so reference is also made to the geographical region in which Part A is located (the northeast of England region (**Figure 14-3** below).

Figure 14-1 – Location of 25 km^2 grid box used for UKCP18 (412500.00, 587500.00)

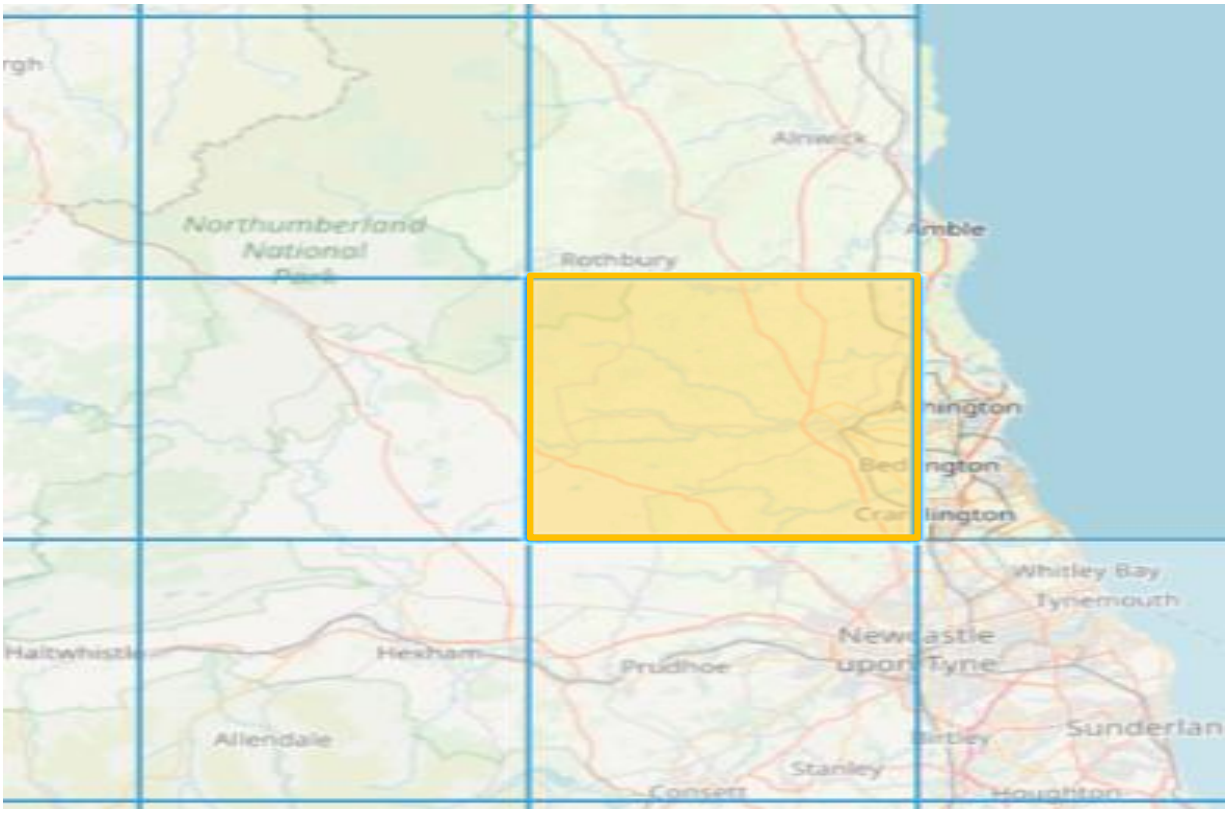


Figure 14-2 – Location of 25 km^2 grid square (ID 965) used for UKCP09

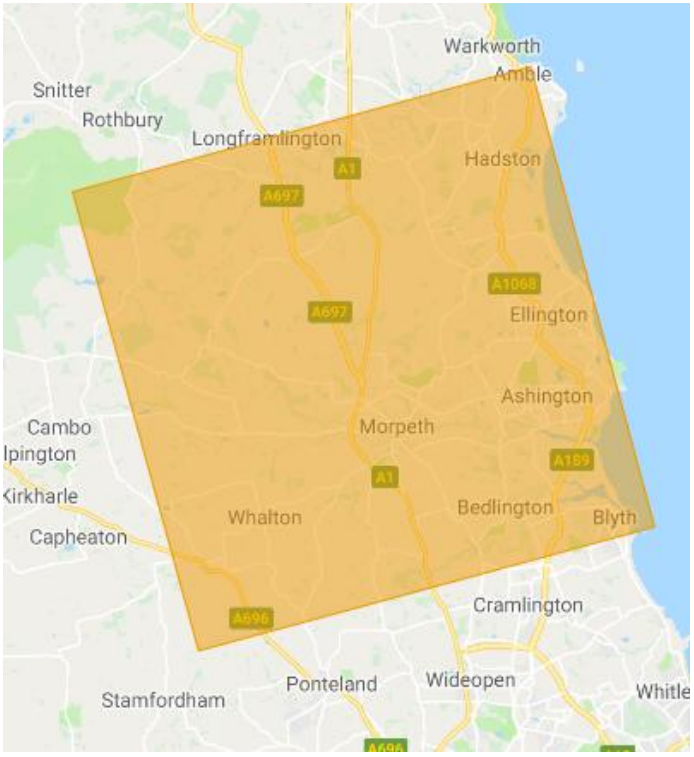


Figure 14-3 – Location of Northeast of England Region

14.7 BASELINE CONDITIONS

EFFECTS OF PART A ON CLIMATE (GHG EMISSIONS)

14.7.1. The baseline conditions set out in this section describe the current likely emissions sources from within the Order Limits. This section describes how this baseline would be likely to change in a 'do-minimum' scenario (without Part A).

14.7.2. In the baseline scenario, GHG emissions occur constantly and widely as a result of human and natural activity including energy consumption (fuel, power), industrial processes, land use and land use change. The GHG emissions assessment only considers where Part A results in additional or avoided emissions in comparison to the baseline scenario and its assumed evolution.

14.7.3. No construction works are anticipated to take place in the ‘do minimum’ scenario, and as such no construction emissions are included within the baseline.

14.7.4. The operation and management of the existing A1 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.

14.7.5. The do-minimum option would be unlikely to change the emission sources generated by the current consumption of materials within the Order Limits.

14.7.6. In terms of end-user emissions from road traffic, the existing A1 has a large number of junctions and private accesses which result in traffic delays. Slow-moving traffic is also caused by a high proportion of heavy goods vehicles, agricultural vehicles and lack of overtaking opportunities.

14.7.7. The total end-user GHG emissions from traffic flows in the 'do minimum' (baseline) scenario are presented in **Table 14-12** below. The total end-user traffic GHG emissions has been based on a 60-year operational life of Part A (2024 to 2083). This exceeds the pavement design life of 40 years and covers half of the standard bridge design life (120 year). It is not considered proportionate to model GHG emissions beyond a 60-year timeframe for Part A due to a lack of certainty in GHG emissions beyond this timeframe. The average annual GHG emissions for the 60 year period is also provided.

14.7.8. In the do-minimum (baseline) scenario, total CO2 emissions are expected to decrease after 2024 (opening year) by 4% until the future year 2039 (15 years after opening), as shown in **Table 14-12**. This is due to the effects of, for example, vehicle types, fuel type, forecast fuel consumption and vehicle emission factors.

Table 14-12 – Baseline GHG Emissions Data for End User Traffic in the Region of Part A

Scenario	Total GHG emissions for all traffic in the traffic model area (thousand tonnes of carbon dioxide equivalent; $ktCO_2e$)			
	2024	**2039**	**Average per year (2024 – 2083)**	**Total (2024-2083)**
Baseline (do minimum)	114	109	110	6,582

14.7.9. In addition to the baseline traffic emissions presented above, emissions during 2016 within North East and nationally (**Ref. 14.33**) are presented in **Table 14-13** for context.

