A303 Sparkford to Ilchester Dualling Scheme TR010036

6.1 Environmental Statement Chapter 13 Climate

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Infrastructure Planning

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

A303 Sparkford to Ilchester Dualling Scheme

Development Consent Order 201[X]

6.1 Environmental Statement
Chapter 13 Climate

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13 Climate

13.1 Introduction

13.1.1 This chapter considers the likely significant effects of the proposed A303 Sparkford to Ilchester Dualling scheme (hereafter referred to as 'the scheme') on climate change, and the likely significant effects of climate upon the scheme.

13.1.2 The chapter has been divided into 2 separate aspects:

- Effects on climate - effects of greenhouse gas (GHG) emissions on climate change of GHG emissions arising from the proposed scheme.
- Vulnerability of the scheme to climate change – the resilience of the proposed scheme to climate change impacts and impacts relevant to adaptation.

13.1.3 Chapter 2 The Scheme of Volume 6.1 contains a detailed description of the scheme. The drawings referenced in this chapter can be found in Volume 6.2, while the technical appendices are presented in Volume 6.3.

13.2 Competent expert evidence

13.2.1 The competent expert for climate has 12 years' experience in environmental consultancy, energy and environmental policy, and 4 years' experience of climate change assessments for infrastructure projects. The competent expert is also a member of the Institution of Environmental Sciences.

13.2.2 The competent expert for carbon is a chartered Environmentalist with the Institute of Environmental Sciences and has 10 years' experience in environmental consultancy and carbon management.

13.3 Legislative and policy framework

13.3.1 The principal legislative and planning context for the assessment of the environmental effects of the scheme on climate is presented below.

National legislation

Climate Change Act 2008

13.3.2 The *Climate Change Act 2008* forms part of the UK government's plan to reduce GHG emissions, committing the government to a reduction of GHG by at least 80% of 1990 levels by 2050. The *Climate Change Act* creates a new approach to managing and responding to climate change in the UK, by:

- Setting ambitious, legally binding emission reduction targets.
- Taking powers to help meet those targets.

- Strengthening the institutional framework.
- Enhancing the UK's ability to adapt to the impact of climate change.
- Establishing clear and regular accountability to the UK Parliament and to the devolved legislatures[1].

13.3.3 Key provisions of the Act in respect of climate change mitigation include the requirement for the government to set legally binding carbon budgets capping the amount of GHG emitted in the UK over a 5-year period, as set out in Table 13.1.

Table 13.1: UK carbon reduction targets

Carbon Budget	Carbon Budget Level	Reduction Below 1990 Levels
3rd carbon budget (2018- 2022)	2,544MtCO_2e	37% by 2020
4th carbon budget (2023- 2027)	1,950MtCO_2e	51% by 2025
5th carbon budget (2028- 2032)	1,725MtCO_2e	57% by 2030

13.3.4 Key provisions of the act in respect of climate change adaptation include:

- A requirement for the government to report, at least every 6 years, on the risks to the UK of climate change, and to publish a programme setting out how these will be addressed. This Act also introduces powers for government to require public bodies and statutory undertakers to carry out their own risk assessment and make plans to address those risks
- The Adaptation Sub-Committee of the Committee on Climate Change, will provide advice to, and scrutiny of, the government's adaptation work

National policy

National Policy Statement for National Networks

13.3.5 The *National Policy Statement for National Networks (NPSNN)*[2] contains a section on climate change adaptation, particularly paragraph 4.40, setting out how the effects of climate change should be taken into account when developing and consenting infrastructure. It states that the latest UK Climate Projections should be used to assess the potential impacts of climate change and influence adaptation measures, covering the estimated lifetime of the new infrastructure. The current UK Climate Projections, produced by the Met Office,

[1] DECC (2012) *Climate Change Act* 2008
[2] Department for Transport (2014) *National Policy Statement for National Networks* (NPSNN) [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387223/npsnn-web.pdf (last accessed May2018).

are the UKCP09[3]. These will be replaced in late 2018 by the UKCP18[4] climate projections.

National Planning Policy Framework (2012)

13.3.6 Chapter 10 of the *National Planning Policy Framework (NPPF)*[5] (*Meeting the challenge of climate change, flooding and coastal change*) applies to this scheme. It states that local authorities should adopt proactive strategies to mitigate and adapt to climate change (in line with the objectives and provisions of the *Climate Change Act 2008*), taking into account flood risk, coastal change and water supply and demand considerations.

