A585 Windy Harbour to Skippool Improvement Scheme

TR010035

6.15 Environmental Statement Chapter 15: Climate

APFP Regulation 5(2)(a)

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

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A585 Windy Harbour to Skippool Improvement Scheme

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ENVIRONMENTAL STATEMENT CHAPTER 15: CLIMATE

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15 CLIMATE

15.1 Introduction

15.1.1 This Chapter presents the assessment of climate impacts associated with the Scheme. This Chapter presents the regulatory framework, assessment methodology, study area, existing and future baseline, mitigation measures, residual effects, monitoring and a summary. To align with the requirements of the Environmental Impact Assessment (EIA) Regulations 2017 and the National Networks National Policy Statement (NN NPS) 2014, this Chapter is divided into 2 separate assessments:

- Effects on climate (from) emissions) – the effects on climate of GHG emissions arising from the Scheme, including how the Scheme would affect the ability of Government to meet its carbon reduction plan targets (in accordance with NN NPS paragraph 5.17)
- Vulnerability of the Scheme to climate change (and impacts relevant to adaptation) – the resilience of the Scheme to impacts resulting from a changing climate, including how the Scheme design would take account of the projected impacts of climate change (in accordance with NN NPS paragraph 4.40 and the EIA Regulations 2017)

15.2 Regulatory Framework / NN NPS

15.2.1 This assessment has been undertaken considering current legislation and guidance, along with national, regional and local plans and policies. A summary is provided within Table 15-1 and full details are within the Planning Statement and NN NPS Accordance (document reference TR010035/APP/7.1).

Table 15-1: Climate – Regulatory Framework and NN NPS Requirements

Policy / Legislation
National Policy
The Climate Change Act 2008
NN NPS 2014
National Planning Policy Framework (NPPF) 2018
The Carbon Plan 2011
Regional Policy
Lancashire County Council - Lancashire Climate Change Strategy 2009 -2020
Local Policy
Adopted Fylde Borough Local Plan, (2005)
Adopted Wyre Local Plan (1999)
Fylde Local Plan to 2032 (emerging document – due to be adopted 2018)
Wyre Local Plan to 2031 (emerging document – due to be adopted 2018)
Adopted Blackpool Local Plan Part 1: Core Strategy 2012-2027 (2016)
Highways England Delivery Plan 2015 - 2020

15.4 Methodology

15.4.1 This section describes the methodology which has been used for the assessment of climate which may affect, or be affected by, the construction and operation of the Scheme.

15.4.2 The assessment of climate covers the following elements as required by the EIA Directive:

- Effects on climate (from greenhouse gas emissions)
- Vulnerability of the Scheme to climate change (and impacts relevant to adaptation)

15.4.3 The approach to the assessment of climate is contained collectively within:

- Interim Advice Note (IAN) 114/08 – Highways Agency Carbon Calculation and Reporting Requirements. This methodology allows an estimate of the contribution from construction activities, also referred to as 'construction carbon' and the maintenance/refurbishment activities. The IAN is supplemented by reference to the latest carbon reporting tool https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/553866/Task_446_Carbon_Tool_v1.03.xlsm
- HA 207/07 – regional assessment methodology within Chapter 3. This methodology estimates the contribution from traffic on the road, also referred to as 'road user carbon (operation)'

Effects on Climate (from Greenhouse Gas Emissions)

15.4.4 Both construction and operational phases of the Scheme have been considered for the GHG assessment. The assessment is based on the operation of the Scheme in 2022 and the anticipated construction period of approximately 2 years commencing in Spring 2020.

15.4.5 The GHG emissions assessment takes an approach consistent with the principles set out in PAS 2080:2016. The GHG emissions associated with the construction and operation of the Scheme is reported in the form of the 'carbon footprint' - reported in tonnes of carbon dioxide equivalent (tCO2e).

15.4.6 Direct and indirect emissions are considered in line with GHG reporting and the total carbon footprint is reported in CO_2 equivalents (CO2e). This allows for the emissions of the 6 key GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6); to be expressed in terms of their equivalent global warming potential in mass of CO2e.

15.4.7 The assessment of GHG emissions associated with the Scheme is considered through the following stages:

- Construction of the Scheme, including material supply, transport, manufacturing and construction process:

a) The GHG emitted through the materials used to construct the Scheme, and the significance of the effects of this

b) The GHG emitted through the construction activities associated to the Scheme, calculated in line with PAS2080 methodology

- Operation of the Scheme, including:

a) Road user carbon – use of the asset or vehicle emissions in line with HA207/07 and WebTAG Unit A3 Chapter 4 Vulnerability of the Scheme to Climate Change[1]

b) Emissions associated with maintenance and refurbishment

15.4.8 In line with the NN NPS, the significance of effects have been assessed by comparing the estimated GHG emissions arising from the Scheme with UK carbon budgets, and the associated reduction targets, outlined in Table 15-2.

Table 15-2: Climate – UK Carbon Reduction Targets

Carbon Budget	Carbon Budget Level	Reduction Below 1990 Levels
3rd carbon budget (2018 – 2022)	2,544 $MtCO_{2e}$	37% by 2020
4th carbon budget (2023 – 2027)	1,950 $MtCO_{2e}$	51% by 2025
5th carbon budget (2028 – 2032)	1,725 $MtCO_{2e}$	57% by 2030

15.4.9 It is important to note that the NN NPS 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.'*

15.4.10 In the context of the above statement, it is unlikely that the Scheme would conclude significant effects on climate. The assessment, therefore, has been carried out implementing a proportionate approach to estimate the principal contributing factors associated with GHG emissions.