Table 14-13 – GHG Emissions, Northeast and National, 2016

Source	Northeast ($kTCO_2e$)	National ($kTCO_2e$)
A. Industry and Commercial Electricity	2,049.3	51,531.7
B. Industry and Commercial Gas	1,766.0	35,973.1
C. Large Industrial Installations	3,622.3	32,465.9
D. Industrial and Commercial Other Fuels	512.7	17,657.9
E. Agriculture	176.6	5,381.6
Industry and Commercial Total	8,126.9	143,010.3
F. Domestic Electricity	1,141.1	31,441.6
G. Domestic Gas	2,870.7	60,202.5
H. Domestic 'Other Fuels'	273.6	10,788.0
Domestic Total	4,285.4	102,432.0
I. Road Transport (A roads)	2,349.8	54.350.7
J. Road Transport (Motorways)	285.5	28,031.8
K. Road Transport (Minor roads)	1,727.3	41,483.3
L. Diesel Railways	97.5	2,150.7
M. Transport Other	34.7	2,036.2
Transport Total	4,494.9	128,052.7
N. LULUCF Net Emissions	-1,437.8	-16,025.6
Grand Total	15,469.4	357,469.5
Population ('000s, mid-year estimate)	2,636.6	65,648.1
Per Capita Emissions (t)	5.9	5.4

14.7.10. For land use change emissions, the ‘do minimum’ scenario includes the sequestration of emissions without Part A in place. A summary of these emissions is presented in **Table 14-14**. The emissions from land use change are presented as negative values as they are emissions reductions.

Table 14-14 – Baseline Land Use Change Emissions

Method	Baseline (Do Minimum) Emissions ($ktCO_2e$)
IPCC 2006	-11.18
Woodland Carbon Code	-11.41

VULNERABILITY OF PART A TO CLIMATE CHANGE

14.7.11. **Appendix 14.1: Vulnerability to Climate Change Baseline**, **Volume 7** of this ES (**Application Document Reference: TR010041/APP/6.7**) provides details of current climate and projected climate for the Study Area.

14.7.12. In summary, the northeast of England has a temperate climate, although rainfall is significant, even in the driest month (typically February). Current mean temperatures in the northeast of England region are, relative to elsewhere in England, generally cool throughout the year.

FUTURE BASELINE

14.7.13. UKCP18 suggest that the region will become wetter in winter and drier in summer, with more extreme rainfall events. Projections for the region in the 2080s under a high emissions scenario (RCP8.5) are as follows:

a. Mean winter precipitation is projected to increase by up to 24% (50th percentile)
b. Mean summer precipitation is projected to decrease by up to 23% (50th percentile)

14.7.14. In terms of temperature, UKCP18 suggests that the region will experience hotter summers and warmer winters, with more extreme temperature events (heatwaves). Projections for the region in the 2080s under a high emissions scenario (RCP8.5) are as follows:

a. Mean winter temperature is projected to increase by approximately 3ºC (50th percentile)
b. Mean summer temperature is projected to increase by approximately 4ºC (50th percentile)

14.7.15. UKCP18 projections show 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 frequency of winter storms.

14.7.16. The vulnerability of Part A to climate change depends on the level of exposure of the receptors to changes in different climate variables. Due to the lag in the climate system and given past emissions of GHGs some degree of climate change is inevitable in the near-term (<20-30 years). In the short-term, natural variability will dominate the weather-related risks that are experienced, including extreme events (such as storms and heatwaves).

14.7.17. Over the long term, the climate we experience will be influenced by levels of GHG emissions. To model and predict future climate it is necessary to make assumptions about the economic, social and physical changes to our environment that will influence climate change. RCPs are a method for capturing those assumptions within a set of scenarios. RCPs specify the concentration of GHG in the atmosphere which will result in target amounts of radiative forcing at the top of the atmosphere by 2100, relative to pre-industrial levels. Four RCPs are modelled in UKCP18 (RCP2.6, RCP4.5, RCP6.0 and RCP8.5), representing four different climate outcomes; RCP8.5 is the highest emissions scenario.

14.7.18. In combination, climate change and extreme weather events will bring challenges for the UK's infrastructure over time, including in the short- (2020s), medium- (2050s) and long-term (2080s). The design life of Part A (as detailed in **Chapter 2: The Scheme**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**)) has been used to identify the temporal boundary for the climate vulnerability assessment (a pavement design life of 40 years and a standard bridge design life of 120 years). UKCP18 data does not extend beyond the 2080s timescales. In light of the above, the assessment presented here considers the 2020s, 2050s and 2080s timescales under RCP8.5, where appropriate.

14.7.19. The projections provided by UKCP18 (**Ref. 14.22**) are probabilistic, which means that rather than a single 'best-guess' of the impact of climate change they provide a range of outcomes based on an 'ensemble' of multiple climate model runs. This better represents the uncertainty of climate prediction science. To help demonstrate consideration of uncertainty inherent within climate modelling, projections for the 10th, 50th (central) and 90th percentiles are stated, where possible. The 10th percentile describes the value at which 10% of the model runs fall at or below; the 50th percentile is the value at which half the climate scenarios fall below the figure and half fall above it; and the 90th percentile described the value at which 90% of the model runs fall at or below.

14.7.20. The elements of Part A have been broadly classified as 'road' 'bridges' and 'pedestrian and cycle' as presented in **Table 14-5**. Specific receptors within the classifications may be summarised as:

a. **Road**: comprising the hard surfaces such as pavements and road surface (including the online section of Part A, the offline section of Part A and de-trunked A1), roadside infrastructure, soft estate, earthworks, embankments and foundations.
b. **Bridges**: The new bridge over the River Coquet, built structures including over and under bridges and earthworks, embankments and foundations.
c. **Pedestrian and cycle**: Pedestrian and cycle provision.

14.8 POTENTIAL IMPACTS

EFFECT OF PART A ON CLIMATE (GHG EMISSIONS)

14.8.1. The impacts of GHG emissions relate to their contribution to global warming and climate change. These impacts are global and cumulative in nature, with every tonne of GHG contributing to adverse effects upon natural and human systems.

14.8.2. GHGs are natural and man-made gases occurring in the atmosphere, which absorb and emit infrared radiation, thereby retaining the Sun's energy within the Earth's atmosphere. There is an overwhelming scientific consensus that the major increase in the concentration of GHGs from man-made sources is contributing to global warming and climate change (**Ref. 14.34**).

14.8.3. The seven main GHGs defined by the Kyoto Protocol are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride. In combination, these GHG emissions are commonly expressed in terms of carbon dioxide equivalents according to their relative global warming potential. For this reason, the shorthand 'carbon' may be used to refer to GHG.

14.8.4. GHG emissions result in the same impacts wherever and whenever they occur, and as such it is not possible to link specific Part A emissions, with specific environmental outcomes beyond their contribution to climate change at large.

14.8.5. GHG emissions would occur as a result of human activities with or without Part A. The baseline data shows that, in the absence of Part A, end-user traffic emissions would decrease after 2024 (opening year) by 4% until the future year 2039.

14.8.6. Any increase in emissions and the corresponding concentrations of GHG present in the atmosphere will contribute to climate change, and as such emissions of GHG due to Part A would contribute to climate change.

Construction

14.8.7. Part A would result in increases in GHG emissions associated with construction activities (such as manufacturing of materials and construction processes).

Operation

14.8.8. Part A would result in changes to end-user traffic emissions throughout its operational life, which could be an increase or decrease depending on the effect on traffic flows and speeds. In addition, the road is anticipated to be resurfaced in years 12, 20, 30, 40, 45 and 57, which would also increase GHG emissions for Part A.

VULNERABILITY OF PART A TO CLIMATE CHANGE

14.8.9. **Table 14-15** describes the potential climate and weather related impacts on Part A receptors during the construction and operational phases. Unless stated, the impacts identified in the table below are expected to impact the whole of Part A during construction and operation.

