14 CLIMATE

GREENHOUSE GASES

14.1 LEGISLATIVE AND POLICY FRAMEWORK

14.1.1 The various legislative, policy and guidance documents used to shape the assessment of Greenhouse Gases are outlined in **Table 14.1**.

Table 14.1 – Legislative and Policy Framework

LEGISLATION	United Nations Framework Convention on Climate Change (UNFCCC) [283]
	The Climate Change Act (2008)[284]
POLICY	Infrastructure Carbon Review[285]
	National Planning Policy Framework[286]
	National Policy Statement for National Networks[287]
	Environment Strategy for East Sussex[288]
	East Sussex Local Transport Plan 2011 - 2026[289]
GUIDANCE	IAN 114/08 – Highways Agency Carbon Calculation and Reporting Requirements[290]
	DMRB Volume 11 Section 3 HA 207/07 Air Quality[291]
	IEMA EIA Guide to Assessing GHG Emissions and Evaluating their Significance[292]

[283] United Nations Framework Convention on Climate Change https://unfccc.int/
[284] HM Government Climate Change Act (2008) https://www.legislation.gov.uk/ukpga/2008/27/introduction
[285] HM Treasury, Infrastructure Carbon Review (2013) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/260710/infrastructure_carbon_review_251113.pdf
[286] Ministry of Housing, Communities and Local Government National Planning Policy Framework (July 2018)https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/728643/Revised_NPPF_2018.pdf
[287] Department for Transport, National Policy Statement for National Networks (2014). https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf
[288] East Sussex Strategic Partnership, Environment Strategy for East Sussex (2011): https://www.eastsussex.gov.uk/media/1988/environment_strategy_for_east_sussex.pdf
[289] East Sussex County Council, Local Transport Plan –2011-2026 East Sussex Local Transport Plan 2011 – 2026 (2011) https://www.eastsussex.gov.uk/media/2336/ltp3_main_doc_2011-2026.pdf
[290] Highways Agency Interim Advice Note 114/08 Highways Agency Carbon Calculations and Reporting Requirements (2008) http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian114.pdf
[291] DMRB Volume 11 Section 3 HA 207/07 (2007) http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/Section3/ha20707.pdf

	TAG Unit A3 Environmental Impact Appraisal[293]
	PAS 2080:2016 Carbon Management in Infrastructure[294]

14.1.2 Further detail on legislation and policy is provide in **Appendix 1.1**.

14.2 ASSESSMENT METHODOLOGY

14.2.1 GHGs are natural and man-made gases occurring in the atmosphere which absorb and emit infrared radiation thereby maintaining the Sun's energy within the Earth's atmosphere. There is a scientific consensus that the major increase in the concentration of GHGs from man-made sources is contributing to climate change.

14.2.2 The seven main GHGs defined by the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride. In combination, these GHG emissions are commonly expressed in terms of carbon dioxide equivalents (CO_{2e}) according to their relative global warming potential. For this reason, the term 'carbon' may be used to refer to GHGs.

14.2.3 The assessment approach considers the likely magnitude of GHG emissions (or avoided emissions) of the scheme in comparison to the baseline scenario with no scheme. It considers emissions throughout the lifecycle of the scheme including:

- Construction stage – for example the embodied emissions associated with materials, transportation of materials to site and waste / arisings from site, and the construction process; and
- Operation - for example emissions (or avoided emissions) from end-user vehicles.

14.2.4 The decommissioning stage has not been assessed as the expected timescales for the scheme reaching its end of life, are so far into the future that there is insufficient certainty about the likelihood, type or scale of emissions activity to enable a meaningful assessment to be undertaken. Lifecycle stages relevant to; maintenance; repair, replacement and refurbishment; and emissions sources at end of life have been scoped out of this assessment due to the negligible changes in emissions expected from these sources.

For the applicable construction and operation lifecycle stages of the scheme the assessment includes the following:

[292] IEMA EIA guide to Assessing GHG emissions and evaluating their significance (2017) https://www.iema.net/policy/ghg-in-eia-2017.pdf
[293] Department for Transport Tag Unit A3 Environmental Impact Appraisal (2015) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/638648/TAG_unit_a3_envir_imp_app_dec_15.pdf
[294] BSI PAS 2080:2016 Carbon management in infrastructure (2016) https://shop.bsigroup.com/ProductDetail?pid=000000000030323493

- Collection of available data / information on the scale of GHG emitting activities for the baseline scenario and for the scheme e.g. tonnes of concrete, litres of diesel, average daily traffic flows. In each case, this covers the whole life cycle of the assets; and
- Calculation of the GHG emissions using a standard emissions calculation methodology applying a suitable emissions factor e.g. kgCO2e per tonne of concrete.

14.2.5 The construction stage emissions have been calculated using an industry recognised carbon calculation tool. Highways England's carbon tool[295] has been used for this assessment. It multiplies emissions activity (for example; quantities of material consumed, transport distances, fuel and power) by the relevant emissions factors, expressed in carbon dioxide equivalents. Values have been reported as tonnes of carbon dioxide equivalents (tCO_2e). Professional judgement has been applied when interpreting the bill of quantities for input into the Highways England Carbon Calculation Tool. This was based upon knowledge of similar schemes.

14.2.6 The total operational stage end-user GHG emissions from traffic have been modelled as part of the air quality assessment. The modelling includes the total GHG emissions for vehicles covering the strategic and local road network in the area of the scheme and its surrounding region.

SIGNIFICANCE CRITERIA

14.2.7 IEMA guidance (IEMA's EIA guide to Assessing GHG emissions and evaluating their significance[292]) and professional judgement has been used to assess the significance of GHG effects. In line with the National Networks NPS[287], the GHG emissions arising from the scheme are presented against the respective UK carbon budgets (see **Appendix 1.1**) which have been set by the UK government covering the period 2018 to 2032.

There are currently no agreed thresholds for what level of GHG emissions is considered significant in EIA terms. Professional judgement is used regarding the likely magnitude of emissions, the context of the Scheme and the potential impact on the Government meeting its carbon reduction targets.

EFFECT SIGNIFICANCE

14.2.8 Professional judgement based on schemes of a similar size and nature will be used to identify the likely significance of effects. The following terms have been used to define the significance of the effects identified:

- Major effect: where the Scheme could be expected to have a significant effect (either positive or negative) on receptors;
- Moderate effect: where the Scheme could be expected to have a noticeable effect (either positive or negative) on receptors;
- Minor effect: where the Scheme could be expected to result in a small, barely noticeable effect (either positive or negative) on receptors; and

[295] Highways England Carbon emissions calculation tool https://www.gov.uk/government/publications/carbon-tool

- Negligible: where no discernible effect on receptors is expected due to the scheme.

14.3 ASSESSMENT ASSUMPTIONS AND LIMITATIONS

14.3.1 There is currently no specific guidance or carbon emissions threshold, which, if exceeded, would be considered significant. The assessment will therefore be based on professional judgement and Highways England guidance.