Vulnerability of the Scheme to Climate Change

15.4.11 A 4-stage framework has been adopted for the assessment, which looks at the likelihood and consequence of the impact occurring to each receptor, leading to evaluation of the significance of the effect.

15.4.12 Stage 1 involves the assessment of climate effects on the Scheme using the lifespan of the Scheme (taken as 120 years as this represents the longest individual asset lifespan) and the long-term lifecycle stage (2080s) over which the baseline projections have been presented within Section 15.6.

15.4.13 The UK Climate Projections (UKCP) programme provides probabilistic projections for the whole of the UK, at regional level and at local level. To identify the future changes to the climate baseline, the following factors have been identified and used in the assessment:

- The lifespan of the Scheme (including timescales for construction and operational life cycle stages)
- Climate trends associated with the UKCP high emissions scenario (50% probability) projection

15.4.14 UKCP09 projections include a range of different climate variables (e.g. mean daily

[1] Department for Transport (2015) TAG UNIT A3: Environmental Impact Appraisal [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/638648/TAG_unit_a3_envir_imp_app_dec_15.pdf (last accessed June 2018).

temperature for summer and winter, mean daily maximum temperatures for summer and mean daily minimum temperatures for winter).

15.4.15 Stage 2 involves the identification of receptors which are vulnerable to climate change. Stage 3 involves the identification of the impacts (hazards and opportunities) for each receptor using the UKCP09 data, including the vulnerability of the Scheme to both normal weather and extreme weather-related disaster scenarios.

15.4.16 Stage 4 of the framework includes an assessment of the identified impacts. The assessment has been undertaken using the categories in Table 15-3 and Table 15-4. Details of the significance of effects are reported using Table 15-5.

Table 15-3: Climate – Likelihood Categories

Likelihood Category	Description (probability and frequency of occurrence)
Very high	• The event occurs multiple times during the lifetime of the Scheme (120 years) e.g. approximately annually, typically 120 events.
High	• The event occurs several times during the lifetime of the Scheme (120 years) e.g. approximately once every 5 years, typically 24 events.
Medium	• The event occurs limited times during the lifetime of the Scheme (120 years) e.g. approximately once every 15 years, typically 8 events.
Low	• The event occurs during the lifetime of the Scheme (120 years) e.g. once in 120 years.
Very low	• The event may occur once during the lifetime of the Scheme (120 years).

Table 15-4: Climate – Measure of Consequence

Consequence of impact	Description
Very large adverse	• National level (or greater) disruption to strategic route(s) lasting more than 1 week.
Large adverse	• National level disruption[1] to strategic route(s) lasting more than 1 day but less than 1 week Or • Regional level disruption to strategic route(s) lasting more than 1 week.
Moderate adverse	• Regional level disruption to strategic route(s) lasting more than 1 day but less than 1 week.
Minor adverse	• Regional level disruption to strategic route(s) lasting less than 1 day.
Negligible	• Disruption to an isolated section of a strategic route lasting less than 1 day.

Table 15-5: Climate – Significance Matrix

Measure of consequence	Measure of Likelihood				
	Very low	Low	Medium	High	Very High
Negligible	NS	NS	NS	NS	NS
Minor	NS	NS	NS	**S**	**S**
Moderate	NS	NS	**S**	**S**	**S**
Large	NS	**S**	**S**	**S**	**S**
Very Large	NS	**S**	**S**	**S**	**S**

Table notes: NS = Not significant S = Significant

Assessment Assumptions and Limitations

15.4.17 Information on the climate baseline and future projections are based on freely available information from third parties, including the historical meteorological variables recorded by the Met Office and the UKCP09.

15.4.18 Climate projections are not predictions or forecasts but simulations of potential scenarios of future climate, under a range of hypothetical emissions scenarios and assumptions. Therefore, the results from running the climate models cannot be treated as exact or factual, but projection options. They represent internally consistent representations of how the climate may evolve in response to a range of potential forcing scenarios, and their reliability varies between climate variables.

15.4.19 The UKCP18 data is due to be released in November 2018. Therefore, a review of UKCP18 provides the latest information on our future climate.

15.4.20 In the absence of suitable detailed information for plant and equipment, the GHG emissions from plant and equipment that would be used during the construction phase has not been included within the assessment.

15.5 Study Area

Effects on Climate (Greenhouse Gas Emissions)

15.5.1 In relation to effects on climate, the study area considered for the construction phase includes the embodied carbon of the materials and the emissions caused by the construction activities and their associated transport.

15.5.2 The study area considered for the operation phase comprises the draft order limits and the traffic model area.

Vulnerability of the Scheme to Climate Change

15.5.3 The study area used for vulnerability of the Scheme to climate change, comprises the draft order limits and the north west of England.

15.5.4 It has also been defined as the physical infrastructure assets associated with the Scheme (for example, earthworks, structures, pavement). In addition, the environmental receptors identified and scoped in within other topic chapters' have also been considered where climate change has the potential to impact upon them.

15.6 Existing and Future Baseline

Effects on Climate (Greenhouse Gas Emissions)

Existing Baseline

15.6.1 In accordance with the NN NPS, where the Scheme is subject to EIA, the Environmental Statement (ES) must describe an assessment of any likely significant climate factors. This section provides evidence of the existing GHG emissions within the study area and describes GHG emissions from the transport sector in the UK and the north west of England.

