A66 Northern Trans-Pennine Project
TR010062

3.4 Environmental Statement Appendix 7.2 Climate Change Resilience Assessment

APFP Regulations 5(2)(a)

Planning Act 2008

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

Volume 3

June 2022

Infrastructure Planning

Planning Act 2008

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

A66 Northern Trans-Pennine Project Development Consent Order 202x

3.4 ENVIRONMENTAL STATEMENT APPENDIX 7.2 CLIMATE CHANGE RESILIENCE ASSESSMENT

Regulation Number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010062
Application Document Reference	3.4
Author:	A66 Northern Trans-Pennine Project Team, National Highways

Version	Date	Status of Version
Rev 1	13 June 2022	DCO Application

CONTENTS

7.2 Climate Change Resilience Assessment

7.2.1 Introduction

7.2.1.1 This Appendix 7.2: Climate Change Resilience assessment provides the detailed climate change resilience (CCR) assessment completed as part of the Environmental Statement. The assessment methodology is described in ES Chapter 7: Climate (Application Document 3.2).

7.2.2 CCR Assessment

Project-wide assessment

7.2.2.1 As outlined in the assessment methodology, risks have been assessed on a project-wide basis, based on the 'worst-case' climate projection for each climate parameter across the extent of the route, on the basis that many risk types will have the same risk of impact regardless of where they take place within the proposed scheme (with respect to the scale of the assessment methodology).

7.2.2.2 Schemes for which identified project-wide risks are either not applicable, or for which the likelihood and consequence of a risk is likely to differ (e.g. due to scheme or location specific factors or design) to the project-wide assessment, have also been identified.

7.2.2.3 As outlined in the assessment methodology, conclusions of 'not significant' take account of embedded mitigation that is designed into the infrastructure and assets that constitute the project within the Order Limits, as advised by the project designers. The assessment assumes this mitigation is implemented successfully, in full and that it is effective in mitigating the identified risk.

7.2.2.4 Table 1: Project-wide climate change resilience risk assessment outlines: the potential impacts to the project as a result of climate change; any relevant embedded mitigation considered already in place prior to the assessment of each risk; the assessment of risk itself (of likelihood, consequence and significance); and notes on any scheme-specific considerations, e.g. where a risk is considered less relevant to a particular scheme.

Table 1: Project-wide climate change resilience risk assessment

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
High temperatures	Increased heat stress for staff, particularly outdoor maintenance works, due to increased number of hot days (operational phase maintenance).	Proposed maintenance delivery regimes to incorporate potential temperature impacts on maintenance workers through risk assessments. These will be reviewed regularly to ensure health and safety requirements within National Highways are met Workers will be provided with appropriate equipment, including personal protective equipment where required and will be briefed on working in high temperatures.	Low	Minor adverse	Not significant	Relevant to all schemes
High temperatures	Increased risk of thermal expansion joints being pushed beyond their design capability, presenting a direct risk of damage to structures and assets.	Structures are designed to accommodate the range of worst case high and low temperatures specified in the standards which differ depending on geographical locations. These are specified in BS EN 1991-1-5 and NA BS EN 1991-1-5 which apply to all structure design development.	Very low	Large adverse	Not significant	Relevant to all schemes
High temperatures	Asphalt surfaces may exhibit permanent deformation in long periods of hot, sunny conditions.	Engineers will incorporate resilience through appropriate pavement design and material specifications at detailed design. Regular monitoring and	Low	Minor adverse	Not significant	Relevant to all schemes

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
		maintenance regimes will preserve pavement surface conditions throughout operation.				
High temperatures	High temperatures increase the risk of asphalt surface deterioration. This can reduce skid resistance and increase risk of vehicle accidents.	Mitigated through appropriate pavement design and material specifications which will be determined at detailed design. Regular monitoring and maintenance regimes will preserve pavement surface conditions throughout operation.	Low	Minor adverse	Not significant	Relevant to all schemes
High temperatures	Increased temperatures can impact the bitumen hardening rate, leading to an inability to flex under heavy traffic loads, leading to surface cracking.	Mitigated through regular monitoring and maintenance regimes.	Low	Minor adverse	Not significant	Relevant to all schemes
High temperatures	In higher temperatures fuel has a decreased viscosity and so leads to faster spreading of diesel in the event of a spillage. Higher temperatures and increased number of hot, dry days increase the likelihood of ignition	Mitigated through regular monitoring and maintenance regimes The likelihood of this risk is expected to decrease over time with the increase in proportion of electric vehicles used on the highway infrastructure.	Low	Minor adverse	Not significant	Relevant to all schemes