The Carbon Plan 2011

13.3.7 The *Carbon Plan* was presented to UK Parliament pursuant to Sections 12 and 14 of the *Climate Change Act 2008*. The plan sets out how the UK will achieve decarbonisation within the framework of the energy policy. UK local authorities and at a regional level, must report on their CO_2 emissions. However, all emissions from the motorways sector have been removed and are not factored into the annual CO_2 emissions.

UK Climate Change Risk Assessment 2017

13.3.8 The *UK Climate Change Risk Assessment*[6] replaces the first UK climate change risk assessment published in 2012, and fulfils the requirement of the *Climate Change Act* for the Government to report on the climate change risks to the UK every 5 years.

13.3.9 The assessment identified 6 priority areas of risks and opportunities. The area of relevance to this scheme is:

- Flooding and coastal change risks to communities, business and infrastructure.

[3] UK Climate Projections (2014) UK Climate Projections 2009 (CP09) [online] available at: http://ukclimateprojections.metoffice.gov.uk/21684 (last accessed June 2018).
[4] UK Climate Projections (2018) UK Climate Projections 2018 [online] available at: http://ukclimateprojections.metoffice.gov.uk/24125 (last accessed June 2018).
[5] Department for Communities and Local Government (2012) *National Planning Policy Framework* (NPPF) [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf (last accessed May 2018).
[6] HM Government (2017) *UK Climate Change Risk Assessment* [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/584281/uk-climate-change-risk-assess-2017.pdf (last accessed June 2018).

National Adaptation Programme

13.3.10 The *National Adaptation Programme*[7] sets out over 370 actions for the UK government, businesses, councils, civil society and academia to address the findings of the first *UK Climate Change Risk Assessment* (2012) and to build the nation's resilience to climate change. The programme addresses the requirement in the *Climate Change Act* to publish a programme for adaptation to climate change.

13.3.11 The programme contains the following objectives relevant to the scheme:

- Objective 1: To work with individuals, communities and organisations to reduce the threat of flooding and coastal erosion, including that resulting from climate change, by understanding the risks of flooding and coastal erosion, working together to put in place long-term plans to manage these risks and making sure that other plans take account of them;
- Objective 7: To ensure infrastructure is located, planned, designed and maintained to be resilient to climate change, including increasingly extreme weather events;
- Objective 9: To better understand the particular vulnerabilities facing local infrastructure from extreme weather and long-term climate change to determine actions to address the risks.

Local policy

South Somerset District Council Local Plan 2006-2028

13.3.12 *South Somerset District Council's Local Plan*[8] contains the following policy which is relevant to climate change:

13.3.13 "*Policy EQ1: Addressing Climate Change in South Somerset*

13.3.14 *The Council will support proposals for new development where they have demonstrated how climate change mitigation and adaptation will be delivered, through inclusion of the following measures (as appropriate).*

- *New development will ensure that carbon dioxide emissions are minimised through energy efficiency measures, renewable and low carbon energy, and where necessary Allowable Solutions.*

[7] HM Government (2013) The *National Adaptation Programme*: *making the country resilient to a changing climate* [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/209866/pb13942-nap-20130701.pdf (last accessed June 2018).
[8] South Somerset District Council (2015) *South Somerset District Council Local Plan 2006 – 2028* [online] available at: https://www.southsomerset.gov.uk/media/707200/south_somerset_local_plan_2006-2028_adoption_version_march_2015.pdf (last accessed June 2018).

- *Susceptibility to climate change should be taken into account on all proposals to develop sites with biodiversity interest."*

Highways England policy

Highways England Delivery Plan

13.3.15 The *Highways England Delivery Plan*[9] states that, in complying with Section 4.2 (g) and its general duty under Section 5(2) of the *Infrastructure Act 2015*, to have regard for the environment, the Licence holder must:

- *"Adapt its network to operate in a changing climate, including assessing, managing, and mitigating the potential risks posed by climate change to the operation, maintenance and improvement of the network.*
- *Develop approaches to the construction, maintenance and operation of the Licence holder's network that are consistent with the government's plans for a low carbon future.*
- *Take opportunities to influence road users to reduce the greenhouse gas emissions from their journey choices".*

13.4 Assessment methodology

13.4.1 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.