15.6.2 The UK GHG emissions have decreased in 2016 by 41% from 1990. In 2016, UK net CO_2 emissions were estimated at 468 million tonnes of CO_2e, a decrease of 5% in comparison to 2015 levels[2]. In 2016, 26% of UK GHG emissions were from the transport sector with emissions of 125 million tonnes of CO_2e in 2016.

Table 15-6: Climate - GHG Emissions from Transport Sector in UK

Years	CO_{2e} (tonnes)
2010	124,369,319
2011	122,259,339
2012	121,299,991
2013	119,862,378
2014	121,233,962
2015	123,430,096
2016	125,753,853

Table 15-7: Climate - GHG Emissions from the Transport Sector in the North West

Years	CO_{2e} (tonnes)
2010	9,071,315
2011	8,903,479
2012	8,732,642
2013	8,587,392
2014	8,698,528
2015	8,761,584
2016	8,884,577

15.6.3 The UK construction industry is the largest consumer of natural resources with an average of over 400 million tonnes of material consumed every year. This accounts for approximately 10% of the total UK carbon emissions. Therefore, approximately 40.38 million tonnes of CO_2 are attributed to the embodied carbon of construction materials.

[2] Department for Business, Energy and Industrial Strategy (2015) 2015 UK Greenhouse Gas Emissions [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/589602/2015_Final_Emissions_Statistics_one_page_summary.pdf (last accessed August 2018).

15.6.4 Within Lancashire, total carbon emissions in 2016 were estimated at 8.5 million tonnes. This represented 21.2% of the north west total of 40.2 million tonnes and 2.4% of the UK total. Overall, 36.6% of Lancashire's emissions (2.9 million tonnes) were attributable to transport. Wyre transport-related emissions were estimated at 0.24 million tonnes CO_2, Blackpool at 0.12 million tonnes $CO_2$and Fylde at 0.183 million tonnes of CO_2[3].

Future Baseline

15.6.5 The transport sector is a key driver in projected UK emissions increases, with road transport emissions projected to rise by 28 million tonnes of CO_{2e} over 2023 and 2027[4].

Vulnerability of the Scheme to Climate Change

Existing Baseline

15.6.6 Across England as a whole, land temperature in the decade 2005 - 2014 was 1.0°C warmer than 1961 - 1990. There has been a significant human influence on the observed warming in annual central England temperature since 1950.

15.6.7 There has been a small observed increase in annual mean rainfall in recent decades. Between 1961 - 1990 and 1981 - 2010 annual mean rainfall increased by 3.2%. However, this change is not statistically significant in the context of rainfall totals over the last century.

15.6.8 Extreme temperature and rainfall values are not broken down for each UK county. The average count for hot and wet UK days during 1981 - 2010 was 4.63 for both hot days and wet days, compared with 3.65 for 1961 - 1990. Statistical results from extreme value analysis suggest that the UK daily maximum and minimum temperature extremes have increased by just over 1°C since the 1950s, and that heavy seasonal and annual rainfall events have also increased.

15.6.9 Evidence exists that demonstrates how the weather is already changing in the north west including[5]:

- 0.4ºC rise in annual mean temperature at Manchester Airport between 1988 and 1997 (compared to the 1961-1990, 30-year average)
- 20% decrease in summer rainfall over the last century
- Increased high intensity rainfall since the 1960s
- Seasonal rainfall varying by as much as 15% from the average in the last 30 years
- Sea level rise at Liverpool of around 6cm in the last 50 years

[3] Lancashire County Council (2016) Lancashire Insights: carbon dioxide emissions [online] available at: https://www.lancashire.gov.uk/lancashire-insight/environment/carbon-dioxide-emissions/ (Last accessed: August 2018)
[4] Department for Business, Energy and Industrial Strategy (2017) Updated Energy and Emissions Projections 2016 [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/599539/Updated_energy_and_emissions_projections_2016.pdf (last accessed June 2018).
[5] The Lancashire Climate Change Strategy 2009-2020 [online] available at: https://www.lancashire.gov.uk/council/strategies-policies-plans/environmental/lancashire-climate-change-strategy/ (last accessed August 2018).

- Increased flooding of some of the region's major rivers in the last few decades

15.6.10 High-level climate observations for north west England[6] over a 30-year averaging period between 1981 – 2010, are presented in Table 15-8.

Table 15-8: Climate – Climate baseline for the north west (1981-2010)

Climatic condition	Climatic description
Temperature	Mean daily minimum temperatures in the north west can range from 0°C to 2°C in winter, whilst summer daily maximum temperatures are in the region of 21°C.
Rainfall	Vigorous Atlantic lows are the source of the majority of rain in the north west in autumn and winter. The exposure of north west of England to westerly maritime air masses and the presence of extensive areas of high ground mean that the region has some of the wettest places in the UK. Annual rainfall in the north west averages between less than 800 mm and over 3,200 mm of rain each year in higher parts. In the higher parts in winter (December-February), between 50 and 60 days is the norm but this decreases to 40 or 45 days in summer (June-August).
Wind	North west England is one of the more exposed areas of the UK. The strongest winds are associated with the passage of deep areas of low pressure close to or across the UK. The frequency and strength of these depressions is greatest in the winter when mean speeds and gusts are strongest at approximately 79 knots at Lancashire.
Sunshine	Average annual sunshine durations over the north west of England range from around 1,200 hours to about 1,500 hours.
Air Frost	The first air frost in the north west of England can be expected around October with an average between 50 and 100 days per year experiencing air frost.