14.3.2 This assessment has been completed based on the currently available information regarding the scale and nature of the scheme. Type and quantities of material and waste provided by the design team at this stage are indicative and will be refined as the design of the scheme progresses. Assumptions regarding the quantities have been made based on the current design drawings, such as the thickness of asphalt and aggregates, quantity of concrete required for culverts and catch pits, signage and lighting column dimensions.

14.3.3 The availability of robust information on the transportation of materials and waste to and from site (the source of materials and destination of waste) has been taken from RICS[296] transportation scenarios in the absence of location specific data.

14.4 STUDY AREA

14.4.1 The greenhouse gas (GHG) assessment is not restricted by geographical area but instead includes any increase or decrease in emissions as a result of the scheme, wherever that may be. This includes:

- Construction emissions in the area of the scheme footprint but also related to the transport of materials to and from the site, their manufacturing and disposal (this may be far from the scheme location (for example emissions for manufacture of concrete and steel).
- Operational emissions (or reduction in emissions) which result from the end-use of the scheme and any shifts in transport modes/patterns which may occur. Such emissions include those for traffic using the scheme as well as the surrounding regional road network.

14.5 BASELINE CONDITIONS

CURRENT EMISSIONS SOURCES AND FUTURE BASELINE

14.5.1 In the baseline (do nothing) 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 baseline GHG assessment considers the current emissions due to the existing traffic in the study area, and the future baseline is the predicted increase in these emissions sources without the scheme. The emissions generated during the baseline (do nothing) and future baseline construction activities (repair or maintenance) is not assessed as data on the manufacturing of materials and construction processes is not available.

[296] RICS (2017) Whole life carbon assessment for the built environment. RICS professional standards and guidance, UK.

14.5.2 Total end-user GHG emissions are presented in **Table 14.2** - Baseline GHG emissions data and end user traffic in the region of the scheme for the baseline 'do nothing' scenario, and future baseline year 2037. The baseline GHG emissions are expected to increase by 13% between 2023 (operational year) and 2041 (future year) as traffic growth outweighs increased vehicle efficiency. The total end-user traffic emissions for the 60-year operational life of the scheme (2022 to 2081) are also presented along with the average annual emissions for that period.

Table 14.2 - Baseline GHG emissions data and end user traffic in the region of the scheme

SCENARIO	TOTAL GHG EMISSIONS FOR ALL TRAFFIC IN THE TRAFFIC MODEL AREA (THOUSAND TONNES OF CARBON DIOXIDE EQUIVALENT; KTCO2E)			
	2022 (OPERATIONAL YEAR)	2037 (FUTURE YEAR)	AVERAGE PER YEAR (2022-2081)	TOTAL (2022-2081)
BASELINE ('DO NOTHING')	125.0	141.5	139.3	8357

14.5.3 In addition to the baseline traffic emissions presented above, emissions during 2016 within East Sussex and nationally[297] are presented in **Table 14.3** - Greenhouse gas emissions, East Sussex and National, 2016 for context.

Table 14.3 - Greenhouse gas emissions, East Sussex and National, 2016

SOURCE	EAST SUSSEX (KTCO2)	NATIONAL (KTCO2)
A. Industry and Commercial Electricity	240	51,532
B. Industry and Commercial Gas	162	35,973
C. Large Industrial Installations	7.7	32,466
D. Industrial and Commercial Other Fuels	96	17,658
E. Agriculture	47	5,382
Industry and Commercial Total	*552*	*143,010*
F. Domestic Electricity	294	31,442
G. Domestic Gas	490	60,203
H. Domestic 'Other Fuels'	101	10,788

[297] Department for Business, Energy & Industrial Strategy (2018), UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2016, https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-2016

Domestic Total	*884*	*102,432*
I. Road Transport (A roads)	460	54,351
J. Road Transport (Motorways)	-	28,032
K. Road Transport (Minor roads)	438	41,483
L. Diesel Railways	17	2,151
M. Transport Other	5	2,036
Transport Total	*919.5*	*128,053*
N. LULUCF Net Emissions	-268	-16,026
Grand Total	2088	357,470
Population ('000s, mid-year estimate)	545	65,648
Per Capita Emissions (t)	4	5

14.6 POTENTIAL IMPACTS

14.6.1 The impacts of GHGs relate to their contribution to climate change. These impacts are global and cumulative in nature, with every tonne of GHGs contributing to impacts on natural and human systems. GHG emissions result in the same global effects wherever and whenever they occur and, therefore, the sensitivity of different human and natural receptors is not considered.

CONSTRUCTION PHASE GHG EMISSIONS

14.6.2 The scheme has the potential to result in increases in greenhouse gas emissions associated with construction activities (such as manufacturing of materials and construction processes). During construction, notable sources of emissions will include 'embedded carbon' emissions generated during extraction and manufacturing of construction materials including: asphalt, aggregate, structural and reinforced steel and concrete. These are required for: the pavement for junction improvements; development of the Shared Use Path; construction of the new bridge over the Cuckmere River; and widening of the existing bridge over the railway at Polegate.

14.6.3 The construction lifecycle stages included within the scope of this EAR and corresponding potential sources of emissions are outlined in **Table 14.4**.

Table 14.4 - Key emissions activity during the scheme lifespan

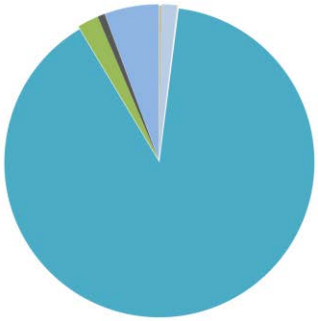
CONSTRUCTION LIFECYCLE STAGE	POTENTIAL SOURCES OF EMISSIONS (NOT EXHAUSTIVE)
Product stage (manufacture and transport of raw materials to suppliers)	Embodied emissions associated with extraction and manufacturing of the required raw materials, including: → 33,820 tonnes asphalt for surfacing the Shared Use Path and junction improvements → 13,499 tonnes aggregate for structural backfill and drainage → 13.474 tonnes of imported earthworks (fill) → 2,462 tonnes concrete for the bridge structures and retaining walls, drainage feature and lighting and signage foundations. → 76 tonnes steel for bridge structures, reinforcement and retaining walls. → Smaller quantities of ancillary aspects such plastic drainage pipes, aluminium signage and lighting columns, copper cabling and timber for fencing and formwork.
Construction process stage (transport of materials and arisings to/from site; construction process, earth movements)	Emissions from the construction stage include such emissions sources as fuel/energy consumption from: → Delivery of materials for junction improvement, new Shared Use Path and bridge, widening of existing bridge at Polegate as well as fill material → Export and disposal of 19,699 tonnes carriageway planings → Export and disposal of 5,438 tonnes of surplus topsoil → Export and disposal of 639 tonnes concrete → Export and disposal of smaller quantities of arisings such as mixed metals and timber.