Table 14-15 – Potential Impacts of Climate Change and Associated Hazards / Opportunities

Climate Variable	Potential Impacts/Opportunities	Potential Impact (Construction and Operational Phase)					
		Structures (Relevant during construction of structures and operational phase)	**Soft Estate** (Relevant during construction and operational phases)	**Ancillary Equipment** (Relevant during use construction of plant and equipment and for operational equipment)	**Materials** (Relevant during construction and operation)	**Site Contents and Business Continuity** (Relevant to construction works and operational maintenance works)	**Users (Operators and Customers)** (Relevant to operational Phase)
Precipitation	Extreme rainfall events	Damage to carriageway structures due to increased run-off Soil saturation and water damage Undercutting particularly in relation to the bridge over the River Coquet Increased slope instability Damage to unpaved shoulders Erosion, silting and sedimentation	Changes in growing season and more vigorous growth during wet periods Damage to unpaved shoulders	Drains and culverts becoming overwhelmed	Softening of subsurface materials below the carriageway and structures	Water accumulation causing disruption to construction and operation Reduced opportunities for maintenance	Difficult working conditions Movement of debris causing slip, trip and fall hazards Health and safety risks to road users
	Drought	Loss of vegetation across Part A leading to greater erosion risk Deformation of rigid structures (roads, cycleway and footpath, bridges, culverts etc)	Drying out and loss of vegetation	Not applicable	Enhanced reactions when cement stabilising and drying of concrete Increased rate of deterioration of materials, potentially leading to need for early replacement Drying out of construction materials and cracking Increased dust and windborne materials affecting site construction, operation and maintenance, including silting and sedimentation	Evaporation of construction water	More dust

Climate Variable	Potential Impacts/Opportunities	Potential Impact (Construction and Operational Phase)					
		Structures (Relevant during construction of structures and operational phase)	**Soft Estate** (Relevant during construction and operational phases)	**Ancillary Equipment** (Relevant during use construction of plant and equipment and for operational equipment)	**Materials** (Relevant during construction and operation)	**Site Contents and Business Continuity** (Relevant to construction works and operational maintenance works)	**Users (Operators and Customers)** (Relevant to operational Phase)
	Change in seasonal average – drier summers	Subsidence impacting roads, cycleway and footpath and structures (bridges, culverts) Failure of earthworks due to desiccation impacting roads, cycleway and footpath, bridges and culverts Shrinking and cracking of soils	Drying out and loss of vegetation		Enhanced reactions when cement stabilising and drying of concrete Increased dust and windborne materials affecting site construction, operation and maintenance, including silting and sedimentation	Not applicable	Not applicable
	Change in seasonal average – wetter winters (including flooding and/or repeated wet cycles)	Damage due to increased run-off Soil softening and erosion leading to collapse and settlement of soil structures Increased slope instability Soil saturation Damage to unpaved shoulders Undercutting, particularly in relation to the bridge over the River Coquet	Changes in growing season and more vigorous growth during wet periods Damage to unpaved shoulders	Blockage of drains and associated assets Water accumulation in low spots and / or on impermeable surfaces	Greater mobilisation of pollutants in the soil / ground	Increasingly difficult working conditions, including time available to undertake works Reduced opportunities for maintenance	Movement of debris causing slip, trip and fall hazards
Temperature	Extreme temperature events	Cracking and expansion, particularly impacting bridge structures Increased risk of erosion	Fire Drying out and loss of vegetation	Overheating of equipment, including during construction and operation (e.g. electronic signage)	Deformation of pavement surfaces	Reduced opportunities for maintenance Operational disruption	Difficult working conditions Increased fire risk Hot surfaces which may cause injury

Climate Variable	Potential Impacts/Opportunities	Potential Impact (Construction and Operational Phase)					
		Structures (Relevant during construction of structures and operational phase)	**Soft Estate** (Relevant during construction and operational phases)	**Ancillary Equipment** (Relevant during use construction of plant and equipment and for operational equipment)	**Materials** (Relevant during construction and operation)	**Site Contents and Business Continuity** (Relevant to construction works and operational maintenance works)	**Users (Operators and Customers)** (Relevant to operational Phase)
							Failure of temperature controls Health and safety risks to road users
	Change in seasonal average – hotter summers	Not applicable	Drying out and loss of vegetation	Overheating of equipment	Enhanced reactions when cement is stabilising and drying of concrete	Reduced opportunities for maintenance Greater demand for cooling	Difficult working conditions
	Change in seasonal average – warmer winters	Not applicable	Changes in growing season and more vigorous growth during autumn and winter	Not applicable	Fewer freeze-thaw events causing potholes	Less disruption from fewer ice and snow events	Better working conditions for road operatives
	Changes in solar radiation	Not applicable	Changes in growing season and more vigorous growth	Increased solar gain (i.e. glare and warming of exposed surfaces)	UV degradation of materials	Not applicable	Not applicable
Wind	Gales and extreme wind events	Risk of damage to structures and foundations, including from flood scour and run-off Erosion of banks and exposed surfaces	Loss of vegetation Falling trees	Damage to signage	Increased rate of deterioration of materials, potentially leading to need for early replacement Damage from high winds and rain-infiltration into surfaces and materials	Not applicable	Difficult working conditions Health and safety risks to road users, particularly high sided vehicles
	Storms (snow, hail, lighting)	Destabilisation due to lighting strike	Falling trees	Destabilisation due to lighting strike	Not applicable	Risk to power sources Electrical surges Fire risk	Difficult working conditions Health and safety risks to road users

Climate Variable	Potential Impacts/Opportunities	Potential Impact (Construction and Operational Phase)					
		Structures (Relevant during construction of structures and operational phase)	**Soft Estate** (Relevant during construction and operational phases)	**Ancillary Equipment** (Relevant during use construction of plant and equipment and for operational equipment)	**Materials** (Relevant during construction and operation)	**Site Contents and Business Continuity** (Relevant to construction works and operational maintenance works)	**Users (Operators and Customers)** (Relevant to operational Phase)
Relative humidity	Humidity	Not applicable	Changes in growing season and more vigorous growth	Damage from condensation, mould growth and mildew	Excessive moisture in building materials Excessive moisture in sheltered (i.e. north-facing) surfaces	Not applicable	Uncomfortable working conditions
Water quality and soils	Soil moisture and runoff	Shrinking and cracking of soils leading to subsidence Soil softening and erosion leading to collapse and settlement of structures Increased slope instability Soil saturation Flooding and damage due to increased run-off	Shrinking and cracking of soils leading to loss of vegetation Damage to unpaved shoulders	Shrinking and cracking of soils leading to subsidence Blockage of drains Water accumulation in low spots and/or on impermeable surfaces	Greater mobilisation of pollutants in the soil/ground	Increased maintenance costs and risks to operation Increasingly difficult working conditions, including time available to undertake works	Difficult working conditions Increased risk of aquaplaning
	Salinity / pH	Not applicable	Change in soil chemistry may lead to loss of vegetation	Not applicable	Increased rate of deterioration of materials, potentially leading to need for early replacement	Not applicable	Not applicable
	Soil stability	Subsidence impacting road, cycleway and footpath and structures (bridges and culverts) Failure of earthworks due to desiccation	Loss of soil leading to loss of vegetation	Not applicable	Not applicable	Increased maintenance costs	Not applicable

14.9 DESIGN, MITIGATION AND ENHANCEMENT MEASURES

EFFECTS OF PART A ON CLIMATE (GHG EMISSIONS)

14.9.1. The effects on climate from the construction of Part A are inherently linked to the consumption of material resources, the generation and disposal of waste and transport of these items to, within and from site.

14.9.2. Measures within the design of Part A are identified below and included within the **Outline Construction Environmental Management Plan** (**Outline CEMP**) (**Application Document Reference: TR010041/APP/7.3**).

Design Measures

14.9.3. The following principles, as identified in **Section 2.5** of **Chapter 2: The Scheme**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**), have been adopted within the design of the road surfacing to ensure sustainability:

a. Re-use of materials to minimise resource consumption, waste disposal and emissions resulting from material haulage.
b. Whole-lifecycle design, including that which maximises the residual life of existing surfacing components.
c. Recycling of end-of-life materials.
d. Innovative and best practice design to ensure environmental protection and minimise construction periods and traffic disruption.