Future Baseline

Effects on Climate

15.6.11 The UKCP09 provides the best scientific picture of how global climate change is likely to affect the north west region of England. It is predicted that climate change will increase the frequency and severity of some types of extreme weather events in England. UK CP09 generally show that warmer, drier summers are more likely along with warmer, and wetter winters.

15.6.12 By the 2080s, the high emission central estimate provides the following projection:

- An increase in winter mean temperature of 3.1ºC
- An increase in summer mean temperature of 4.7ºC
- An increase in summer mean daily maximum temperature of 6ºC
- An increase in summer mean daily minimum temperature of 4.6ºC

[6] 18 The Met Office (2016) South West England: Climate [online] available at: http://www.metoffice.gov.uk/climate/uk/regional-climates/sw (last accessed June 2018).

- A 1% increase in annual mean precipitation
- A 26% increase in winter mean precipitation
- A 28% decrease change in summer mean precipitation

15.6.13 The frequency of severe weather events is also projected to increase due to climate change. UKCP09 medium projections indicate that by 2080s, there could be up to 5 annual heatwaves per year (e.g. 2 days of hot weather with a maximum temperature of > 29 ºC and a minimum of >15 ºC and up to 11 dry spells lasting more than 10 days. As noted by the Climate Change Risk Assessment (CCRA) 2017, England is already impacted by extreme weather events. The CCRA also identifies key risks and implications from a changing climate, which include:

- Changes in extreme weather conditions, which would impact on infrastructure, in particular through storm damage, flooding and high temperatures
- Flooding of transport infrastructure, including roads and rail is likely to increase, affecting both urban and rural access routes

15.6.14 In relation to key infrastructure such as roads, the CCRA notes that England has a number of roads and railways at significant likelihood of river and tidal flooding. Flooding of transport infrastructure and the associated disruption is projected to increase, affecting both urban and rural access routes.

Receptors Potentially Affected (including measure of likelihood)

15.6.15 The Highways England Climate Change Risk Assessment 2016 defines the receptors of climatic events as the assets, such as pavement, drainage, structures or geotechnics.

15.6.16 In addition, Highways England has embedded a culture of climate change adaptation planning, by giving ownership of the adaptation plans to the areas of their operations at risk from climate change (e.g. drainage, signs and signals, vehicle restraint systems, etc.). Therefore, this assessment has aligned the Scheme 's receptors with those presented within the Highways England Climate Change Risk Assessment.

15.6.17 Table 15-9 outlines materials receptors potentially affected by the Scheme.

Table 15-9: Climate – Receptors Potentially Affected

Receptor	Measure of Likelihood
Pavement	Medium
Structures	Low
Drainage	Medium
Geotechnics	Low
Signs and signals	Low
Technology	Low
Soft estate	Low
Vehicle Restraint Systems (during operation only)	Low

Receptor	Measure of Likelihood
Non-motorised user (NMU) facilities	Medium
Motorised users (during operation only)	Low

15.7 Mitigation and Enhancement Measures

Effects on Climate (Greenhouse Gas Emissions)

15.7.1 Mitigation measures for effects on climate consist of strategic approaches that drive reduction across all lifecycle stages and encouraging carbon reduction behaviors with those specific to the separate lifecycles stages.

15.7.2 In line with Highways England's licence requirement for minimising GHG emissions and the UK Governments carbon reduction plan, the Scheme seeks to reduce GHG emissions as far as practicable to contribute to the UK's net reduction in carbon emissions. The following high-level options shall be applied and developed when seeking to reduce GHG emissions on the Scheme:

- Step 1: Avoid and prevent: maximise potential for reusing or refurbishing existing assets to reduce the extent of new construction required, and explore alternative lower carbon options to deliver the Scheme's objectives
- Step 2: Reduce: apply low carbon solutions (including technologies, materials and products) to minimise resource consumption during the construction, operation and at end-of-life; and construct efficiently: use techniques (e.g. during construction and operation) that reduce resource consumption over the life cycle of the Scheme
- Step 3: Remediate: after addressing steps 1 and 2, the Scheme will identify, assess and integrate measures to further reduce carbon through on or off-site offsetting or sequestration

15.7.3 The Scheme's design (described in Chapter 2: Description of the Scheme (document reference TR010035/APP/6.2)) aims to reduce the overall carbon footprint of the Scheme by reusing the Scheme's excavated materials where practicable.

15.7.4 The footprint of structures and junctions have been made as compact as practicable, ensuring minimal land use change and materials use. The Scheme would involve substantial earthworks and import of material (e.g. to build up features such as embankments). Where fill material would be required, it has been designed as far as is practicable to come from within the same section of works. The remaining import would be sourced locally or obtained from the proposed borrow pits described in Section 4.5 of the Appendix 2.1: Construction Information (document reference TR010035/APP/6.2.1). Furthermore, the design aims to zone earthworks to avoid double handling, which would be achieved through early engagement with the Contractor. This would reduce the fuel consumption of plant, resulting in lower CO_2 emissions.

15.7.5 Throughout the Scheme's design, material resources have been evaluated and their carbon emissions calculated. This has ensured that material resources with lower carbon outputs would be considered.