13.4.2 The methodology was presented in Chapter 14 Climate of the ***Environmental Impact Assessment (EIA) Scoping Report*** (***document reference: HE551507-MMSJV-EGN-000-RP-LP-0014***) submitted to the Planning Inspectorate in November 2017. The Scoping Opinion is contained within Appendix 4.1 of Volume 6.3. A schedule of responses detailing how each of the Scoping Opinion comments has been considered as part of this chapter is contained within Appendix 4.2 of Volume 6.3. No amendments to the methodology as presented within the EIA Scoping Report have been necessary.

Effects on climate

13.4.3 The assessment has been undertaken in accordance with the principles set out in Chapter 4 Environmental Assessment Methodology in Volume 6.1. There is at present no single accepted methodology for the assessment of climate change within EIAs. The methodology used for effects on climate has been

[9] Highways England (2015) *Highways England Delivery Plan 2015 – 2020* [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/424467/DSP2036-184_Highways_England_Delivery_Plan_FINAL_low_res_280415.pdf (last accessed March 2018).

produced in line with DMRB Volume 11 Section 2 Part 5 and webTAG Unit A3 Chapter 4. This includes the *Infrastructure Carbon Review*[10] and *PAS 2080*[11].

13.4.4 For *PAS 2080*, this sets out a common approach and understanding of whole life carbon management in the provision of economic infrastructure as a result of the *Infrastructure Carbon Review*. It promotes reduced carbon, reduced cost infrastructure delivery, more collaborative ways of working and a culture of challenge in the infrastructure value chain.

13.4.5 The *Infrastructure Carbon Review* sets out carbon reduction actions required by infrastructure organisations. In terms of the scheme, this means that emission reduction actions should be taken into account when developing scheme specific mitigation measures, where relevant.

13.4.6 The assessment of the effects of the scheme on climate has included:

- Construction (of the scheme): material supply, transport, manufacturing and construction process
  - The GHG emitted through the materials used to construct the scheme, and the significance of the effects of this. See Appendix 13.1 Carbon Assessment Report in Volume 6.3 for greater detail.
  - The GHG emitted during the lifecycle of the scheme, calculated using the Mott MacDonald Carbon Portal which is PAS2080 compliant for the scheme design.
- Operation:
  - Road user carbon - use of the asset or vehicle emissions use in line with HA207/07 and webTAG Unit A3 Chapter 4[12].
  - Emissions associated with maintenance and refurbishment
- Opportunities to minimise production and use of GHG emissions, in other words the potential for GHG reduction of emissions through reuse and recycling during the construction of the scheme.

13.4.7 In line with the NPSNN significance of effects will be assessed by comparing estimated GHG emissions arising from the proposed scheme with UK carbon budgets, and the associated reduction targets, outlined in Table 13.1.

[10] HM Treasury (2013) Infrastructure Carbon Review [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/260710/infrastructure_carbon_review_251113.pdf (last accessed July 2018).
[11] BSI (2016) *PAS 2080*: *Carbon management in infrastructure* [online] available at: https://shop.bsigroup.com/ProductDetail?pid=000000000030323493 (last accessed June 2018)
[12] 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).

13.4.8 The NPSNN 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."*

13.4.9 Considering the above statement, assessments will only report significant effects where increases in carbon emissions will impact on the ability of the government to meet its carbon reduction targets.

Vulnerability of the scheme to climate

13.4.10 The assessment has been undertaken in accordance with the principles set out in Chapter 4 Environmental Assessment Methodology in Volume 6.1. There is at present no single accepted methodology for the assessment of climate change within EIAs. Therefore, a qualitative methodology for assessing the vulnerability of the scheme assets to climate change has been produced in line with DMRB Volume 11 Section 2 Part 5 and current best practice which has set out how projects will assess the likelihood and consequence of the impact occurring to each receptor using professional judgement. This involves the use of the lifespan of the project and the climate trends associated with the UKCP high emissions scenario to inform the assessment, outlined in Table 13.8.

13.4.11 For the purposes of assessing the climate baseline and future climate projections, data used is from the Met Office[13]. The Met Office uses regional climate data with the site falling in the South West England region. This includes Cornwall, Devon, Somerset, Avon and the Isles of Scilly.