14.6.4 The total construction related GHG emissions arising from: material supply; the manufacturing of materials; waste generation and disposal; and transportation of materials and waste to and from site; has been calculated to be 17.4 thousand tonnes of carbon dioxide equivalent (KTCO2e), as presented in **Figure 14.1**.

14.6.5 **Figure 14.1** also shows a breakdown of the GHG emissions 'hot spots' from materials, as the main source of emissions from construction of the scheme.

Materials

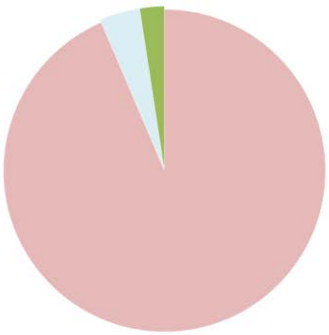
The table and pie chart displayed below show the total CO_2e emissions associated with materials purchased for the contract.



Category	CO_2e Emissions
Fencing / RRS / barriers	43.955
Drainage	264.020
Earthworks	15.720
Pavements	14,512.330
Street furniture	360.590
Civil Structures	115.984
Bulk Materials	918.362
Total	**16,230.961**

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	16,230.961
Materials Transport	702.295
Energy Use	0.000
Business and Employee transport	0.000
Waste	417.044
Total	**17,350.300**

highways england driving forward
delivering through RAMBOLL
on behalf of the WSP | PARSONS BRINCKERHOFF
supplier group

Figure 14.1 Total GHG Emissions Breakdowns Associated with Materials

14.6.6 The majority (93.5%) of GHG emissions are associated with materials (product stage 'cradle to gate' or 'embodied' emissions) with 4.1% from transport of those materials and wastes and 2.4% from waste generation and disposal.

14.6.7 The majority (89.4%) of the emissions for materials relate to the pavement for the junction improvements and bridge widening. Other significant contributions are from bulk materials (5.7%) required for the scheme which comprise aggregate and concrete required for all aspects of the scheme and asphalt for the Shared Use Path. Smaller contributions are from street furniture (lighting and signage, 2.2%), drainage (1.6%), civil structures (steelwork and formwork only, concrete is accounted for in bulk materials, 0.7%) and less than 1% from earthworks and fencing.

14.6.8 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, and presenting the scheme GHG emissions against the respective UK carbon budgets and total road CO_2 emissions for East Sussex has been used to assess the significance of effects.

14.6.9 The GHG emissions from the construction of the scheme is likely to have an adverse impact. The magnitude of change in GHG emissions is considered to be ***negligible***.

14.6.10 The scheme is therefore expected to have an effect of ***neutral*** significance on climate, during construction. This assessment takes into consideration the confirmed construction phase mitigation measures, the magnitude of GHG emissions and the context of the scheme, and using professional judgement it is considered that the neutral effect of this scheme will not be significant. Furthermore, as presented in **Table 14.6** - Key emissions activity during the scheme lifespan, the GHG impacts of the scheme would not have a material impact on the Government meeting its carbon reduction targets.

OPERATIONAL GHG EMISSIONS

14.6.11 The scheme will 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, percentage of Heavy Duty Vehicles (%HDV) and speed. Any increase in emissions and the corresponding concentrations of GHGs present in the atmosphere will contribute to global warming and climate change.

14.6.12 Total end user emissions are presented in **Table 14.5** for the year 2022 (the first year of operation for the scheme) and the year 2037 (the future modelled year). In addition, the average annual and total emissions for the 60 year assumed operational period of 2022 to 2081 are presented. The baseline figures (without the scheme) are included to show the impact due to the scheme.

Table 14.5 - End user GHG emission data for traffic in the region of the scheme

SCENARIO	TOTAL GHG EMISSIONS FOR ALL TRAFFIC IN THE TRAFFIC MODEL AREA (THOUSAND TONNES OF CARBON DIOXIDE EQUIVALENT; KTCO2E)			
	2022 (OPERATIONAL YEAR)	2037 (FUTURE YEAR)	AVERAGE PER YEAR (2022-2081)	TOTAL (2022-2081)
BASELINE ('DO NOTHING')	125.0	141.5	139.3	8357
THE SCHEME	125.5	141.7	139.5	8372

14.6.13 The total regional traffic emissions for the operational lifespan of the scheme (2022-2081) are 14 tCO_2e higher (+0.2%) than the baseline (do nothing) scenario.

14.6.14 The magnitude of change in GHG emissions during operation is predicted to be ***negligible.*** GHG emissions from the operation of the scheme are likely to have an effect of ***neutral*** significance. this assessment take into consideration the magnitude of GHG emissions (slight increase) and the context of the scheme, using professional judgement including previous experience of road infrastructure schemes, it is considered that the neutral effect of this scheme will not be significant. Furthermore, as presented in **Table 14.6** - Key emissions activity during the scheme lifespan, the GHG impacts of the scheme would not have a material impact on the Government meeting its carbon reduction targets.

SCHEME IMPACT ON UK CARBON BUDGETS AND EAST SUSSEX 2016 ROAD EMISSIONS

14.6.15 The total estimated GHG emissions arising from the scheme have been estimated as part of the air quality assessment, and are presented in **Table 14.6** below. They are presented for the construction stage to first year of operation (2020-2022), the operation stage (2022-2081) and the overall total for the whole lifecycle (2020-2081).

14.6.16 The total emissions during each of the UK National Carbon Budget periods is presented and compared in percentage terms to the respective National budget. The Third Carbon Budget covering 2018 to 2022 is 2,544 million tCO2e. The Fourth Carbon Budget covering 2023 to 2027 is 1,950 million tCO2e. The Fifth Carbon Budget covering 2028 to 2032 is 1,725 million tCO2e (the latest carbon budget agreed by the government).

14.6.17 The percentage of 1 year's operational phase total GHG emissions arising from the scheme are also presented in comparison with the 2016 road CO2 emissions for East Sussex in 2016[297].