15.7.6 Where relevant mitigation measures above are secured by the Outline Construction Environmental Management Plan (CEMP) (document reference

TR010035/APP/7.2) and specific commitments are outlined within the Record of Environmental Actions and Commitments (REAC) (document reference TR010035/APP/7.3). Both documents are secured by Requirement 4 in the Draft Development Consent Order (DCO).

Vulnerability of the Scheme to Climate Change

15.7.7 Mitigation and adaptation measures have been considered and are already considered to be embedded within the design, such as Sustainable Drainage Systems (SuDS).

15.7.8 The Scheme has been designed to be resilient to impacts arising from current weather events and climatic conditions and designed in accordance with current planning, design and engineering practice and codes (e.g. the Environment Agency's (EA) guidance on allowances for rainfall and flood probability due to climate change, within the context of flood risk assessments). The Scheme has also been designed incorporating the wind loading standards which incorporate site specific criteria, based on a number of factors including wind direction, altitude and topography.

15.7.9 To mitigate against any increases in peak flow that may exacerbate flooding as a result of climate change, hydraulic models of both the fluvial and tidal systems have been developed. These models represent the baseline scenario (e.g. the current state and a scenario in 100 years taking into account climate change). This allows for a more accurate scenario against which to assess the design and to identify measures to mitigate against these effects. Mitigation being considered includes flood compensatory storage, alterations to the locations of embankments, or localised re-profiling of land. Further detail is provided within the Flood Risk Assessment (document reference TR010035/APP/5.2).

15.7.10 In addition, materials that would not deteriorate due to high temperatures would be selected. This would avoid the deterioration of the pavement such as softening, deformation and cracking. Reduced CCTV deterioration (over time) from less exposure to freezing, snow and ice would lead to a reduced need for winter maintenance.

15.7.11 Allowances for climate change e.g. effects on planting would be identified and incorporated into the design. Longer vegetation growing seasons leading to a reduction in soil moisture and/or increased tree leaf coverage with an increased magnitude and frequency of storms events which could result in tree fall and increased maintenance and management requirements.

15.7.12 Where practicable, any surpluses or permanently displaced soils would be used to reinstate soils with profiles thicker than the original. In these situations, wet soils could be better drained and so more resilient to intense rainfall; and dry soils are generally shallow and do not retain water in the profile so they could be more moisture retentive. In both cases, higher organic matter content would make them more resilient.

15.7.13 Where relevant the mitigation measures above are secured by the Outline CEMP (document reference TR010035/APP/7.2) and specific commitments are outlined within the REAC (document reference TR010035/APP/7.3). Both documents are secured by Requirement 4 in the Draft DCO.

15.7.14 In addition, the following aspects would further reduce the Scheme's vulnerability to

climate change, these measures are outlined within the Draft Materials Management Plan (appended to the Outline CEMP) (document reference TR010035/APP/7.2):

- Foundation strength would be increased to reduce the risk of failure caused by increased winter precipitation, by evaluating the moisture regime. Foundations would incorporate hydraulically bound materials or the use of reinforcement such as geotextiles
- The pavement structural design methodology would be used for example, specific non-frost and heave susceptible layers to reduce the risk of pavement heaving through the pavement expanding in the winter (due to increased rainfall) and shrinking in the summer (due to reduced rainfall)
- The Contractor would ensure appropriate measures are implemented and, as appropriate, additional measures to ensure the resilience of the proposed mitigation of impacts during extreme weather events. For example, avoidance of storing construction materials in floodplains and dampening of soils and stockpiles
- The concrete would be laid in accordance with best practice and relevant standards.

15.8 Residual Effects

Effects on Climate (Greenhouse Gas Emissions)

Construction

15.8.1 The carbon assessment from the Highways England Carbon Tool has indicated that the Scheme would result in emissions of approximately 22,574 tonnes of CO_2e from the construction phase of the Scheme. This makes up 0.0009% of the 4th carbon budget (2,544 million tonnes of CO_2e). Therefore, it is concluded that the construction phase of the Scheme **would not have a substantial adverse effect or impact the government's ability in achieving the budget.**

15.8.2 The carbon output from the materials is estimated to be 16,442 tonnes of CO_2e. When compared to the 10% contribution from construction material resources to the annual UK emissions, this only contributes 0.04%.[7]

15.8.3 The carbon output from plant and equipment. utilised throughout the construction phase, is estimated to be 6,132 tonnes of CO_2e. This could potentially be reduced by implementing early engagement with the contractor to avoid double handling during earthworks.

15.8.4 In the absence of established assessment criteria for the effects on climate, it is considered that the construction stage effects of the Scheme are **Not Significant** on climate, due to the relatively low quantity of emissions in comparison to overall UK emissions for construction.

Operation

15.8.5 During the operation phase, emissions from the operational phase energy created from the lighting installed for the Scheme result in 54.839 tonnes of CO_2e per annum. This is assuming, the use of LED for columns and that the lighting runs for 4,099 hours per year.

[7] Note that the annual UK emissions are in CO2 and the scheme emissions in CO2e.

15.8.6 During the operation phase, as per the results of webTAG Unit A3 Chapter 4, the Scheme is estimated to cause an increase of 397,268 tonnes of CO_{2e} in non-traded emissions and increase by 31,118 tonnes of CO_{2e} in traded emissions over 60 years.