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
	of this diesel leading to road and wildfires.					
High temperatures	Increased temperatures may impact the performance of electrical equipment, such as the reduced efficiency and lifespan of LED luminaries.	Mitigated through monitoring regimes to identify equipment failures and maintenance regimes to replace failed equipment as quickly as possible.	Medium	Negligible	Not significant	Relevant to all schemes
High temperatures	Prolonged dry periods in summer could lead to soil shrinkage, leading to possible ground movement and impact upon foundations of civil structures.	Mitigated through conservative assumptions for foundation depths during design, although the risk of soil shrinkage across the project, considering the geotechnical context, is considered very low.	Very low	Minor adverse	Not significant	Relevant to all schemes
High temperatures	Prolonged dry periods could lead to increased desiccation of soils, reducing slope stability and leading to potential remedial earthworks following summer storm events.	Mitigated through conservative assumptions made during design development, informed by geotechnical ground investigations.	Very low	Minor adverse	Not significant	Relevant to all schemes
High winds	Increased risk of extreme winds leading to possible blockage of drainage systems due to	Mitigated through drainage design and monitoring and maintenance regimes. Access paths will be	Medium	Minor adverse	Not significant	Relevant to all schemes

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
	obstructions from wind-blown debris.	provided to drainage ponds to allow regular maintenance.				
High winds	Increased risk of wind borne debris on the road during high winds, affecting road user safety.	No specific mitigation identified, however, design barriers, including noise barriers and landscaping features will help to mitigate the risk in locations where they are present.	Medium	Minor adverse	Not significant	Relevant to all schemes
High winds	Increased risk to high-sided vehicles due to high wind speeds.	No embedded mitigation identified during assessment.	Medium	Moderate adverse	Significant	Temple Sowerby to Appleby, Appleby to Brough (Warcop), and Cross Lanes to Rokeby
High winds	Failure of, or damage to road infrastructure as a result of high winds.	Structures are designed to accommodate wind loading criteria as specified in design standard BS EN 1991-1-4 (European Union, 2005)[1] and NA BS EN 1991-1-4 (Rees et al., 2011)[2].	Very low	Moderate adverse	Not significant	Relevant to all schemes
Lightning	Increased risk of lightning strikes leading	No embedded mitigation identified during assessment.	Medium	Minor adverse	Not significant	Relevant to all schemes

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

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
	to indirect and direct damage to roadside equipment and damaging trees and vehicles.					
High humidity	Increased humidity leading to accelerated stripping process of road surface.	Mitigated through appropriate pavement design and material specifications which will be determined at detailed design. Regular monitoring and maintenance regimes will preserve pavement surface conditions throughout operation.	Low	Minor adverse	Not significant	Relevant to all schemes
High temperatures	Increased temperatures and humidity lengthening the growing season for weeds, leading to road infrastructure damage.	Mitigated through appropriate pavement design and material specifications which will be determined at detailed design. Regular monitoring and maintenance regimes will preserve pavement surface conditions throughout operation.	Medium	Negligible	Not significant	Relevant to all schemes
High temperatures	Low albedo of road surface leading to increased insolation (retention of solar radiation) leading to higher road surface temperatures,	Mitigated through appropriate pavement design and material specifications which will be determined at detailed design. Regular monitoring and maintenance regimes will	Low	Minor adverse	Not significant	Relevant to all schemes