14.9.4. In addition, the following measures are included within the design of Part A and included within the **Outline CEMP** (**Application Document Reference: TR010041/APP/7.3**):

a. Where possible, existing structures would be retained, such as footpaths, bus stops, laybys, culverts and River Coquet bridge drainage, as set out in **Chapter 2: The Scheme**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**).
b. The selection of structural elements (each bridge and culvert) has been completed using a matrix examination of the various potential structural forms. Sustainability considerations are one of the main areas through which the options were assessed. Wherever possible, the most appropriate low carbon solution has been chosen for Part A.
c. During detailed design, the most appropriate low carbon solution would be selected for Part A, in line with good practice.
d. Use of pre-fabricated elements and off-site construction to optimise efficiency, such as the girders and bracing for the deck works and culvert elements as set out in **Chapter 2: The Scheme**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**).
e. Design initiatives would be realised through working with the Pavement Efficiency Group to ensure that emerging or improved practices are adopted wherever possible. The design aspects would be confirmed as detailed design progresses; however, this may include specialist road recycling through cold reconstruction processes which reduces

waste to landfill and energy reduction, mobile batching plant which would reduce vehicle movements, and warm mix asphalt, manufactured at lower temperatures reducing the carbon footprint and using less fuel in the manufacturing process.

f. As far as possible, incorporating material resource efficiency and waste minimisation best practice into design, in particular improving the cut and fill balance of Part A.
g. Select and engage with material suppliers and the main contractor taking into account their policies and commitments to reduction of GHG emissions, including embodied emission in materials.
h. Minimise energy consumption would include fuel usage by, for example, reducing the requirement for earth movements to/from and within the construction site.

Mitigation Measures

Construction

14.9.5. As detailed in the **Outline CEMP** (**Application Document Reference: TR010041/APP/7.3**), a Site Waste Management Plan (SWMP) and Materials Management Plan (MMP) would be developed by the main contractor (as outlined in **Chapter 13: Material Resources** of this ES) to ensure waste minimisation and re-use of materials on site. The Outline CEMP would be developed into a detailed full CEMP by the main contractor and secured through **Requirement 4** of the **draft DCO** (**Application Document Reference: TR010041/APP/3.1**).

14.9.6. As described in the **Outline CEMP** (**Application Document Reference: TR010041/APP/7.3**), measures to reduce GHG emissions include:

a. The re-use of site arisings (earthworks, road planings, concrete (through crushing and use on haul roads) and vegetation (through mulching and use as temporary footways)) (as outlined in **Chapter 13: Material Resources** of this ES).
b. Minimise transportation of materials and waste through local sourcing of materials, use of local waste facilities and backhauling. **Chapter 13: Material Resources** of this ES identifies that materials would be sourced from the North East in the first instance and then nationally depending on the availability of construction materials.
c. Collection of rainwater on-site to minimise transportation of freshwater for bowsers.
d. Use of vehicles fitted with telematics and start – stop technology on construction plant to minimise fuel use.

Operation

14.9.7. There are no operation measures in relation to the effects of Part A on climate.

Enhancement Measures

14.9.8. No enhancement measures are proposed for the construction and operation of Part A. The mitigation measures described above are sufficient in reducing potential GHG emissions as far as reasonably possible.

VULNERABILITY OF PART A TO CLIMATE CHANGE

Construction

14.9.9. **Table 14-16** outlines the embedded mitigation measures that have been integrated into the design and construction methodology of Part A in order to improve the resilience of Part A to the potential impacts identified in **Table 14-15**. These measures and how they have been secured are detailed in the **Outline CEMP** (**Application Document Reference: TR010041/APP/7.3**).

Table 14-16 – Embedded Mitigation Measures

Climate Variable and Components Affected	Potential Impacts	Embedded Mitigation Measure(s)
Precipitation Structural stability Structural robustness Ancillary equipment Material durability Site contents and business continuity H&S of users (operators and customers)	Extreme rainfall events - Damage to carriageway structures due to increased runoff - Blockages of drainage assets - Damage due to increased runoff - Water accumulation causing disruption to construction and operation - Stopping of services due to asset failure - Scour of embankments leading to increased maintenance - Traffic disruption and congestion - Excessive vegetation growth - Reduced opportunities for maintenance - Difficult working conditions - Movement of debris causing slip, trip and fall hazards Health and safety risks to road users (e.g. skidding)	Structures - Flood risk during construction has been considered under the heading of sustainability in the assessment of structural options - Close liaison with flooding team during preliminary design to ensure culvert spans are compatible with predicted flow rates during period of high rainfall (during operation), particularly for extreme rainfall events with regard to surrounding topography and other watercourses - Piled foundations (to manage structural stability and robustness) would be used for Burgham Park Overbridge, River Coquet Bridge and Parkwood Subway abutments Drainage - The drainage design includes Sustainable drainage system (SuDS) to limit the effect of the new works by attenuating the runoff during operation - An allowance has been made for increased intensity of rainfall. An increase of 20 % has been used in line with DMRB Flood Risk - The design of Part A incorporates both new culverts and use of existing culverts - The culverts have been modelled and designed for the 1 in 100 year plus 25 % climate change allowance - The culvert design includes for 300-600 mm freeboard allowance Buildability - Where landscape planting is included on embankments this would improve stability during operation. - Embankment slopes would be constructed from sub soil rather than topsoil with appropriate planting. - Drainage would be designed such that maintenance (during operation) is more accessible and easier to undertake. - Drainage would be designed for minimal maintenance during operation. - Self-cleansing drainage systems would be provided to remove silting. - Agree higher discharge levels with Environment Agency to remove excess stored water from drainage system quicker during operation. - Incorporate effective seals to equipment such as the weather station, Automatic Number Plate Recognition (ANPR), Technology cabinets, Electricity cabinets to minimize water ingress and subsequent equipment failure during operation.
	Drought - Loss of vegetation leading to greater erosion risk - Damage and disruption (fires) - More dust and particulates	Structures - Modelling for temperature effects have been undertaken in accordance with modern standards and incorporated into the design Watercourses - Low flow channel to improve fish passage during operation would be installed at Fenrother Burn and Earsdon Burn

Climate Variable and Components Affected	Potential Impacts	Embedded Mitigation Measure(s)
		Buildability - Selection of native woodland and hedgerow species - Complete of regular inspections of landscape elements to ensure they meet their environmental functions, with replacement planting where necessary
	Drier summers - Loss of vegetation leading to greater erosion risk - Damage and disruption (fires) - More dust and particulates	Structures - Use of admixtures to maintain water/cement ratio during construction, thus enabling increase in consistency - Identify opportunities to use CEM 1 (cement grade using unblended cement) during construction to increase the rate and heat of hydration and reduce curing time, although careful consideration and testing must be given to reduction in concrete strength but under certain situations this may be an applicable approach - Manage concreting work during periods of day when temperature is not at maximum/cooler (during construction) Buildability - Implement dust suppression during construction - Manage construction working hours to avoid concreting in middle of day
	Wetter winters (including flooding and/or repeated wet cycles) - Damage due to increased runoff - Blockage of drains and associated assets - Water accumulation - Excessive vegetation growth - Increasingly difficult working conditions, including time available to undertake works - Reduced opportunities for maintenance	Structures - As above for increased precipitation and extreme rainfall events Drainage - The drainage design includes SuDS to limit the effect of the new works by attenuating the runoff during operation - An allowance has been made for increased intensity of rainfall, an increase of 20% has been used in line with DMRB - Structure drainage systems would have maintenance access built in to ensure blockages are reduced as much as practically possible to eliminate build-up of water Buildability - Schedule earthworks (where possible) to avoid work during winter months of construction phase - Provide appropriate temporary measures for maintaining site free from flood waters during construction phase - Use controlled methods for construction of embankments
Temperature Structural stability Structural robustness Ancillary equipment Material durability Site contents and business continuity H&S of users (operators and customers)	Extreme temperature events - Cracking and expansion particularly impacting bridge structures - Overheating of equipment, including during construction and operation (e.g. electronic signage) - Damage and disruption (e.g. fires) - Reduced working periods and delays due to extreme weather - Reduced opportunities for maintenance	Structures - The North abutment of the River Coquet Bridge has been designed with expansion joints of greater capacity - Ensure appropriate storage of inflammable materials during construction and operation - Risk during construction of reduced working periods and delays from extreme temperature events is deemed to be very low, with no legal maximum temperature in the UK. However, HSE offers no specific guidance of when it's too hot to work - Where relevant, structures have been designed for temperature effects to current standards Buildability - The North abutment of the River Coquet Bridge has been designed with expansion joints of greater capacity