15.8.7 The CO_{2e} by carbon budget is detailed in Table 15-10. This shows the traded and non-traded emissions that would contribute to emissions within the carbon budgets.

Table 15-10: Climate – CO_2e by Carbon Budget

	Carbon budget 2	Carbon budget 3	Carbon budget 4	Carbon budget 5
Traded energy	0	0	274	274
Non-traded energy	0	4,845	26,773	26,773

15.8.8 This increase of 397,268 tonnes of CO_{2e} in non-traded emissions an increase by 31,118 tonnes CO_{2e} in traded emissions over 60 years, would be caused primarily by an increase in traffic volume and flow along the route. Maintenance work undertaken as part of the Scheme would also increase carbon, but to a much lesser extent compared to the projected road transport emissions. This increase in emissions as a result of the Scheme would be negligible, and therefore, effects would be **Not Significant**.

15.8.9 Table 15-11 summarises the assessment of Scheme's emissions against the carbon budgets.

Table 15-11: Climate – Total CO_2e by Carbon Budget for Construction and Operation

Scheme Stage / Activity	Net Tonnes of CO_{2e}	Relevant Carbon Budgets
Construction	22,574	3rd carbon budget period
Operation	58,939	3rd, 4th and 5th carbon budget period

Vulnerability of the Scheme to Climate Change

15.8.10 Following identification of the future climate projections, the Scheme receptors which are vulnerable to climate change have been identified as below:

- The construction process (i.e. workforce, plant, machinery etc.)
- The assets and their operation, maintenance and refurbishment (i.e. pavements, structures, earthworks and drainage, technology assets, etc.)
- End-users (members of public, commercial operators etc.)

15.8.11 The Scheme has the potential to be vulnerable to a range of climate changes, including an increased frequency and severity of prolonged and/or heavy precipitation events, prolonged droughts and heatwaves, a greater frequency of very hot days, and an increased risk of storms. Warmer temperatures may also mean that the risks associated with ice and snow would decrease over time. Retaining the ability to respond to these events would remain important.

Construction

15.8.12 The vulnerability of the Scheme to climate during the construction phase is outlined in Table 15-12.

Table 15-12: Climate – Residual Effects - Vulnerability of the Scheme to the Climate During Construction

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
Pavements	Design of foundations	An increase in winter precipitation or a decrease in summer precipitation would result in a change in ground water level and soil moisture. This has the potential to affect the foundation settlement. In addition, it has the potential to generate larger ground movement and heave.	Very Low	Moderate Adverse	**Not Significant**
	Materials specification and construction details	An increase in extreme temperatures has the potential to put the Scheme at risk from a greater degree of surface failure or deterioration. For example, for concrete pavements, thermal gradients have the potential to create uneven internal stresses which can then give rise to curling or warping, sometimes called hogging, of the slabs. These can be compounded by loading from passing traffic.	Very Low	Minor Adverse	**Not Significant**
		Large changes in temperature have the potential to generate thermal contraction and expansion of the slabs which, if not taken into consideration at the design stage, can generate unacceptably large longitudinal internal stresses and excessive movements at joints.	Very low	Minor Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
	Construction – laying surface dressing, micro-surfacing and other temperature susceptible materials	During extended periods of hot, sunny conditions, asphalt can remain workable for a considerable time, making it difficult to maintain profile during compaction.	Very Low	Minor Adverse	**Not Significant**
Structures	Thermal actions (loads) applied to superstructure	An increase in extreme temperatures may require the use of more expensive components like joints, bearings, paint systems etc. Also, greater care would be required to set the gaps, to ensure that movement does not cause a problem. This may require rescheduling works to night or at specific times of the year. Small structures and road lighting columns should not be affected as the design standards require a reduced design life (30 years on average) and it is unlikely that climate change impacts would be present significant risks over this period.	Very Low	Moderate Adverse	**Not Significant**
	Wind actions (loads) applied to superstructure	An increase in wind speed has the potential for minor structures to have to be designed larger, to withstand larger loads. The effect on the bridge should be minimal, as wind is rarely a dominant load. There is an increased risk of disruption to construction work (unable to operate in high winds).	Very Low	Moderate adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