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
	increasing the risk of cracking and surface rutting.	preserve pavement surface conditions throughout operation.				
High temperatures	Extended periods of hot dry weathers leading to a risk of spontaneous grassland fires and peatland habitat fires in the vicinity of the route, affecting safety on the road.	Standard emergency procedures to manage the impacts of smoke and fire risk on the carriageway. The road would act as a firebreak, providing a gap in combustible material that would act as a barrier to slow or prevent the progress of a wildfire which may reduce the spatial scale of operational disruption.	High	Moderate adverse	Significant	Not considered applicable to M6 Junction 40 to Kemplay Bank scheme because the surrounding area is highly urbanised. Relevant to all other schemes.
High precipitation	Increased flooding of the A66 road surface.	Where the carriageway is in a cutting, the top of drains in the cutting will route overland flow to the nearest watercourses. Flood risk assessment and modelling informs design mitigation and includes climate change allowances of Q100+94% for peak river flow, Q100+40% for drainage ponds, and Q5+40% for road drainage.	High	Minor adverse	Not significant	Relevant to all schemes. Particular risks identified for Temple Sowerby to Appleby, Appleby to Brough (Warcop), and Bowes Bypass (A66/A67) schemes. The reasons for this and the specific design mitigation

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
						measures discussed in main chapter (paragraph 7.9.32)
High precipitation	Increased flooding of access roads and infrastructure.	Flood risk assessment and modelling informs design mitigation and includes climate change allowances including Q100+94% for peak river flow, Q100+40% for drainage ponds, and Q5+40% for road drainage.	High	Minor adverse	Not significant	Relevant to all schemes
High precipitation	Increased risk of sewage outflow in floodwater causing damage and impacting health of maintenance workers.	Mitigated through monitoring and maintenance regimes which may be adapted to ensure health and safety requirements within Highways England are met.	Very low	Minor adverse	Not significant	Not considered applicable to Bowes Bypass (A66/A67); Cross Lanes to Rokeby; and Stephen Bank to Carkin Moor schemes (as sewage pipes not present)
High precipitation	Increased risk of scouring of structures due to increased wet weather or flooding. Scouring refers to the exposure of foundations	No piers of vulnerable structures will be located within the river channel itself and will therefore only be vulnerable to scour during flood events or if the existing	Medium	Large adverse	Significant	Relevant to all schemes but significant risk associated with the multi-span bridge structures

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
	due to the disturbance and removal of the surrounding soils and other materials by flowing water, leading to a potential reduction in structural stability.	channel migrates to incorporate the location of a pier.				within the Temple Sowerby to Appleby and Appleby to Brough (Warcop) as discussed in main chapter
High precipitation	Increased pore water pressure in embankments and cuttings.	Geotechnical design of slopes considers long-term stability and risk from surface water scouring, groundwater and pore water pressure. Where possible, slopes have been designed to no greater than a 1 in 3 gradient to improve stability. For steeper slopes, earth retention systems or reinforcement will be used to improve stability.	Medium	Minor adverse	Not significant	Relevant to all schemes
High precipitation	Increased erosion at the toe of embankments through increased surface run-off.	Cut-off drains and toe-of-earthworks drains to be provided in the design. Geotechnical appraisals are informing the design in relation to groundwater. Drainage designs will be informed by Environment Agency guidance	Medium	Minor adverse	Not significant	Relevant to all schemes.

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
		on the future impacts of climate (Environment Agency, 2016)[3].				
High precipitation	Water ingress to signalling, lighting and other operational electrical equipment.	Street furniture design will consider the potential for water ingress. Watertight cables will be housed in plastic ducts.	Low	Negligible	Not significant	Relevant to all schemes
High and low precipitation	Changes in ground water level affecting earth pressures and foundation settlement, causing possible large ground movements.	Geotechnical appraisals will inform the structural design in relation to groundwater.	Low	Moderate adverse	Not significant	Relevant to all schemes
High precipitation	Increased risk of debris deposit from water seeping up to the surface through the pavement (e.g. calcium sulphate) leading to reduced skid resistance.	Mitigated through appropriate pavement design, material specifications as informed by geotechnics, and regular monitoring and maintenance regime.	Low	Moderate adverse	Not significant	Relevant to all schemes
High precipitation	Increased water levels in winter may lead to flooding of underpasses.	In line with drainage design standards, run-off drainage systems will be designed to take into account a 40% increase in peak rainfall intensity by the 2080s.	Medium	Minor adverse	Not significant	Relevant to all schemes M6 Junction 40 to Kemplay Bank scheme is