Table 14.6 - Key emissions activity during the scheme lifespan

STAGE / TIMING	TOTAL GREENHOUSE GAS EMISSIONS (THOUSAND TONNES OF CARBON DIOXIDE EQUIVALENT; $kTCO_2e$)
Construction phase (2020-2022)	17.4
Operational phase (2022 – 2081)	14.5 (0.2 per year)
Total for lifecycle (2020 – 2081)	31.9
Total for third carbon Budget period (2018 – 2022) [% of budget]	17.9 [0.00070%]
Total for fourth carbon Budget period (2023 – 2027) [% of budget]	2.2 [0.00011%]

Total for fifth carbon Budget period (2028 – 2032) [% of budget]	1.7 [0.00010%]
East Sussex Total Road Co2 emissions estimates 2016 [% of 1 year's operational phase]	460 [0.0525%]

Table 14.7 - Summary of GHG Effects

EFFECT	RECEPTOR	BENEFICIAL/ ADVERSE	DIRECT/ INDIRECT	LONG TERM/ MEDIUM SHORT TERM/ TEMPORARY /PERMANENT	SIGNIFICANCE (VERY LARGE – NEUTRAL)
CONSTRUCTION					
INCREASE IN GHG EMISSIONS FROM MANUFACTURE AND SUPPLY OF MATERIALS AND CONSTRUCTION ACTIVITIES	GHG emissions result in the same global effects wherever and whenever they occur and, therefore, the sensitivity of different human and natural receptors is not considered	Adverse	Direct	Long term Permanent	Neutral
OPERATION					
CHANGE GHG EMISSIONS FROM END-USER EMISSIONS (REGIONAL TRAFFIC FLOWS)	GHG emissions result in the same global effects wherever and whenever they occur and, therefore, the sensitivity of different human and natural receptors is not considered	Adverse	Direct	Long term Permanent	Neutral

14.7 DESIGN, MITIGATION AND ENHANCEMENT MEASURES

CONSTRUCTION PHASE

14.7.1 The confirmed mitigation measures to reduce the impact of GHG emissions during construction comprise; the use of site won arisings (earthworks and topsoil), local sourcing of materials and waste management facilities, and the use of materials containing recycled content (for example aggregate, asphalt and cement binder).

14.7.1 A summary of further measures for consideration are noted in **Table 14.8** - Recommended design, mitigation or enhancement measures.

Table 14.8 - Recommended design, mitigation or enhancement measures

MEASURE	DESCRIPTION	MECHANISM/ TIMING	RESPONSIBILITY
Reduce embodied carbon through finessing the detailed design	Design optimisation to reflect the carbon reduction hierarchy.	Detailed design	Detailed designer
	Reduce the elements required for the scheme.	Detailed design	Detailed designer
	Reduce the requirement for construction materials through design and use of site won arisings;	Detailed design and Construction	Detailed designer and Lead Contractor
	Substitute construction elements for lower-carbon alternatives (e.g. changing the design and materials for the bridge).	Detailed design and Construction	Detailed designer and Lead Contractor
	Specify materials and products with reduced embodied GHG emissions including through material substitution, recycled or secondary content and from renewable source.	Detailed design and Construction	Detailed designer and Lead Contractor

EMBODIED CARBON THROUGH CONSTRUCTION PHASE EFFICIENCIES	Maximise opportunities for local sourcing of materials and use of local waste management facilities.	Construction	Lead Contractor
	Select and engage with material suppliers and construction contractors taking into account their policies and commitments to reduction of GHG emissions, including embodied emission in materials.	Detailed design and Construction	Detailed designer and Lead Contractor
	Minimise energy consumption including fuel usage by, for example, reducing the requirement for earth movements to/from and within the construction site.	Construction	Lead Contractor
	Use energy-efficient plant; minimising vehicle idling; and use renewable energy devices wherever possible.	Construction	Lead Contractor
CHANGE GHG EMISSIONS FROM END-USER EMISSIONS (REGIONAL TRAFFIC FLOWS)	Designing, specifying and constructing the scheme with a view to maximising the operational lifespan and minimising the need for maintenance and refurbishment (and all associated emissions).	Detailed design	Detailed designer
	Designing, specifying and constructing the scheme with a view to maximising the potential for reuse and recycling of materials/elements at the end-of-life stage.	Detailed design	Detailed designer
	Specifying high efficiency mechanical and electrical equipment such as lighting and telecoms.	Detailed design	Detailed designer
	Operating, maintaining and refurbishing the scheme using best-practice efficient approaches and equipment. Ensure designs are focussed upon reduction of emissions from end-user vehicle movement (traffic) for example by providing the conditions for efficient low-carbon vehicles and driving practices, such as increasing capacity, which would potentially result in a reduction in emission per vehicle where congestion is relieved.	Detailed design	Detailed designer

14.8 ASSESSMENT OF LIKELY SIGNIFICANT EFFECTS

Table 14.9 - Summary of effects

Effect	Receptor	Assessment of Effect				Mitigation			Residual Effect	
		Beneficial/ Adverse	Direct/ Indirect	Long term/ medium short term/ Temporary /Permanent	Significance (Very large – neutral)	Description	Mechanism/ Timing	Responsibility	Beneficial/ Adverse	Significance
Construction Phase										
Increase in GHG emissions from manufacture and supply of materials and construction activities	Global receptors sensitive to climate change	Adverse	Direct	Long term Permanent	Neutral	Design optimisation to minimise material usage, recover site arisings, minimise waste generation and maximising efficient construction and transportation methods Specifying materials and products with reduced embodied GHG emissions Selection of material suppliers and construction contractors committed to reducing GHG emissions. Use of efficient construction plant and equipment.	During Design and construction	Designer and Contractor	Adverse	Neutral

Operational Phase										
Change GHG emissions from end-user emissions (regional traffic flows)	Global receptors sensitive to climate change	Adverse	Direct	Long term Permanent	Neutral	Design optimisation to maximise operational efficiency; Focus design on reduction of emissions from end-user vehicle movements.	During operation	Designer	Adverse	Neutral

CLIMATE RESILIENCE

14.9 INTRODUCTION

14.9.1 The requirement to consider a scheme's vulnerability to climate change results from the 2014 amendment to the EIA Directive (2014/52). The Directive has been fully transposed into UK law in The Environmental Impact Assessment (Miscellaneous Amendments Relating to Harbours, Highways and Transport) Regulations 2017 and came into force in the UK on the 2017. The Directive requires:

"A description of the likely significant effects of the project on climate (for example the nature and magnitude of greenhouse gas emissions) and the vulnerability of the project to climate change."

14.9.2 This section assesses the vulnerability of the scheme to the impacts of climate change.

14.10 SCHEME

14.10.1 The scheme consists of the elements outlined in **Chapter 2 – The Project**.:

14.11 STUDY AREA

14.11.1 The assessment of vulnerability of the scheme to the impacts of climate change has been informed by regional scale information on historic and projected change in climate variables. The UK Climate Projections 2018 (UKCP18)[298] are the most up-to-date projections of climate change for the UK, however, data from the probabilistic projections at the administrative region scale were not available. Information on the projected climate has therefore been taken from previous projections, UKCP09[299], for the South-East England administrative area. The vulnerability of scheme elements within the scheme extent to changes in climate (at the regional scale) has been assessed.