	Increased thermal range giving rise to increased earth pressures for bridge	An increase in mean temperatures and extreme temperatures has the potential to lead to the requirement of stronger fill material and therefore increasing the quantities of excavated material becoming waste.	Very Low	Minor Adverse	**Not Significant**
	Earth pressures used in design affected by change in ground water level	An increase in winter precipitation and a decrease in summer precipitation has the potential to change the ground water level. This could potentially lead to larger ground movement and heave. In addition, this could mean that additional drainage and stronger materials would be required.	Very Low	Minor Adverse	**Not Significant**
	Foundation settlement affected by change in ground water level	Increase in winter precipitation and decrease in summer precipitation has the potential to change the ground water level. This could potentially lead to the requirement of more robust foundations for increased settlement.	Very Low	Minor Adverse	**Not Significant**
	Design for increased scour risk for foundations	An increase in extreme precipitation has the potential to lead to flooding. Mitigation measures have already been embedded within the Scheme's design. Chapter 12: Document reference 6.12	Very Low	Minor Adverse	**Not Significant**
	Design of structure drainage	An increase in extreme precipitation has the potential to lead to the requirement of additional drainage, larger components and more extensive works.	Very Low	Minor Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
	Design of bearings and expansions joints	An increase in extreme temperature has the potential to lead to the requirement of larger bearings.	Very Low	Large Adverse	**Not Significant**
Drainage	Surface water drainage systems, cross-culvert, road-edge drainage, attenuation outfalls and drainage ditches	The Scheme may require additional drainage, larger components and more extensive works to deal with an increase in extreme precipitation events.	Very Low	Minor Adverse	**Not Significant**
		Risks to the design and construction of the Scheme's drainage assets include congestion and accidents, an increased risk of flooding, impacts the performance of the road, including congestion and incidents (safety). Mitigation measures have already been embedded within the Scheme's design.	Very Low	Minor Adverse	**Not Significant**
Geotechnics	Erosion	An increase in winter precipitation has the potential to result in increased erosion rates, most notably for valuable soil resources.	Very Low	Moderate Adverse	**Not Significant**
	Stability of earthworks	Increased precipitation could increase risk to the earthworks stability resulting in the requirement of fill materials that are less susceptible to moisture such as Pulverised Fuel Ash and aggregate.	Very Low	Moderate Adverse	**Not Significant**
	Earthworks compaction	An increase in extreme temperature and a decrease in summer precipitation has the potential to lead to reduction in soil moisture. Risks to compaction relate to the need for greater compactive effort being required with potential increased costs, delays etc.	Very Low	Moderate Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
	Earthworks construction across existing landslip	An increase in winter precipitation and extreme precipitation has the potential to change the ground water level.	Very Low	Minor Adverse	**Not Significant**
Signs and signals	Stability	An increase in extreme precipitation and wind speed has the potential to create wind loading risks for the signs and signals.	Very Low	Moderate Adverse	**Not Significant**
	Road markings design and specification	An increase in winter precipitation and extreme precipitation has the potential to alter the performance of the road markings.	Very Low	Moderate Adverse	**Not Significant**
Technology	Wind loading	An increase in wind speed has the potential to create wind loading risks for the technology assets.	Very Low	Moderate Adverse	**Not Significant**
Soft estate	Capital investment landscape	An increase in mean temperature and a decrease in summer precipitation has the potential to lead to longer growing season and a reduction in soil moisture.	Very Low	Moderate Adverse	**Not Significant**
Non motorised user (NMU) facilities	Workforce	Increase in projected mean daily rainfall, especially in winter months could result increase safety risk of slips, trips and falls to construction workers.	Very Low	Minor Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
	Construction site	Increase in projected mean daily rainfall, especially in winter months could potentially result in the construction site flooding, excavations flooding during construction phase. Site roads may also become impassable through flooding. Mitigation measures have already been embedded within the Scheme's design.	Very Low	Minor Adverse	**Not Significant**
	Plant and equipment	Water ingress to critical equipment, including traction power distribution sites, leading to signaling or other electronic equipment failures, requiring switch off or, possibly causing damage.	Very Low	Minor Adverse	**Not Significant**