13.4.12 During the 2.5 year construction period, climate change is not expected to bring about a change in the risk of severe weather or additional impacts upon scheme construction. Therefore, no likely significant effects are predicted, due to the short-term duration of the construction period upon the workforce, plant machinery or the construction processes. The vulnerability of the scheme to climate change during construction is subsequently not considered further within this chapter.

13.4.13 The receptors to be considered by this assessment are as follows:

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

[13] Met Office (2016), *South West England: Climate* [online] available at: https://www.metoffice.gov.uk/climate/uk/regional-climates/sw (last accessed June 2018)

13.4.14 The assessment identifies the likelihood and consequence of the impact occurring to each receptor leading to the evaluation of the significance of the effects as follows:

- The impacts (hazards and opportunities) for each receptor shall be identified using the climate projections data. The vulnerability of the scheme to both normal weather and extreme weather-related disaster scenarios, throughout the project lifecycle, shall be identified and reported.
- Once the climate change impacts (hazards and opportunities) have been identified, a risk assessment of those impacts on the scheme shall be undertaken using the following framework outlined in Table 13.2 (likelihood categories) and Table 13.3 (consequence of impact).
- Report on the significance of effects using Table 13.4.

Table 13.2: Likelihood categories

Likelihood category	Description (probability and frequency of occurrence)
Very high	The event occurs multiple times during the lifetime of the scheme (60 years) for example, approximately annually, typically 60 events.
High	The event occurs several times during the lifetime of the scheme (60 years) for example approximately once every five years, typically 12 events;
Medium	The event occurs limited times during the lifetime of the scheme (60 years) for example, approximately once every 15 years, typically 4 events.
Low	The event occurs during the lifetime of the scheme (60 years) for example, once in 60 years.
Very low	The event may occur once during the lifetime of the scheme (60 years).

Notes: Scheme lifetime is considered to include construction and operational stages. Scheme lifetime is taken to be 60 years in line with WebTAG.

Table 13.3: 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 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 13.4: Significance matrix

		Measure of likelihood				
		Very low	Low	Medium	High	Very High
Measure of consequence	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**

Notes: NS = Not significant, S = Significant

Consultation

13.4.15 No additional consultation specific to climate has been required. Scheme-wide consultation details are provided in Section 4.5, Chapter 4 Environmental Assessment Methodology of Volume 6.1.

13.5 Assessment assumptions and limitations

13.5.1 The climate assessment has been based on the description of the scheme detailed in Section 2.5 of Chapter 2 The Scheme (Volume 6.1), including the horizontal and vertical limits of deviation.

13.5.2 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 UK Climate Projections (UKCP09) developed by the Met Office.

13.5.3 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. Scenarios exclude outlying surprise or disaster scenarios in the literature, and any scenario necessarily includes subjective elements and is open to various interpretations. Generally global projections are more certain than regional, and temperature projections are more certain than those for precipitation. Furthermore, the degree of uncertainty associated with all climate change projections increases for projections further into the future.

13.5.4 Accordingly, any further research, analysis or decision-making should take account of the nature of the data sources and climate projections and should

consider the range of literature, additional observational data, evidence and research available, and any recent developments in these.

13.5.5 Emissions associated with the end of the life stage (lifecycle stages C1-4), known as decommissioning, shall not be considered given the uncertainty of the length of operation of the scheme.

13.5.6 Limitations and assumptions in relation to the carbon assessment can be found in the Carbon Assessment Report contained in Appendix 13.1 of Volume 6.3.

13.6 Study area

Effects on climate

13.6.1 The study area to be considered for the construction phase includes the embodied carbon of the materials and the emissions caused by the construction activities and their associated transport. These are defined in terms of lifecycle stages, as detailed in Section 7 of PAS2080:2016 and as follows:

- Products and materials (A1-3) - use of materials for temporary and permanent construction activities.
- Construction / installation processes (A5) - construction plant use

13.6.2 The study area to be considered for operation includes the Affected Road Network (ARN) for road user carbon (vehicle emissions) and the carbon used for the maintenance and refurbishment of the scheme assets, which comprises embodied carbon, emissions from construction activities and their associated transport. Road user carbon and the use of the asset or vehicle emissions use are undertaken in line with HA207/07 and webTAG Unit A3 Chapter 4.