14.12 ASSESSMENT APPROACH

14.12.1 This section outlines the approach to assessment of climate vulnerability and risk. This approach aligns with the following UK and international guidance:

- IEMA (2015) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation[300]
- European Commission (2013) Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment[301];

[298] United Kingdom Climate Projections 2018 https://ukclimateprojections-ui.metoffice.gov.uk/
[299] United Kingdom Climate Projections 2009 http://ukclimateprojections.metoffice.gov.uk/
[300] IEMA (2015) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation. Available at: https://www.iema.net/assets/templates/documents/iema_guidance_documents_eia_climate_change_resilience_and_adaptation%20(1).pdf.
[301] European Commission (2013) Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment. http://ec.europa.eu/environment/eia/pdf/EIA%20Guidance.pdf

- European Commission (2016) Climate change and major projects[302]; and
- European Commission Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient[303].

14.12.2 The full approach consists of 4 steps:

- Step 1: Identify receptors and analyse policy context;
- Step 2: Climate vulnerability assessment;
- Step 3: Risk assessment; and
- Step 4: Adaptation measures.

14.12.3 The PCF Stage 3 Scoping Report (July 2018) presented the detailed assessment and results of Step 1 and Step 2 describing the level of vulnerability of the scheme to the impacts of climate change, and determining which vulnerabilities should be assessed further (Steps 3 and 4). This vulnerability assessment is presented in **Appendix 14.1**. This EAR completes the assessment Steps 3 and 4.

STEP 1: IDENTIFY RECEPTORS AND ANALYSE POLICY CONTEXT

14.12.4 During this stage, relevant receptors which may be affected by climate change were identified with consideration given to the impact of extreme weather and changes in climate on the scheme over its lifetime. This stage includes a definition of the policy context.

STEP 2: CLIMATE VULNERABILITY ASSESSMENT

14.12.5 This stage comprised an assessment of the vulnerability of the receptors identified in Step 1 to projected climate change and extreme weather variables. The vulnerability of a receptor to extreme weather and climate change is a function of:

- The typical sensitivity of the receptor to climate variables – based on literature review and expert judgement.
- The exposure of the receptor to projected change in climate variables – based on information on observed climate and projected climate.

14.12.6 For each element of the vulnerability assessment (sensitivity and exposure), a categorisation is assigned to each climate variable based on the following scale:

- **High**: High climate sensitivity or exposure.
- **Moderate**: Moderate climate sensitivity or exposure.
- **Low**: No significant climate sensitivity or exposure.

14.12.7 This is a qualitative assessment informed by expert opinion and supporting literature.

[302] European Commission (2016) Climate Change and Major Projects. : https://ec.europa.eu/clima/sites/clima/files/docs/major_projects_en.pdf
[303] European Commission (undated) Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient. Available at: http://climate-adapt.eea.europa.eu/metadata/guidances/non-paper-guidelines-for-project-managers-making-vulnerable-investments-climate-resilient/guidelines-for-project-managers.pdf

14.12.8 The vulnerability of receptors to climate variables was determined from the combination of the sensitivity and exposure categorisation, using the matrix shown in **Table 14.11**. At this point, climate variables to which the scheme's vulnerability has been assessed as 'Low' were scoped out of further assessment. Climate variables to which the scheme's vulnerability has been assessed as 'High' or 'Medium' were taken forward to Steps 3 and 4.

TABLE 14.10 - VULNERABILITY MATRIX			
SENSITIVITY	EXPOSURE		
	LOW	MODERATE	HIGH
Low	Low vulnerability	Low vulnerability	Low vulnerability
Moderate	Low vulnerability	Medium vulnerability	Medium vulnerability
High	Low vulnerability	Medium vulnerability	High vulnerability

STEP 3: RISK ASSESSMENT

14.12.9 Impacts related to the 'scoped in' variables were identified. Typical impacts are shown in **Table 14.12**.

TABLE 14.11 - TYPICAL HAZARDS ASSOCIATED WITH CLIMATE VARIABLES	
CLIMATE VARIABLE	CLIMATE-RELATED IMPACTS
Average air temperature change (annual, seasonal, monthly)	High temperatures, longer growing season Fewer incidences of low temperature related hazards such as ice, snow, damage from freeze-thaw
Extreme air temperature (frequency and magnitude)	Heatwaves
Average precipitation (annual, seasonal, monthly)	Flooding (fluvial, pluvial), reduced ground stability Soil moisture deficit, snow, ice and hail
Extreme rainfall (frequency and magnitude)	Flooding (fluvial, pluvial), reduced ground stability
Average wind speed change (annual, seasonal, monthly)	Increase wind loading
Gales and extreme winds (frequency and magnitude)	Increase in storm intensity, storm surge, lightning
Humidity	Fog
Solar radiation	High UV levels
Sea level	Coastal flooding, coastal erosion

14.12.10 The risk assessment is undertaken by considering the likelihood of climate hazards occurring and the consequence to the scheme elements if they occur.

14.12.11 Likelihood and consequence are qualitatively assessed using the descriptions in **Table 14.13** and **Table 14.14**.

TABLE 14.12 – QUALITATIVE DESCRIPTION OF CONSEQUENCE	
CONSEQUENCE OF IMPACT	DESCRIPTION
Negligible	Disruption to an isolated section of a strategic route lasting less than 1 day.

Minor adverse	Regional level disruption to strategic route(s) lasting less than 1 day.
Moderate adverse	Regional level disruption to strategic route(s) lasting more than 1 day but less than 1 week.
Large adverse	National level disruption1 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.
Very large adverse	National level (or greater) disruption to strategic route(s) lasting more than 1 week.

TABLE 14.13 – QUALITATIVE DESCRIPTION OF LIKELIHOOD

LIKELIHOOD OF IMPACT	DESCRIPTION
Very low	The event may occur once during the lifetime of the scheme (60 years).
Low	The event occurs during the lifetime of the scheme (60 years) e.g. once in 60 years.
Medium	The event occurs limited times during the lifetime of the scheme (60 years) e.g. approximately once every 15 years, typically 4 events.
High	The event occurs several times during the lifetime of the scheme (60 years) e.g. approximately once every five years, typically 12 events;
Very high	The event occurs multiple times during the lifetime of the scheme (60 years) e.g. approximately annually, typically 60 events.

14.12.12 These determinants are then combined to develop a climate risk rating for each scheme element in respect to specific climate hazards (**Table 14.15**). The assessment is a qualitative assessment based on expert judgment, engagement with the design team and a review of relevant literature.