Climate Variable and Components Affected	Potential Impacts	Embedded Mitigation Measure(s)
	- Operational disruption - Difficult working conditions - Increased fire risk - Hot surfaces may cause injury - Failure of temperature controls - More dust	- Provide protection to all UV resistant materials during construction - Provide appropriate curing methods for concrete during construction - Consider materials for surface course that would withstand higher temperatures before skid resistance is affected during design - Manage site working hours to avoid working in hotter times of day during construction
Wind Structural stability Structural robustness Ancillary equipment Material durability Site contents and business continuity H&S of users (operators and customers)	Gales and extreme wind events - Risk of damage to structures and foundations, including flood scour and/or runoff - Damage to signage and site structures - Increased rate of deterioration of materials, potentially leading to early replacement - Difficult working conditions - Health and safety risks to road users (e.g. from falling trees and vegetation)	Structures - Structures have been designed to current standards for wind loading - Schedule of general inspections and principal inspections of each structure to determine condition of the structure and identify any potential maintenance requirements Buildability - Manage construction works to avoid working at heights, craneage during high wind events - Use of adequate safety equipment
Relative humidity Ancillary equipment Material durability H&S of users (operators and customers)	Humidity - Uncomfortable working conditions	Structures - Relative humidity can lead to excessive condensation and water accumulation, particularly on steel surfaces. This would be managed during operation with suitable drip details and water collection/drainage - The River Coquet bridge would be the only steel structure. Detailed design would consider provision of suitable drip/drainage details Buildability - Carry out site testing of materials during construction to optimise moisture content and therefore ensure stability of any structures / embankments

Operation

14.9.10. There are no operation measures in relation to the vulnerability of Part A to climate change.

Enhancement Measures

14.9.11. No enhancement measures are proposed for the construction and operation of Part A. The mitigation measures described above are sufficient in reducing the vulnerability of Part A to climate change as far as reasonably possible.

14.10 ASSESSMENT OF LIKELY SIGNIFICANT EFFECTS

EFFECTS OF PART A ON CLIMATE (GHG EMISSIONS)

14.10.1. This assessment takes account of the following design, mitigation and enhancement measures (**Section 14.9**), that have been incorporated within the design of Part A:

a. Retention of existing structures where possible and selection of low carbon structural elements – this is expected to provide a carbon saving for Part A. The anticipated material quantities for Part A have been incorporated into the assessment, based on the current design. It has not however been possible to obtain data to calculate the carbon reduction without the retention of existing structures and selection of low carbon elements as developing specification data for such aspects is not considered proportional to the benefits of the assessment.

b. All other mitigation measures noted in **Section 14.9** are not quantifiable, in terms of inputting into the Highways England Carbon Tool, at this stage of the design. This would be confirmed during the detailed design of Part A, and also during the construction phase.

Construction Phase Estimated GHG Emissions

14.10.2. During construction, the main source of emissions is anticipated to be embedded carbon in construction materials including those associated with the pavement for road widening and the new dual carriageway and junctions (i.e. asphalt and aggregate); and the new structures such as the new bridge over the River Coquet, over and under bridges and the extended or renewed culverts (i.e. structural and reinforced steel and concrete). Refer to **Chapter 13: Material Resources** of this ES for further details on construction materials. Another important source of GHG emissions during construction is the transport of materials to/from site and the use of construction plant.

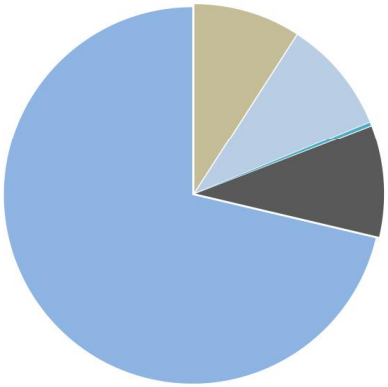
14.10.3. The total GHG emissions (tonnes of carbon dioxide equivalent) arising from the consumption of material supply, the manufacturing of materials, waste generation and disposal and transportation of materials to and from site for the construction of Part A (based on data available at the time of writing) are presented in **Figure 14-4** below.

14.10.4. **Figure 14-4** below also shows a breakdown of the GHG emissions ‘hot spots’ from materials, as the main source of emissions from construction of Part A. These are the outputs from the Highways England Carbon Tool covering the construction phase. This does not include operational phase emissions.

Figure 14-4 – Total GHG Emissions (Tonnes of Carbon Dioxide Equivalent) Breakdown Associated with Materials

Materials

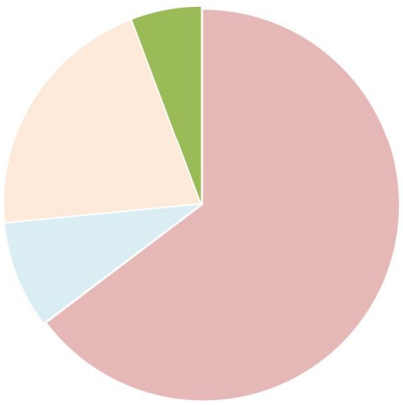
The table and pie chart displayed below show the total CO_2e emissions associated with materials purchased for the contract.



Category	CO_2e Emissions
Fencing / RRS / barriers	2,053.031
Drainage	2,175.345
Earthworks	0.000
Pavements	68.581
Street furniture	0.000
Civil Structures	2,152.960
Bulk Materials	16,037.771
Total	**22,487.688**

Materials, Transport, Energy and Waste Emissions

This table and pie chart show the total CO_2e emissions associated with materials compared to materials transport, energy use, business and employee transport and waste



Category	CO_2e Emissions
Materials Total	22,487.688
	3,038.666
Energy Use	7,232.551
Business and Employee transport	0.000
Waste	1,990.640
Total	**34,749.544**

14.10.5. The majority (64.7%) of GHG emissions are associated with materials (product stage 'cradle to gate'[2] or 'embodied' emissions) with 20.8% from diesel consumption from construction vehicles (energy use), 8.7% from transport of materials and wastes to the site, and 5.7% from waste generation and disposal.

14.10.6. Of the emissions for materials, the majority (71.3%) relate to the bulk materials required for Part A which comprise asphalt, aggregate, reinforcement steel and ready-mixed concrete.

[2] This is a measure of emissions incurred between resource extraction and the point at which a completed product leaves the factory (C. Cao (2017) *Sustainability and life assessment of high strength natural fibre composites in construction*, Woodhead Publishing)

Other significant contributions relate to the structures (9.6 %) comprising steel, pre-cast concrete and shuttering for the new bridge over the River Coquet, over and under bridges and culverts; drainage materials (9.7%); and fencing and barriers (9.1%).

Operation Phase Estimated GHG Emissions

14.10.7. During operation, the main GHG emissions source would be from end-users (traffic). Another lesser source of GHG emissions is those associated with the repair and refurbishment (resurfacing) of Part A over its operational life cycle.

14.10.8. Total end user GHG emissions are presented in **Table 14-17** for the year 2024 (the first year of operation for Part A) and the year 2039 (the future modelled year). In addition, the average annual and total GHG emissions based on a 60-year operational period of 2024 to 2083 are presented. The baseline figures (do minimum) are included for comparison.