13.6.3 These are defined in terms of lifecycle stages, as detailed in Section 7 of PAS2080:2016 and as follows:

- Operational energy use (B6) - operational energy.
- User utilisation of infrastructure (B9) - in use traffic.

13.6.4 The effect of the *PAS 2080* lifecycles scoped into the assessment on climate and their study areas are explored in Table 13.5 below.

Table 13.5: Effects on climate study area

Lifecycle scope	Study area	Emissions scope
A1-3- Products and materials	Permanent construction materials within the construction site boundary and the supply chains associated with these will be included. These quantities will be calculated with those in the Materials Chapter 10.	Primary raw material extraction, manufacturing, and transportation within the supply chain of all materials required for the permanent assets.
A5- Construction plant	Construction plant will consider the same plant quantities, sizes and operating hours as defined within Chapter 2 The Scheme Volume 6.1.	Direct plant emission, where only plant specification data is available. If direct fuel consumption data is available, the emissions scope will consider direct plant emissions.
B6- Operational energy use	Lighting columns within the footprint of the scheme.	Energy emissions from the lighting columns within the footprint of the scheme.
B9- User utilisation of infrastructure	Emissions from traffic use of the infrastructure within the red line boundary.	Direct exhaust emissions from vehicles.

Vulnerability of the scheme to climate

13.6.5 For the purposes of the vulnerability assessment, the study area has been defined as the physical infrastructure assets associated with the scheme (for example, earthworks, structures, pavement) as described in Chapter 2 The Scheme, Volume 6.1. In addition, environmental receptors identified within respective disciplines' scope have been considered where climate change has the potential to impact upon them as an in-combination impact.

13.7 Baseline conditions

Effects on climate

13.7.1 UK 2016 GHG emissions have decreased by 41% from 1990. In 2016, UK net CO_2 emissions were estimated at 468 million tonnes, a decrease of 5% in comparison to 2015 levels[14]. In 2016, 26% of UK GHG emissions were from the transport sector with emissions of 120 $MtCO_2e$ in 2016.

13.7.2 Within the South Somerset region, the carbon emissions from A roads in 2015 was 221.1$ktCO_2$, which represents a 13% decrease since 2005 and an 8.2% decrease in overall transport emissions[15]. There were 36.5 million vehicles licensed for use on roads in the UK in 2015, which is approximately an additional 3.5 million extra vehicles in 2015 compared to 2014. However, in

[14] 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 June 2018).

[15] Local Authority Carbon Dioxide Emissions estimates 2015 (June 2017)- https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/623015/2005_to_2015_UK_local_and_regional_CO2_emissions_statistical_release.pdf (last accessed June 2018).

2015 the percentage of ultra-low emission vehicles (ULEVs) reached 0.9% which is an 800% increase since 2013[16].

13.7.3 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[17]. Therefore, approximately 40.38 million tonnes of CO_2 are attributed to the embodied carbon of construction materials.

Vulnerability of the scheme to climate change

13.7.4 High-level climate observations for south west England[18] over a 30-year averaging period between 1981 – 2010, are presented in Table 13.6 below.

Table 13.6 Climate baseline for South West England (1981-2010)

Climatic conditions	Climate observations
Temperature	Mean daily minimum temperatures in Somerset can range from 1°C to 2°C in winter, whilst summer daily maximum temperatures are in the region of 21.5°C.
Rainfall	Vigorous Atlantic depressions are the source of the majority of rain in the south west in autumn and winter. Annual rainfall in the low-lying parts of central Somerset averages 700mm. Monthly rainfall is variable, but is highest in the autumn and winter months. The number of days with rainfall totals greater than 1mm in Somerset are 12-13 days in winter, dropping to an average of 7-9 days in summer.
Wind	South west England is one of the more exposed areas of the UK. The strongest winds are associated with the passage of deep depressions close to or across the British Isles. The frequency and strength of these depressions is greatest in the winter when mean speeds and gusts are strongest at approximately 15 knots.
Sunshine	The southwest of England has a favoured location with respect to the Azores high pressure when it extends its influence north eastwards towards the UK, particularly in summer. Average annual sunshine totals are between 1,450 and 1,600 hours.
Air Frost	The first air frost in Somerset can be expected around mid-October with over 50 days per year experiencing air frost.