TABLE 14.14 - SIGNIFICANCE RATING MATRIX

LIKELIHOOD OF IMPACT OCCURRING	CONSEQUENCE OF IMPACT OCCURRING				
	NEGLIGIBLE	MINOR ADVERSE	MODERATE ADVERSE	LARGE ADVERSE	VERY LARGE ADVERSE
Very low	Not significant	Not significant	Not significant	Not significant	Not significant
Low	Not significant	Not significant	Not significant	Significant	Significant
Medium	Not significant	Not significant	Significant	Significant	Significant
High	Not significant	Significant	Significant	Significant	Significant
Very high	Not significant	Significant	Significant	Significant	Significant

STEP 4: MITIGATION MEASURES

14.12.13 Mitigation measures for the significant risks are identified through consultation with the design team and based on expert opinion. Taking account of the contribution of incorporated mitigation measures, a summary of the level of climate resilience of the scheme elements to climate change is applied:

- **Low** - a low level of climate resilience leading to *significant* residual climate risk. Remedial action or adaptation is required as a priority.
- **Moderate** – a moderate degree of climate resilience leading to *no significant* residual climate risk. However, ongoing monitoring and/or remedial action or adaptation could be considered; and

→ **High** – a strong degree of climate resilience leading to *no significant* residual climate risk. Remedial action or adaptation may be required but is not a priority.

14.12.14 Recommendations for supplementary climate change adaptation measures are then identified where necessary.

14.13 ASSESSMENT OF EFFECTS

ASSESSMENT ASSUMPTIONS AND LIMITATIONS

14.13.1 In the absence of an agreed methodology for assessing the vulnerability of schemes to climate change, the approach in this chapter has been developed and applied based on existing best practice, and in collaboration with Highways England and expert opinion.

14.13.2 The UK Climate Projections 2018 (UKCP18) are the most up-to-date projections of climate change for the UK. However, at the time of writing this EAR chapter, UKCP18 regional data was not available, so UKCP09 regional data was used.

14.13.3 As future emissions of GHGs, and resulting pathway, is uncertain. A precautionary approach has been applied, by selecting the High emissions scenario and long-term timeslice[304] (2080s), in line with Highways England guidance. This time horizon is consistent with the 60 years design life of the scheme.

14.13.4 The determination of resilience has been undertaken under the assumption that robust design standards will be adhered to where detailed information is unavailable.

STEP 1 AND STEP 2: IDENTIFICATION OF RECEPTORS AND VULNERABILITY ASSESSMENT FINDINGS

14.13.5 Steps 1 and 2 were completed in the PCF Stage 3 Scoping Report (July 2018). **Appendix 14.1** presents the findings of Step 2, the Vulnerability Assessment. The climate variables to which the scheme's vulnerability has been assessed as 'High' or 'Medium' were taken forward to Steps 3 and 4 and are present in **Table 14.15**, **Table 14.16** and **Table 14.17**.

TABLE 14.15 - VULNERABILITY ASSESSMENT - ROAD

CLIMATE VARIABLE		SENSITIVITY RATING	EXPOSURE RATING	VULNERABILITY RATING
Precipitation	Extreme rainfall	Medium	Medium	Medium vulnerability
	Drought	Medium	High	Medium vulnerability
Temperature	Extreme temperature	Medium	High	Medium vulnerability

[304] UKCP09 projections are given for seven overlapping 30-year time periods (timeslice).

Wind	Gales and extreme wind events	Medium	Medium	Medium vulnerability
Soil	Soil moisture	Medium	High	Medium vulnerability
	Stability	Medium	Medium	Medium vulnerability

TABLE 14.16 - VULNERABILITY ASSESSMENT – BRIDGE

CLIMATE VARIABLE		SENSITIVITY RATING	EXPOSURE RATING	VULNERABILITY RATING
Precipitation	Extreme rainfall	Medium	Medium	Medium vulnerability
Temperature	Extreme temperature	Medium	Medium	Medium vulnerability
Wind	Gales and extreme wind events	High	Medium	Medium vulnerability
Soil	Stability	Medium	Medium	Medium vulnerability

TABLE 14.17 - VULNERABILITY ASSESSMENT – CYCLE AND FOOTWAY

CLIMATE VARIABLE		SENSITIVITY RATING	EXPOSURE RATING	VULNERABILITY RATING
Precipitation	Extreme rainfall	Medium	Medium	Medium vulnerability
	Drought	Medium	High	Medium vulnerability
Temperature	Extreme temperature	Medium	High	Medium vulnerability
Wind	Gales and extreme wind events	Medium	Medium	Medium vulnerability
Soil	Soil moisture	Medium	High	Medium vulnerability
	Stability	Medium	Medium	Medium vulnerability

STEP 3: RISK ASSESSMENT

14.13.6 This section describes the assessment of risk based on the medium vulnerability climate variables identified in Step 2. No high vulnerability variables were identified.

14.13.7 Climate and weather-related impacts associated with the identified medium vulnerabilities during construction and operation are described in **Appendix 14.2**. Unless stated otherwise, the impacts identified in **Appendix 14.2** are expected to impact the whole scheme.

14.13.8 **Table 14.19** presents significance ratings for each of the identified climate risks, across both the construction and operational phases, to the scheme based on a qualitative assessment of likelihood and consequence.

TABLE 14.18 – SIGNIFICANT RISKS IDENTIFIED FOR THE SCHEME (PRE MITIGATION)

COMPONENT	DESCRIPTION OF RISK		CONSEQUENCE	LIKELIHOOD	SIGNIFICANCE RATING (WITHOUT MITIGATION)	MITIGATABLE THROUGH DMRB/ DESIGN STANDARDS?
	HAZARD	RISK				
Structural stability	Extreme rainfall	Damage to carriageway structures due to increased runoff	Moderate adverse	Medium	Significant	Yes
		Soil saturation and water damage	Minor adverse	Medium. Areas of the Scheme are located within Flood Zone 2 or 3 although risk could change over time due to climate change.	Not Significant	N/A
		Undercutting and scour particularly in relation to the bridge over the Cuckmere River	Moderate adverse	Medium	Significant	Yes
		Increased slope instability	Moderate adverse	Medium	Significant	Yes
		Damage to unpaved shoulders	Minor adverse	Medium	Not Significant	N/A
		Erosion, silting and sedimentation	Minor adverse	Medium	Not Significant	N/A
	Drought	Loss of vegetation leading to greater erosion risk	Minor adverse	Medium	Not Significant	N/A
	Extreme temperature	Cracking and expansion particularly impacting bridge structures	Moderate adverse	Medium	Significant	Yes
		Overheating of equipment, including during construction and operation (e.g. electronic signage)	Moderate adverse	Medium	Significant	Yes
		Increased risk of erosion	Minor adverse	Medium	Not Significant	N/A

	Gales and extreme wind events	Risk of damage to structures and foundations, including flood scour and/or runoff	Moderate adverse	Medium	Significant	Yes
		Damage to signage and site structures	Minor adverse	Medium	Not Significant	N/A
		Erosion of banks and exposed surfaces	Minor adverse	Medium	Not Significant	N/A
	Soil moisture	Shrinking and cracking of soils leading to subsidence	Moderate adverse	Medium	Significant	Yes
		Soil softening and erosion leading to collapse and settlement of soil structures	Moderate adverse	Medium	Significant	Yes
		Increased slope instability	Moderate adverse	Medium	Significant	Yes
		Soil saturation	Moderate adverse	Medium	Significant	Yes
	Stability	Subsidence impacting road, cycleway and footpath and bridges over the Cuckmere River	Moderate adverse	Medium	Significant	Yes
		Failure of earthworks due to desiccation	Moderate adverse	Medium	Significant	Yes
		Shrinking and cracking of soils	Moderate adverse	Medium	Significant	Yes
		Greater rates of soil erosion	Minor adverse	Medium	Not Significant	N/A
Structural robustness	Drought	Drying out of construction materials and cracking	Minor adverse	Medium	Not Significant	N/A
		Deformation of rigid structures	Moderate adverse	Low	Not Significant	N/A
	Extreme temperature	Risks to stored equipment, including waste	Minor adverse	Medium	Not Significant	N/A