[3] Environment Agency (2016) Flood risk assessments: climate change allowances

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
		Underpasses will be designed to the requirements of *Design Manual for Roads and Bridges (DMRB) CG 501 Design of highway drainage systems (DMRB CG 501*) (Highways England, 2020)[4] and *DMRB CD 521 Hydraulic design of road edge surface water channels and outlets (DMRB CD 521)* (Highways England, 2021)[5] to provide a design to ensure no flooding for a 1:5 year rainfall event plus a climate change allowance of 40%.				assessed separately below
High precipitation	Increased water level in winter may lead to flooding of the underpass on the mainline at Kemplay Bank (M6 Junction 40 to Kemplay Bank scheme).	In line with drainage design standards, run-off drainage systems will be designed to take into account a 40% increase in peak rainfall intensity by the 2080s. Underpasses will be designed to the requirements of *DMRB CG 501* and *DMRB CD 521* to provide a design to ensure no flooding for	Medium	Moderate Adverse	Significant	Only applicable to Kemplay Bank (M6 Junction 40 to Kemplay Bank scheme) where additional proposed mitigation to be implemented at detailed design reduces the

[4] Highways England (2020) Design Manual for Roads and Bridges CG 501 Design of highway drainage systems
[5] Highways England (2021) Hydraulic design of road edge surface water channels and outlets

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
		a 1:5 year rainfall event plus a climate change allowance of 40%.				likelihood of flooding to low (as discussed in ES Chapter 7: Climate (Application Document 3.2)).
High and low precipitation	Increased risk of earthworks failure and landslides exacerbated by variance between high and low precipitation events and soil moisture levels.	Geotechnical design of slopes considers long-term stability and risk from surface water scouring, groundwater and pore water pressure. Where possible, slopes have been designed to no greater than a 1 in 3 gradient to improve stability. For steeper slopes, earth retention or reinforcement will be used to improve stability.	Low	Moderate adverse	Not significant	Relevant to all schemes
High precipitation	Reduced capacity of attenuation ponds due to sediment build up following increased surface run-off.	Maintenance regime will be established to monitor sediment build up.	Medium	Minor adverse	Not significant	Relevant to all schemes
High precipitation	Increased risk of debris washing into drainage gullies and causing blockages.	Regular monitoring and maintenance regime will be established.	Medium	Minor adverse	Not significant	Relevant to all schemes
High precipitation	Increased stripping rate of road surface due to	Mitigated through appropriate pavement design, material	Medium	Minor adverse	Not significant	Relevant to all schemes

Climate Hazard	Potential Climate Change Impacts to Project	Existing or Embedded Mitigation Measure	Likelihood of Impact Occurring	Consequence of Impact (should the impact occur)	Evaluation of Significance	Scheme Specific Considerations
	increased number of high precipitation days.	specifications, and regular monitoring and maintenance regime.				
High precipitation	Reduced skid resistance due to increased frequency of wet surfaces.	Mitigated through appropriate pavement design, material specifications, and regular monitoring and maintenance regime.	Very high	Negligible	Not significant	Relevant to all schemes
High precipitation	Increased likelihood of potholing, rutting and cracking from moisture entering and remaining in road surfaces.	Mitigated through appropriate pavement design and material specifications which will be determined at detailed design. Regular monitoring and maintenance regimes will preserve pavement surface conditions throughout operation.	Medium	Minor adverse	Not significant	Relevant to all schemes
High precipitation	Increased flow of groundwater causing accelerated weathering and weakening of embankments.	Geotechnical appraisals will inform the design of earthworks in relation to groundwater.	Very low	Large adverse	Not significant	Relevant to all schemes
High precipitation	Increased surface run-off resulting in scouring of embankments and cuttings, leading to earthworks failure.	Flood risk assessment and modelling informs design mitigation and includes climate change allowances including Q100+94% for peak river flow, Q100+40% for drainage ponds, and Q5+40% for road drainage.	Medium	Large Adverse	Significant	Relevant to all schemes

7.2.3 References

The European Union (2005) EN 1991-1-4 Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

Rees, J., Harris, T., Smith, B., Denton, S. and Ko, R. (2011) The UK National Annex to BS EN 1991-1-4, BS EN 1991-1-5, and PD 6688-1-4. In Bridge Design to Eurocodes: UK Implementation (pp. 123-147). ICE Publishing.

Environment Agency (2016) Flood risk assessments: climate change allowances

Highways England (2020) Design Manual for Roads and Bridges CG 501 Design of highway drainage systems

Highways England (2021) Hydraulic design of road edge surface water channels and outlets