Table 14-17 – End user GHG Emissions data for the Traffic in the Region

Scenario	Total GHG Emissions for all Traffic in the Traffic Model Area (thousand tonnes of carbon dioxide equivalent; $ktCO_2e$)			
	2024 (operational year)	**2039 (future year)**	**Average per year (2024 – 2083)**	**Total (2024-2083)**
Baseline (do minimum)	114	109	110	6,582
Scheme (do something)	139	140	140	8,417

14.10.9. The total regional traffic GHG emissions for the operational lifespan of Part A (2024-2083) is 1,836 $kTCO_2e$ higher (approximately 28%) than the 'do minimum' scenario.

14.10.10. When considering road resurfacing (operational phase repair and refurbishment), the primary GHG emissions would be from the refurbishment of asphalt materials. The resurfacing schedule provides for renewal of surface course commencing in year 12 of Part A and in years 20, 30, 40, 45 and 57. Material quantity data provided by a Buildability Advisor indicated that 388,440 tonnes of asphalt material would be required, which equates to 23.7 $kTCO_2e$. Of that, 90.7% relates to the asphalt, and 9.3% is for transport of the material.

14.10.11. The emissions from land use change result in a reduction in emissions due to an increase in forest area under Part A. This is because the forest area sequesters carbon from the atmosphere into biomass as the forest grows during the operation of Part A. The emissions reductions from land use change, are presented in **Table 14-18** as negative values as they are emissions reductions.

Table 14-18 – Land Use Change Emissions

Method	Baseline (do minimum) emissions ($ktCO_2e$)	Part A (do something) ($ktCO_2e$)	Emissions over 60 year lifetime ($ktCO_2e$)	Emissions per year ($ktCO_2e$)
IPCC 2006	-11.18	-15.25	-4.07	-0.07
Woodland Carbon Code	-11.41	-15.48	-4.06	-0.07

Total Estimated GHG Emissions

14.10.12. The total estimated GHG emissions arising from Part A have been calculated using the Highways England Carbon Tool (**Ref. 14.15**) and modelling based on Part A traffic data, quantified using WebTAG data tables (**Ref. 14.16**) and data from the Department of Transport, and are presented in **Table 14-19** below. They are presented for the construction phase (2021/2024), the operation phase (2024-2083) and the overall total for the whole lifecycle (2021-2083).

14.10.13. GHG emissions are presented and compared in percentage terms to UK National Carbon Budget periods to aid the assessment of the magnitude of change. This is in line with Paragraph 5.17 of the NPS NN (**Ref. 14.4**). The Third Carbon Budget covering 2018 to 2022 is 2,544 million tCO_2e. The Fourth Carbon Budget covering 2023 to 2027 is 1,950 million tCO_2e. The Fifth Carbon Budget covering 2028 to 2032 is 1,725 million tCO_2e (the latest Carbon Budget agreed by the Government).

14.10.14. An annual average of the total GHG emissions arising from Part A is also presented in comparison with the 2016 road CO_2e emissions for the North East in 2016 (**Ref.14.27**).

Table 14-19 – Part A impacts on Carbon Budgets

Stage / timing	Total GHG emissions (thousand tonnes of carbon dioxide equivalent; $kTCO_2e$)
Scheme GHG Emissions	
Construction (2021/24)	35
Operation (2024-2083)	1,855 (31 per year)

Stage / timing	Total GHG emissions (thousand tonnes of carbon dioxide equivalent; $kTCO_2e$)
Total for lifecycle (2021-2083)	1,890
Comparison of Part A GHG Emissions against Carbon Budget	
Total during third Carbon Budget period* (2018-2022) [% of budget]	23 [0.00091%]
Total during fourth Carbon Budget 4 period (2023-2027) [% of budget]	114 [0.00586%]
Total during fifth Carbon Budget period (2028-2032) [% of budget]	138 [0.00799%]
Comparison of 1 Year Operational Part A GHG Emissions against North East Total Road CO_2e Emissions for 2016	
One year's emission's during the operational phase as a % of North East Total Road CO_2e emission estimate in 2016	0.71%

* Only considering construction emissions as asset would not be operational until 2024.

14.10.15. GHG emissions result in the same global climate change effects wherever and whenever they occur and therefore the sensitivity of different human and natural receptors is not considered.

14.10.16. In line with Paragraph 5.17 of the NPS NN (**Ref. 14.4**), and in the absence of agreed thresholds for what level of GHG emissions is considered significant in an EIA, professional judgement, based on schemes of a similar size and nature, has been used to assess the significance of effects. As shown in **Table 14-19** the impact of Part A against the National Carbon Budgets is less than 0.008%.

14.10.17. The GHG emissions from the construction and operation of Part A are likely to have an adverse impact. The magnitude of change in GHG emissions is considered to be **minor adverse**.

14.10.18. Part A is therefore expected to have a **slight adverse** effect on climate. IEMA guidance (**Ref. 14.20**) suggests that all GHG emissions are significant in the absence of any significance criteria or defined threshold. However, given the embedded mitigation measures, the magnitude of GHG emissions and the context of Part A, using professional

judgement, it is considered that the slight adverse effect of Part A is **not significant** for the purpose of the assessment detailed in this ES.

14.10.19. The NPS NN 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 plans. This is the case not only for Part A but for the Scheme as a whole.

14.10.20. Furthermore, as presented in **Table 14-19**, the GHG impacts of Part A would not have a material impact on the Government meeting its carbon reduction targets.

VULNERABILITY OF PART A TO CLIMATE CHANGE

14.10.21. The significance of climate impacts depends on the likelihood of them occurring and the consequence if they do occur. **Table 14-20** shows the outcome of the significance assessment (taking account of the incorporated mitigation measures described in **Section 14.9**). The effects relate to construction and operation unless specifically stated.

14.10.22. With the mitigation measures described in **Section 14.9**, it is considered that climate change would have no significant impacts on Part A.

Table 14-20 – Significance Assessment for the Vulnerability to Climate Change

Variable		Projected Change	Receptor	Impact	Consequence	Likelihood	Significance
Precipitation	Extreme rainfall events	Increase in magnitude and frequency of extreme rainfall events	Structures	Damage to carriageway structures due to increased runoff	Minor adverse	Low	Not significant
				Soil saturation and water damage	Minor adverse	Low	Not Significant
				Undercutting and scour particularly in relation to the bridge over the River Coquet	Moderate adverse	Low	Not Significant
				Increased slope instability	Moderate adverse	Low	Not Significant
				Damage to unpaved shoulders	Negligible	Low	Not Significant
				Erosion, silting and sedimentation	Negligible	Low	Not Significant
	Drought	Increased risk of drought	Structures	Loss of vegetation leading to greater erosion risk	Negligible	Medium	Not Significant
				Deformation of rigid structures (roads, cycleway and footpath, bridges, culverts etc)	Moderate adverse	Low	Not Significant
	Change in seasonal average	Drier summers	Structures	Subsidence	Moderate adverse	Low	Not Significant
				Failure of earthworks due to desiccation impacting carriageways and bridges	Moderate adverse	Low	Not Significant
				Shrinking and cracking of soils	Moderate adverse	Low	Not Significant
	Change in seasonal average	Wetter winters (including flooding and/or repeated wet cycles)	Structures	Damage due to increased runoff	Minor adverse	Low	Not Significant
				Soil softening and erosion leading to collapse and settlement of soil structures	Moderate adverse	Low	Not Significant
				Increased slope instability	Moderate adverse	Low	Not Significant
				Soil saturation	Minor adverse	Medium	Not Significant
				Damage to unpaved shoulders	Negligible	Low	Not Significant
				Undercutting, particularly in relation to the bridge over the River Coquet	Moderate adverse	Low	Not Significant