		Damage and disruption (e.g. fires)	Minor adverse	Medium	Not Significant	N/A
Ancillary equipment	Extreme rainfall	Drains and culverts becoming overwhelmed	Minor adverse	High	Significant	Yes
		Blockages of drainage assets	Minor adverse	High	Significant	Yes
		Greater mobilisation of pollutants in soil/ground causing premature deterioration of materials	Minor adverse	Medium	Not Significant	N/A
	Drought	Damage and disruption (fires)	Minor adverse	Medium	Not Significant	N/A
	Extreme temperature	Damage to external weather proofing and detailing at ground level	Minor adverse	Medium	Not Significant	N/A
		Higher day and night-time temperatures	Minor adverse	High	Significant	Yes
	Gales and extreme wind events	Damage from high winds and rain-infiltration into surfaces and materials	Minor adverse	Medium	Not Significant	N/A
	Soil moisture	Shrinking and cracking of soils leading to subsidence	Moderate adverse	Medium	Significant	Yes
		Soil softening and erosion leading to collapse and settlement of soil structures	Moderate adverse	Medium	Significant	Yes
	Stability	Increased rate of deterioration, potentially leading to need for early replacement	Minor adverse	Medium	Not Significant	N/A
Material durability	Extreme rainfall	Softening of subsurface materials below the road, cycle and footway and bridge structures	Moderate adverse	Medium	Significant	Yes

	Drought and prolonged dry spells, including drier summers	Enhanced reactions when cement stabilising and drying of concrete	Minor adverse	Medium	Not Significant	N/A
		Increased rate of deterioration of materials, potentially leading to need for early replacement	Minor adverse	Medium	Not Significant	N/A
		Shrinking and cracking	Minor adverse	Medium	Not Significant	N/A
	Extreme temperatures, including hotter summers	Enhanced reactions when cement is stabilising and drying of concrete	Minor adverse	Medium	Not Significant	N/A
		UV degradation of exposed equipment e.g. cabling	Minor adverse	Medium	Not Significant	N/A
	Gales and extreme wind events	Increased rate of deterioration of materials, potentially leading to early replacement	Moderate adverse	Medium	Significant	Yes
	Soil moisture	Greater mobilisation of pollutants in the soil/ground	Minor adverse	Medium	Not Significant	N/A
	Stability	Increased rate of deterioration of materials, potentially leading to need for early replacement	Minor adverse	Medium	Not Significant	N/A
Site contents and business continuity	Extreme rainfall	Water accumulation causing disruption to construction and operation	Moderate adverse	Medium	Significant	Yes
		Stopping of services due to asset failure	Moderate adverse	Medium	Significant	Yes
		Scour of embankments leading to increased maintenance	Moderate adverse	Medium	Significant	Yes
		Traffic disruption and	Moderate	Medium	Significant	Yes

		congestion	adverse			
		Excessive vegetation growth	Minor adverse	Medium	Not Significant	N/A
		Reduced opportunities for maintenance	Minor adverse	Medium	Not Significant	N/A
	Extreme temperature	Reduced working periods and delays	Minor adverse	Medium	Not Significant	N/A
		Reduced opportunities for maintenance	Minor adverse	Medium	Not Significant	N/A
		Operational disruption	Moderate adverse	Medium	Significant	Yes
	Soil moisture	Increased maintenance costs and risks to operation	Moderate adverse	Low	Not Significant	N/A
	Stability	Increased maintenance costs and risks to operation	Moderate adverse	Low	Not Significant	N/A
H&S of users (operators and customers)	Extreme rainfall	Difficult working conditions	Minor adverse	High	Significant	Yes
		Movement of debris causing slip, trip and fall hazards	Moderate adverse	Medium	Significant	Yes
		Health and safety risks to road users	Moderate adverse	Medium	Significant	Yes
	Drought, including long periods of dry weather	More dust	Minor adverse	Medium	Not Significant	N/A
		Evaporation of construction water	Minor adverse	Medium	Not Significant	N/A
	Extreme temperature	Difficult working conditions	Minor adverse	High	Significant	Yes
		Increased fire risk	Moderate adverse	Medium	Significant	Yes
		Hot surfaces may cause injury	Minor	Medium	Not Significant	N/A
		Health and safety risks to	Minor adverse	Medium	Not Significant	N/A

		road users				
	Gales and extreme wind events	Difficult working conditions	Minor adverse	High	Significant	Yes
		Health and safety risks to road users particularly high sided vehicles)	Moderate adverse	Medium	Significant	Yes
	Soil moisture	Difficult working conditions	Minor adverse	Medium	Not Significant	N/A
	Stability	Movement of debris causing slip, trip and fall hazards	Minor adverse	Medium	Not Significant	N/A

14.13.9 Risks which have been assessed as not significant are not considered further in this assessment although ongoing maintenance of the asset by the Applicant in its capacity as highways authority for the scheme will be upheld to ensure that these risks are addressed in the future if their risk status changes and/or new information might affect their risk status.

STEP 4: MITIGATION MEASURES

14.13.10 This section outlines the adaptation measures that have been integrated into the Scheme in response to significant risks.

14.13.11 In consultation with the design and project teams, a range of mitigation options have been identified to reduce the vulnerability of the scheme to the identified climate and weather-related risks (**Table 14.18**). Further adaptation mitigation measures are likely to be integrated into the detailed design at PCF Stage 5 – Construction Preparation.