[16] *Vehicle Licensing Statistics: Quarter 4 (Oct-Dec) 2015*, Department for Transport (April 2016)- https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/516429/vehicle-licensing-statistics-2015.pdf (last accessed June 2018).
[17] Alinden, B. (2014) *Embodied Energy and Carbon*, ICE [online] available at: https://www.ice.org.uk/knowledge-and-resources/briefing-sheet/embodied-energy-and-carbon (last accessed June 2018).
[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).

Future projections

Effects on climate

13.7.5 The transport sector is a key driver in projected UK emissions increases with road transport emissions projected to rise by 28 $MtCO_2e$ over 2023-2027 (the fourth carbon budget)[19].

Vulnerability of the scheme to climate change

13.7.6 The South West of England is projected to experience changes in temperature, rainfall, and frequency of extreme weather events, particularly flooding as a consequence of climate change. These changes are projected to occur under all 3 emissions scenarios (low, medium, and high GHG emissions), which are incorporated into the climate change models produced by the Met Office Hadley Centre. The general trend in the region is for warmer and drier summers, and warmer and wetter winters.

13.7.7 Under the high emissions scenario for the 2080s, projected changes in climatic conditions are outlined in Table 13.7.

Table 13.7 Future Climate Baseline for the 2080s

Climatic conditions	Climate observations
Temperature	The average summer temperature is estimated to increase by 5°C under the central estimate, which represents 'as likely as not' probability of change (50th percentile), and average winter temperature is estimated to increase by 3.4°C (50th percentile).
Rainfall	The average summer rainfall rate is estimated to decrease by 30%, whereas the average winter rainfall rate is estimated to increase by 31% (in the 50th percentile or central estimate).
Wind	Climate projections for wind are more uncertain than those for temperature and precipitation, due to inherent difficulty in modelling future wind conditions. However, overall an increase in extreme weather including wind is projected (Committee on Climate Change, 2017).

Source: UKCP09 Climate Projections

13.7.8 It should be noted that climate projections data corresponding to the 2080s (2070 - 2099) under a high emissions scenario represent a conservative approach to the use of climate projections in the UK, and have been selected in line with NPSNN paragraph 4.41, which states:

13.7.9 *"Where transport infrastructure has safety-critical elements and the design life of the asset is 60 years or greater, the applicant should apply the UK Climate*

[19] 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 2017).

Projections 2009 (UKCP09) high emissions scenario (high impact, low likelihood) against the 2080 projections at the 50% probability level."

13.8 Potential impacts

Construction

13.8.1 The following impacts are predicted for the scheme during construction.

Effects on climate

- The proposed construction duration for the scheme would be approximately 2.5 years. Embodied carbon emissions from the use of construction materials are the main contributor to climate change, with additional greenhouse gas emissions arising from the direct use of plant and transport of materials.

Vulnerability of the scheme to climate

- Due to the short-term nature of construction and limited changes in climate over the 2.5 year construction period, changes in climate are not expected to affect the construction process including the workforce, plant and scheme assets.

Operation

13.8.2 The following impacts are predicted for the scheme during operation.

Effects on climate

- The life of the scheme is anticipated to be 60 years, with the scheme opening in 2022. Over this time, the operation of the scheme has the potential to result in an increase in local CO_2 emissions due to emissions associated with road user carbon (changes in vehicle distributions and speed limits) and maintenance and refurbishment of the scheme assets.

Vulnerability of the scheme to climate

- During the scheme's 60-year appraisal period, changes in climate as outlined in Table 13.3 would be experienced in the scheme area. This has the potential to impact the scheme assets and their operation, such as deformation and deterioration of asphalt surfacing associated with temperature increase, and changes in precipitation affecting the foundation strength and deterioration of the road surface, with the potential to lead to an increased flood risk. This would also have impacts upon the future maintenance and refurbishment regime.

- The end users of the scheme, the public and commercial travellers using the road, have the potential to be impacted due to changes in climate. For instance, increased precipitation may reduce the speed at which vehicles travel along the route and therefore journey times may increase.
- Changes in climate also have the potential to impact environmental receptors. For example, increased precipitation may impact the foraging habits and opportunities of bats, and more frequent rainfall events resulting in higher runoff could increase pollutants within the receiving water.