Variable		Projected Change	Receptor	Impact	Consequence	Likelihood	Significance
Temperature	Extreme temperature events	Increase in magnitude of extreme temperature	Structures	Cracking and expansion particularly impacting bridge structures	Moderate adverse	Low	Not Significant
				Increased risk of erosion	Minor adverse	Medium	Not Significant
Wind	Gales and extreme wind events	Increase in mean wind speed and more frequent gusts	Structures	Risk of damage to structures	Moderate adverse	Low	Not Significant
				Erosion of banks and exposed surfaces	Minor adverse	Low	Not Significant
	Storms (snow, hail and lightning)	Increase in frequency of storms	Structures	Destabilisation due to lightning strike	Moderate adverse	Very low	Not Significant
Soils	Soil moisture and runoff	Decrease in soil moisture in summer	Structures	Shrinking and cracking of soils leading to subsidence	Moderate adverse	Low	Not Significant
		Increase in soil moisture in winter	Structures	Soil softening and erosion leading to collapse and settlement of structures	Moderate adverse	Low	Not Significant
				Increased slope instability	Moderate adverse	Low	Not Significant
				Soil saturation	Minor adverse	Medium	Not Significant
				Flooding and damage due to increased run-off	Moderate adverse	Medium	Not Significant
	Soil stability	Decrease in soil stability	Structures	Subsidence impacting road, cycleway and footpath and structures (bridges and culverts)	Minor adverse	Low	Not Significant
				Failure of earthworks due to desiccation	Moderate adverse	Low	Not Significant
Precipitation	Extreme rainfall events	Increase in magnitude and frequency of extreme rainfall events	Soft Estate	Changes in growing season and more vigorous growth during wet periods	Negligible	Medium	Not Significant
	Drought	Increased risk of drought	Soft Estate	Drying out of construction materials and cracking	Minor adverse	Medium	Not Significant
	Changes in seasonal average	Drier summers	Soft Estate	Drying out and loss of vegetation	Negligible	Medium	Not Significant

Variable		Projected Change	Receptor	Impact	Consequence	Likelihood	Significance
	Changes in seasonal average and/or repeated wet cycles)	Wetter winters (including flooding)	Soft Estate	Changes in growing season and more vigorous growth during wet periods	Negligible	Medium	Not Significant
				Damage to unpaved shoulders	Minor adverse	Medium	Not Significant
Temperature	Extreme temperature events	Increase in magnitude of extreme temperature	Soft Estate	Drying out and loss of vegetation	Negligible	Medium	Not Significant
				Fire	Moderate adverse	Low	Not Significant
	Change in seasonal average temperature	Hotter summers	Soft Estate	Drying out and loss of vegetation	Negligible	Medium	Not Significant
	Change in seasonal average temperature	Warmer winters	Soft Estate	Changes in growing season and more vigorous growth during autumn and winter	Negligible	Medium	Not Significant
	Changes in solar radiation	Increase in solar radiation	Soft Estate	Changes in growing season and more vigorous growth	Negligible	Medium	Not Significant
Wind	Gales and extreme wind events	Increase in mean wind speed and more frequent gusts	Soft Estate	Loss of vegetation	Negligible	Medium	Not Significant
				Falling trees	Minor adverse	Medium	Not Significant
Humidity	Relative humidity	Decrease in summer humidity, increase in winter humidity	Soft Estate	Changes in growing season and more vigorous growth	Negligible	Medium	Not Significant
Soils	Soil moisture and runoff	Decrease in soil moisture in summer Increase in soil moisture in winter	Soft Estate	Shrinking and cracking of soils leading to loss of vegetation	Negligible	Medium	Not Significant
				Damage to unpaved shoulders	Minor adverse	Medium	Not significant
	Soil salinity	Change in soil chemistry	Soft Estate	Change in soil chemistry may lead to loss of vegetation	Negligible	Low	Not Significant
	Soil stability	Decrease in soil stability	Soft Estate	Loss of soil leading to loss of vegetation	Negligible	Medium	Not Significant
Precipitation	Extreme rainfall events	Increase in magnitude and frequency of extreme rainfall events	Ancillary Equipment	Drains and culverts becoming overwhelmed	Minor adverse	Medium	Not Significant
	Change in season average	Wetter winters (including flooding and/or repeated wet cycles)	Ancillary Equipment	Blockage of drains and associated assets	Minor adverse	Medium	Not Significant
				Water accumulation	Minor adverse	Low	Not Significant

Variable		Projected Change	Receptor	Impact	Consequence	Likelihood	Significance
Temperature	Extreme temperature events	Increase in magnitude of extreme temperature	Ancillary Equipment	Overheating of equipment, including during construction and operation (e.g. electronic signage)	Minor adverse	Low	Not Significant
	Change in seasonal average	Hotter summers	Ancillary Equipment	Overheating of equipment, including during construction and operation (e.g. electronic signage)	Minor adverse	Low	Not Significant
	Changes in solar radiation	Increase in solar radiation	Ancillary Equipment	Increased solar gain (i.e. glare and warming of exposed surfaces)	Negligible	Medium	Not Significant
				UV degradation of exposed equipment e.g. cabling	Minor adverse	Low	Not Significant
Wind	Gales and extreme wind events	Increase in mean wind speed and more frequent gusts	Ancillary Equipment	Damage to signage	Negligible	Medium	Not Significant
	Storms (snow, hail, lightning)	Increase in frequency of storms	Ancillary Equipment	Destabilisation due to lightning strike	Minor adverse	Very low	Not Significant
Humidity	Relative humidity	Decrease in summer humidity, increase in winter humidity	Ancillary Equipment	Damage from condensation, mould growth and mildew	Negligible	Medium	Not Significant
Soils	Soil moisture and runoff	Decrease in soil moisture in summer	Ancillary Equipment	Shrinking and cracking of soils leading to subsidence	Minor adverse	Low	Not Significant
		Increase in soil moisture in winter	Ancillary Equipment	Blockage of drains	Minor adverse	Medium	Not significant
				Water accumulation in low spots and/or on impermeable surfaces	Minor adverse	Medium	Not significant
Precipitation	Extreme rainfall events	Increase in magnitude and frequency of extreme rainfall events	Material Durability	Softening of subsurface materials below the carriageway and structures	Moderate adverse	Low	Not Significant
	Drought	Increased risk of drought	Material Durability	Enhanced reactions when cement stabilising and drying of concrete	Negligible	Medium	Not Significant
				Increased rate of deterioration of materials, potentially leading to need for early replacement	Negligible	Medium	Not Significant
				Drying out of construction materials and cracking	Minor adverse	Medium	Not Significant
				Increased dust and windborne materials affecting site construction, operation and maintenance, including silting and sedimentation	Minor adverse	Medium	Not Significant

Variable		Projected Change	Receptor	Impact	Consequence	Likelihood	Significance
	Change in seasonal average	Drier summers	Material Durability	Enhanced reactions when cement stabilising and drying of concrete	Negligible	Medium	Not Significant
				Increased dust and windborne materials affecting site construction, operation and maintenance, including silting and sedimentation	Minor adverse	Medium	Not Significant
	Change in seasonal average	Wetter winters (including flooding and/or repeated wet cycles)	Material Durability	Greater mobilisation of pollutants in the soil/ground	Minor adverse	Low	Not Significant
Temperature	Extreme temperature events	Increase in magnitude of extreme temperature	Material Durability	Deformation of pavement surfaces	Moderate adverse	Low	Not Significant
	Change in seasonal average	Hotter summers	Material Durability	Enhanced reactions when cement is stabilising and drying of concrete	Negligible	Medium	Not Significant
	Change in seasonal average	Warmer winters	Material Durability	Fewer freeze-thaw events causing potholes	Minor adverse	Medium	Not significant
	Changes in solar radiation	Increase in solar radiation	Material Durability	UV degradation of materials	Minor adverse	Low	Not Significant
Wind	Gales and extreme wind events	Increase in mean wind speed and more frequent gusts	Material Durability	Increased rate of deterioration of materials, potentially leading to early replacement	Negligible	Medium	Not Significant
				Damage from high winds and rain-infiltration into surfaces and materials	Minor adverse	Low	Not Significant
Humidity	Relative humidity	Decrease in summer humidity, increase in winter humidity	Material Durability	Excessive moisture in building materials	Minor adverse	Low	Not Significant
				Excessive moisture in sheltered surfaces (i.e. north-facing)	Minor adverse	Low	Not Significant
Soils	Soil moisture and runoff	Increase in soil moisture in winter	Material Durability	Greater mobilisation of pollutants in the soil/ground	Minor adverse	Low	Not Significant
	Salinity / pH	Change in soil chemistry	Material Durability	Increased rate of deterioration of materials, potentially leading to need for early replacement	Negligible	Low	Not Significant
Precipitation	Extreme rainfall events	Increase in magnitude and frequency of extreme rainfall events	Site Contents and Business Continuity	Water accumulation causing disruption to construction and operation	Minor adverse	Low	Not Significant
				Reduced opportunities for maintenance	Minor adverse	Medium	Not Significant