Operation

15.8.13 The vulnerability of the Scheme to climate during operation is assessed based on the varied receptors and Scheme's aspects which could be vulnerable to climate change, due to their diverse ability to withstand climatic conditions. However, not all climatic changes are threats as there are also opportunities which arise and have been explored using expert opinion and relevant literature.

15.8.14 An assessment of the effects of the projected changes in climate, as outlined in Table 13-13, on the Scheme assets during operation is presented in Table 13-10. Significance has been assigned in line with the likelihood category and consequence of impact provided by Highways England and presented within Section 15.4.

Table 15-13: Climate – Residual Effects - Vulnerability of the Scheme to Climate Change During Operation

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
Pavement	Foundation	Pavement has a typical design life of 40 years and could therefore be affected by changes in climate. An increase in mean daily rainfall rates has the potential to alter the moisture content of soils. This could lead to ground movements, soil settlement as well as expansion and contraction. This could also cause the Scheme's pavements and foundations to heave.	Low	Moderate Adverse	**Not Significant**
		For concrete pavements, thermal gradients have the potential to create uneven intern stresses which could then give rise to curling or warping, sometimes called hogging, or the slabs. These could be compounded by loading from passing traffic.	Low	Moderate Adverse	**Not Significant**
	Surface	Large changes in temperature have the potential to generate thermal contraction and expansion of the slabs which, if not taken into consideration at the design stage, could generate unacceptably large longitudinal internal stresses and excessive movements at joints.	Medium	Minor Adverse	**Not Significant**
		The newly laid surfacing layers of a pavement may also maintain temperatures after opening to traffic that are high enough to allow excessive rutting and the rapid embedment of any chippings, with the latter again causing a reduction of texture depth.	Medium	Minor Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
Structures	Superstructure	Increases in temperature have the potential risk of thermal actions (loads) applied to structure (e.g. leading to joint and bearing failure). Some structures have the potential to fail to operate within original design parameters. This could induce failures meaning additional works would then be required to strengthen them.	Very Low	Large Adverse	**Not Significant**
		Increases in precipitation rates could lead to premature deterioration rates for joints, bearings and surfaces. This would lead to increased traffic disruption.	Low	Moderate Adverse	**Not Significant**
		An increase in the frequency and intensity of storms have the potential to cause increased loads on structures, overhead lines and lead to collapse.	Very Low	Large Adverse	**Not Significant**
		Increased precipitation has the potential to lead to flooding, deterring users from their journey.	Low	Minor Adverse	**Not Significant**
	Foundations and substructure	Changes in groundwater levels as a result of an increases in precipitation rates could lead to ground movements and soil settlement.	Low	Minor Adverse	**Not Significant**
Drainage	Drainage	An increase in the frequency and intensity of rainfall and storm events could lead to an increase in particulates entering the drainage system. This may lead to localised flooding events, increase maintenance and increased land take for additional drainage assets.	Medium	Minor Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
		An increase in the mean daily rainfall could lead to an increased risk of pollution mobilisation from accidental spillages associated with the Project. This would increase the risk of releasing contaminates into the water environment.	Medium	Minor Adverse	**Not Significant**
Geotechnics	Earthworks	An increase in frequency and intensity of heavy rainfall and flooding events could cause collapse of embankments.	Low	Moderate Adverse	**Not Significant**
		Changes in mean temperatures and rainfall rates may impact soils reinstated for agricultural use. This has the potential to alter the productivity of the land.	Low	Minor Adverse	**Not Significant**
Signs and signals	Signs and signals	An increase in the frequency and intensity of storm events could reduce the design life of a number of key assets such as signage, lighting, road surface and road markings. This could increase maintenance costs over the lifespan of the road.	Low	Moderate Adverse	**Not Significant**
	Signs	An increase in wind speed and in frequency of extreme wind events has the potential to affect the stability of the signs, which have a design life of 25 years (DMRB Standard BD 94/07).	Low	Moderate Adverse	**Not Significant**
	Lighting columns and fencing	An increase in wind speed and in frequency of extreme wind events has the potential to affect the stability of the lighting columns as well as highway signage and fencing.	Low	Moderate Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
	Road markings	Increase in precipitation and temperature have the potential to weather road markings and change performance.	Low	Minor Adverse	**Not Significant**
Soft Estate	Landscape Design	A decrease in mean rain fall may lead to drought tolerant trees could becoming more prevalent. This may cause a change in the landscape character of the area.	Medium	Negligible	**Not Significant**
		An increase in mean temperature and precipitation may alter the growing characteristics such as soil properties and length of growing season. This may impact the species identified as part of the landscape strategy and thus alter the character of the landscape.	Low	Moderate Adverse	**Not Significant**
		An increase in precipitation and flooding has the potential to destroy plants in higher flood risk areas.	Low	Moderate Adverse	**Not Significant**
		Increased wind speed could lead to the loss of valued landscape features, opening up new views of the Project that were previously shielded.	Low	Minor Adverse	**Not Significant**
		Increased tree loss, habitat loss and/or fragmentation and reduction in woodland blocks may be associated with increased wind speeds.	Low	Moderate Adverse	**Not Significant**
Vehicle Restraint Systems	Safety Barriers	Steel Safety barriers have a design life of approximately 25 years. More frequent extreme weather and changes in temperature and	Low	Moderate Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
		precipitation may result in an increase in rate of deterioration of vehicle restraint systems.			
End-users	Non-motorised Users	An increase in the rate of deterioration of assets due to extreme weather events could lead to an increase the requirements for construction and maintenance workers as well as traffic officers working within the carriageway. Workforce may also have to work within dangerous conditions.	Medium	Negligible	**Not Significant**
		An increase in the frequency and intensity of storm events may discourage the use of non-motorised user facilities to complete journeys. This may lead to more users of the road.	Low	Moderate Adverse	**Not Significant**
		An increase in heavy rain could potentially lead to flooding and closures and diversions of footpaths.	Low	Minor Adverse	**Not Significant**
	Motorised Users	An increase in frequency and intensity of heavy rainfall, flooding and storm events could lead to a higher rate of vehicle collisions causing severe disruption to highway, major accident causing harm to highways users and adjacent receptors.	Medium	Minor Adverse	**Not Significant**
		An increase in temperature has the potential to increase the risk of more incidents due to: • Vehicles having broken down/overheated • A higher frequency of vehicle fires.	Medium	Minor Adverse	**Not Significant**

Receptor	Aspect	Potential effect to Project (Impact)	Likelihood Category	Consequence of Impact	Significance
		• Smoke drifting across carriageways from wildfires. • Heavy Good Vehicles (HGV) blow-overs and flying debris.			

15.9 Monitoring

15.9.1 No significant adverse effects are predicted However, due to the quantity of material resources required for the Scheme, it is recommended the completion of an as-built assessment of carbon emissions upon the construction phase.

15.10 Summary

15.10.1 An assessment has been undertaken of the effects of the Scheme on Climate and the vulnerability of the Scheme to climate change during the construction and operation phases.

15.10.2 Baseline conditions have been included to provide context to the environmental setting of the Scheme in relation to climate.

Effects on Climate

15.10.3 Overall, the effects on climate are anticipated to be **Not Significant** during the construction phase. At this stage, it is anticipated that due to the quantity of material resources required for the Scheme, a further carbon assessment, including GHG emissions, should be undertaken post-construction.

15.10.4 During operation, effects on climate are anticipated to be **Not Significant**.

Vulnerability to Climate

15.10.5 During the construction phase, no likely significant effects, associated with the vulnerability to climate, are anticipated for the Scheme. Due to the short-term nature of construction and limited changes in climate over the construction phase, changes in climate are not expected to affect any receptors through construction. Overall, effects would be **Not Significant**.

15.10.6 During the operation phase, there is the potential for some of the Scheme's receptors to be adversely affected by climate change. However, the balance of likelihood and consequence, means that overall, effects would be **Not Significant**.

15.11 References

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