Table 14.19 - Significant Risks and Planned Mitigation Measures for the Scheme

RISK	MITIGATION MEASURES
Increased precipitation	The drainage design includes Sustainable Drainage Systems (SuDs) to reduce surface water flooding and a climate change factor of 40% on rainfall. The increase in impermeable surface area has been taken into account in the drainage design. The Shared Use Path however is likely to be managed separately to the existing carriageway. The length of culverts (where appropriate) have been increased on the Shared Use Path and boardwalks have been used where possible.
Drought	A dust management plan will be developed. Water efficiency measures will be implemented at PCF Stage 5. Drought resistant vegetation will be considered at PCF Stage 5.
Undercutting and scour	The ground covering/ material will be designed at PCF Stage 5, taking into account outputs from flood modelling.
Soil moisture and stability	Current standards for geotechnical design will be utilised when designing slopes, with appropriate margins incorporated to account for changes in moisture and stability.
Extreme temperatures (overheating equipment, fires):	All equipment will be to current design standards as used throughout the Highways England network. The Polegate Railway Bridge widening aspect has been designed to Eurocodes and DMRB which include measures for wind and thermal action. These cover extreme events commensurate with a 120 year design life.
Gales and extreme wind events	The new cycle / foot bridge over the River Cuckmere and Polegate Railway Bridge widening aspects have been designed to Eurocodes and DMRB which include measures for wind and thermal action. These cover extreme events commensurate with a 120 year design life. Aspects such as signage, lighting, CCTV masts will all be designed for wind loading, anticipated to account for high wind forces, This will be further considered during detailed design (PCF Stage 5).

Delays and reduced maintenance opportunities impacting business continuity	The scheme has been designed to minimise maintenance requirements, for example the sealed surface of the Shared Use Path will last longer than gravel or other similar material. All equipment will be to current design standards as used throughout the Highways England network. Further operational and maintenance business continuity aspects will be reviewed and adopted by A1+ (Highways England Maintenance Contractor for the south-east).
Extreme weather events impacting on health and safety	Operational and maintenance health and safety aspects will be reviewed and adapted by A1+ (Highways England Maintenance Contractor for the south-east).

14.13.12 Further mitigation and resilience to climate and weather-related risks will be considered periodically through maintenance regimes. For example, regular inspections (at minimum two and six yearly intervals) will be undertaken for structures to mitigate the impacts of excessive vegetation growth and deterioration of materials. Inspections will also occur following an extreme weather event to monitor any damage and implement appropriate mitigation as necessary.

14.13.13 A list of weather related incidents (for example, road surface deformations, snow and ice) would be maintained to assist in identifying thresholds which, when exceeded, require maintenance.

RESIDUAL EFFECTS

14.13.14 Where a significant pre-mitigation climate risk was found (**Table 14.18**), the level of resilience has been determined based on the integration of the above planned mitigation measures (presented in **Table 14.19**). Where it has been indicated by the design team that mitigation measures will be considered further at a later stage of the design process, the resilience ratings in **Table 14.20** below are dependent on that further consideration and incorporation of mitigation taking place.

14.13.15 The conclusions of this analysis or resilience and residual significance are presented in **Table 14.20**.

Table 14.20 - Climate resilience rating following integration of the proposed mitigation measures

COMPONENT	IMPACT	RISK	RESILIENCE RATING	RESIDUAL EFFECT
Structural Stability	Extreme rainfall	Damage to carriageway structures due to increased runoff.	High	Not Significant
		Undercutting and scour particularly in relation to the bridge over the Cuckmere River.	Moderate	Not Significant
	Drought	Loss of vegetation leading to greater erosion risk.	High	Not Significant

	Extreme temperature	Overheating of equipment, including during construction and operation (such as electronic signage)	High	Not Significant
	Gales and extreme wind events	Risk of damage to structures and foundations, including flood scour and/or runoff.	Moderate	Not Significant
		Damage to signage and site structures.	High	Not Significant
	Soil moisture	Shrinking and cracking of soils leading to subsidence.	Moderate	Not Significant
		Soil softening and erosion leading to collapse and settlement of soil structures.	Moderate	Not Significant
		Increased slope instability.	Moderate	Not Significant
		Soil saturation.	Moderate	Not Significant
	Stability	Subsidence impacting road, cycleway and footpath and bridges over the Cuckmere River.	Moderate	Not Significant
		Failure of earthworks due to desiccation.	Moderate	Not Significant
		Shrinking and cracking of soils.	Moderate	Not Significant
Structural robustness	Extreme temperature	Damage and disruption (e.g. fires).	High	Not Significant
Ancillary equipment	Drought	Damage and disruption (fires).	High	Not Significant
	Extreme temperature	Higher day and night-time temperatures.	High	Not Significant
	Soil moisture	Shrinking and cracking of soils leading to subsidence.	Moderate	Not Significant
		Soil softening and erosion leading to collapse and settlement of soil structures.	Moderate	Not Significant
	Stability	Increased rate of deterioration, potentially leading to need for early replacement.	Moderate	Not Significant
Material durability	Gales and extreme wind events	Increased rate of deterioration of materials, potentially leading to early replacement.	High	Not Significant

Site contents and business continuity	Extreme rainfall	Water accumulation causing disruption to construction and operation.	High	Not Significant
		Stopping of services due to asset failure.	High	Not Significant
		Scour of embankments leading to increased maintenance.	Moderate	Not Significant
		Traffic disruption and congestion.	High	Not Significant
		Excessive vegetation growth.	High	Not Significant
		Reduced opportunities for maintenance.	High	Not Significant
	Extreme temperature	Reduced working periods and delays.	High	Not Significant
		Reduced opportunities for maintenance.	High	Not Significant
		Operational disruption.	High	Not Significant
H&S of users (operators and customers)	Extreme rainfall	Difficult working conditions.	High	Not Significant
		Movement of debris causing slip, trip and fall hazards.	Moderate	Not Significant
		Health and safety risks to road users.	Moderate	Not Significant
	Drought, including long periods of dry weather	More dust.	High	Not Significant
	Extreme temperature	Difficult working conditions.	High	Not Significant
		Increased fire risk.	High	Not Significant
		Hot surfaces may cause injury.	High	Not Significant
		Failure of temperature controls.	High	Not Significant
		Health and safety risks to road users.	High	Not Significant
	Gales and extreme wind events	Difficult working conditions.	High	Not Significant
		Health and safety risks to road users particularly high sided vehicles).	High	Not Significant

14.13.16 As presented in **Table 14.20**, many climate risks have been assessed to have a high resilience rating when taking account of the planned mitigation measures described in **Table 14.19** - Significant Risks and Planned Mitigation Measures for the Scheme (i.e. where it is considered that there is a strong degree of climate resilience) and are deemed to be not significant.

14.13.17 The application of the mitigation measures will be closely monitored as the detailed design progresses and as operational and maintenance management plans are developed.

14.13.18 Given the uncertainties inherent in climate science and the associated projections used in this assessment, it is recommended that the vulnerabilities and risks identified in this assessment are monitored throughout the design, construction and operational phases of the scheme. The monitoring would be undertaken to assess the appropriateness of the mitigation measures, and be revisited when new or updated information becomes available.

14.14 CLIMATE CHAPTER SUMMARY

14.14.1 The GHG assessment has concluded that the scheme will have an effect of neutral significance on GHG emissions during construction and operational phases. **Table 14.10** provides a summary of the effects.

14.14.2 The climate resilience assessment has concluded that, due to the planned mitigation measures, the climate risks have a high resilience rating and are deemed to be not significant. **Table 14.20** provides a summary of the climate resilience rating and residual effect.