Variable		Projected Change	Receptor	Impact	Consequence	Likelihood	Significance
	Drought	Increased risk of drought	Site Contents and Business Continuity	Evaporation of construction water	Negligible	Medium	Not Significant
	Change in season average	Wetter winters (including flooding and/or repeated wet cycles)	Site Contents and Business Continuity	Increasingly difficult working conditions, including time available to undertake works	Minor adverse	Medium	Not Significant
				Reduced opportunities for maintenance	Minor adverse	Medium	Not Significant
Temperature	Extreme temperature events	Increase in magnitude of extreme temperature	Site Contents and Business Continuity	Reduced opportunities for maintenance	Minor adverse	Medium	Not Significant
	Change in seasonal average –	Hotter summers	Site Contents and Business Continuity	Reduced opportunities for maintenance	Minor adverse	Medium	Not Significant
				Greater demand for cooling	Negligible	Medium	Not Significant
	Change in season average	Warmer winters	Site Contents and Business Continuity	Less disruption from fewer ice and snow events	Minor beneficial	Medium	Not Significant (beneficial)
Wind	Storms (snow, hail and lightning)	Increase in frequency of storms	Site Contents and Business Continuity	Risks to power sources	Moderate adverse	Very low	Not Significant
				Electrical surges	Minor adverse	Very low	Not Significant
				Fire risk	Moderate adverse	Very low	Not Significant
Soils	Soil moisture and runoff	Increase in soil moisture in winter	Site Contents and Business Continuity	Increased maintenance costs	Minor adverse	Low	Not Significant
				Increasingly difficult working conditions, including time available to undertake works	Minor adverse	Low	Not Significant
	Soil stability	Decrease in soil stability	Site Contents and Business Continuity	Increased maintenance costs	Minor adverse	Low	Not significant
Precipitation	Extreme rainfall events	Increase in magnitude and frequency of extreme rainfall events	Users (Operators and Customers)	Difficult working conditions	Minor adverse	Medium	Not Significant
				Movement of debris causing slip, trip and fall hazards	Minor adverse	Medium	Not Significant
				Health and safety risks to road users (e.g. skidding)	Minor adverse	Medium	Not Significant
	Drought	Increased risk of drought	Users (Operators and Customers)	More dust	Negligible	Medium	Not Significant

Variable		Projected Change	Receptor	Impact	Consequence	Likelihood	Significance
	Change in seasonal average	Wetter winters (including flooding and/or repeated wet cycles)	Users (Operators and Customers)	Movement of debris causing slip, trip and fall hazards	Minor adverse	Medium	Not Significant
Temperature	Extreme temperature event	Increase in magnitude of extreme temperature	Users (Operators and Customers)	Difficult working conditions	Minor adverse	Medium	Not Significant
				Increased fire risk	Moderate adverse	Low	Not Significant
				Hot surfaces may cause injury	Minor adverse	Low	Not Significant
				Failure of temperature controls	Minor adverse	Low	Not Significant
	Change in seasonal average	Hotter summers	Users (Operators and Customers)	Difficult working conditions	Minor adverse	Medium	Not Significant
	Change in season average	Warmer winters	Users (Operators and Customers)	Better working conditions for road operatives	Minor beneficial	Medium	Not Significant (beneficial)
Wind	Gales and extreme wind events	Increase in mean wind speed and more frequent gusts	Users (Operators and Customers)	Difficult working conditions	Minor adverse	Medium	Not Significant
				Health and safety risks to road users (e.g. from falling trees and vegetation)	Minor adverse	Low	Not Significant
Humidity	Relative humidity	Decrease in summer humidity, increase in winter humidity	Users (Operators and Customers)	Uncomfortable working conditions	Minor adverse	Low	Not Significant
Soils	Soil moisture and runoff	Increase in soil moisture in winter	Users (Operators and Customers)	Difficult working conditions	Minor adverse	Low	Not significant
				Increased risk of aquaplaning	Minor adverse	Low	Not significant

ASSESSMENT PARAMETERS

14.10.23. The Assessment Parameters are presented in **Section 2.12** of **Chapter 2: The Scheme**, **Volume 1** of this ES (**Application Document Reference: TR010041/APP/6.1**). The parameters are not considered to alter the findings or significance of effects of the climate assessment as a result of Part A.

14.10.24. The Assessment Parameters may slightly alter the requirement for construction materials (as outlined in **Chapter 13: Material Resources** of this ES), and the construction phase GHG emissions. However, this is not considered likely to change the outcome of the effects of Part A on Climate Change (GHG Emissions). This is due to the potential change in volumes of material or waste not being sufficient to change to outcome of the assessment.

14.10.25. The Assessment Parameters are not considered to impact on the vulnerability of Part A to climate change as the assessment uses UKCP18 (**Ref. 14.22**) and UKCP09 (**Ref. 14.23**) 25 km^2 grid square that contains Part A and, where appropriate, regional climate data for the north-east. As such, any effects of the Assessment Parameters are already incorporated in the assessment.

UPDATED DMRB GUIDANCE

14.10.26. The DMRB sensitivity test as described in **Section 14.4** has determined that the application of the updated guidance (**Ref. 14.31**) would not change the likely significance of effects. This is because the approach used for the assessment has recently evolved and been brought in close alignment with the updated guidance (DMRB LA 114) and is therefore considered to be of the same standard. Therefore, with the application of the updated guidance the conclusions of the assessment remain unchanged.

14.11 MONITORING

EFFECTS OF PART A ON CLIMATE (GHG EMISSIONS)

14.11.1. As part of the monitoring activities detailed in the **Outline CEMP** (**Application Document Reference: TR010041/APP/7.3**), the Applicant's supply chain is responsible for providing monthly or quarterly carbon data returns using the Highways England Carbon Tool (**Ref. 14.15**). As such, during the construction phase, data would be collected for materials and fuel/electricity consumption, which would enable embedded GHG emissions and emissions from energy to be monitored. The actual GHG emissions (outturn data) can then be compared to the GHG emissions estimates at the ES stage (i.e. this chapter) and the Applicant can iteratively feedback into the environmental assessment process.

14.11.2. Any noteworthy increases in GHG emissions associated with the outturn data in comparison with the GHG emissions estimates at this ES stage would be managed and mitigated accordingly through measures outlined in the **Outline CEMP** (**Application Document Reference: TR010041/APP/7.3**).

VULNERABILITY OF PART A TO CLIMATE CHANGE

14.11.3. Adaptation and resilience to climate and weather-related risks would be considered periodically through maintenance regimes to be detailed in the CEMP to be developed by the main contractor, as set out in the **Outline CEMP** (**Application Document Reference: TR010041/APP/7.3**).

14.11.4. A schedule of general inspections and principal inspections of each structure should be carried out to determine condition of the structure and identify any potential maintenance requirements. Inspections would be in accordance with DMRB CS 450 (**Ref. 14.35**) and would also occur following an intense rainfall event or heatwave to monitor any damage and implement appropriate mitigation as necessary.

14.11.5. In addition, a list of extreme weather-related incidents (for example, road surface deformations, snow and ice, etc.) would be maintained by the Applicant to assist in identifying thresholds which, when exceeded, would require maintenance.

14.11.6. Given the uncertainties inherent in climate science and projections, the impacts and effects identified should be monitored throughout the construction and operational phases of Part A by the Applicant. The monitoring would be undertaken to assess the appropriateness of the mitigation measures. The assessment would be revisited when new and/or updated information becomes available, for example when further updates to climate projections are published.

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