13.9 Design, mitigation and enhancement measures

Design measures

Effects on climate

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

13.9.2 In line with the UK Governments carbon reduction plan, the scheme shall seek to reduce GHG emissions as far as practicable in all cases to contribute to the UK's net reduction in carbon emissions, and maximise the potential for reducing GHG emissions. The following high-level options shall be applied and developed when seeking to reduce GHG emissions on projects:

- Step 1 - Avoid and prevent: maximise potential for re-using or refurbishing existing assets to reduce the extent of new construction required, and explore alternative lower carbon options to deliver the project 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 (for example, during construction and operation) that reduce resource consumption over the life cycle of the scheme.
- Step 3 - Remediate: after addressing steps 1 and 2 projects will identify, assess and integrate measures to further reduce carbon through on or off-site offsetting or sequestration.

13.9.3 The use of the carbon reduction hierarchy has been an outcome of good design practice and cost efficiencies on the scheme.

13.9.4 The scheme design (described in Chapter 2 The Scheme, Volume 6.1) aims to reduce the overall footprint of the scheme by re-using the existing A303 where practicable. Where the scheme is online, less materials would be required and land use change would be minimal, resulting in lower levels of CO_2e being

emitted. This would also be the case for slip roads, as the road lengths and widths would be reduced where practicable.

13.9.5 The footprint of structures and junctions have been made as compact as practicable, ensuring minimal land use change and materials use. The scheme design (described in Chapter 2 The Scheme, Volume 6.1) aims to balance the cut and fill, reducing the need to import additional fill material. 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.

13.9.6 Throughout the scheme design, materials have been evaluated and their carbon emissions calculated. This has ensured that materials with lower carbon outputs are considered. For example, for the vehicle restraints system used in the verges only, steel containment barriers have been chosen over concrete, which saves 45kgCO_2e per meter of barrier, resulting in an overall saving of 206tCO_2e.

Vulnerability to climate change

13.9.7 The storm design includes an allowance for the effects of climate change by allowing for a 40% increase[20]. This goes above the 20% required standard in DMRB Volume 4, Section 2, Part 3, HD 33/16 *Surface and Sub-Surface Drainage Systems for Highways*[21].

13.9.8 The use of open surface drainage features such as channels and ditches reduces the need for pipes to be used reducing quantities of materials as well as ensuring easier maintenance by the drainage system being open. Further information is contained within Appendix 4.7 Drainage Strategy Report, Volume 6.3.

13.9.9 Species of grass which are more tolerant to seasonal flooding have been used around the attenuation ponds and open drainage features ensuring greater resilience. These species are outlined within Figure 2.8 Environmental Masterplan, Volume 6.2.

13.9.10 The use of integral structures to avoid the need for joints or the of use semi-integral details to reduce risk of failure caused by increases in temperature, have been considered within the design.

13.9.11 In addition, the following aspects would further reduce the scheme's vulnerability to climate change, and these have been detailed within the ***Outline***

[20] Environment Agency (2017) *Flood risk assessments: climate change allowances* [online] available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances (last accessed June 2018).
[21] Highways England (2016) DMRB Volume 4, Section 2, Part 3, HD 33/16 *Surface and Sub-Surface Drainage Systems for Highways*.

***Environmental Management Plan (OEMP) (document reference TR010036/APP/6.7*)**:

- Foundation strength will be increased to reduce the risk of failure caused by increased winter precipitation, by evaluating the moisture regime. Foundations should incorporate hydraulically bound materials or the use of reinforcement such as geotextiles.
- The pavement structural design methodology will be used for example, specific non-frost / 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).
- Increase the frequency of inspection and maintenance of Advanced Direction Sign (ADS), road markings, NMU facilities such as footpaths and signs, vehicle restraint systems, lighter structures and foundation strengthening.
- Hydraulically bound materials or the use of reinforced geotextiles will be used in the foundations to reduce the risk of premature pavement failure caused by increased rainfall and saturated material.
- Better quality pain systems will be used for existing structures for weathered steel.
- The laying of concrete in accordance with best practice and relevant standards.
- Increased precipitation could increase risk to the earthworks stability resulting in the use of fill material that is less susceptible to moisture such as Pulverised Fuel Ash and aggregate.

Mitigation measures

Effects on climate

13.9.12 Plant equipment and vehicles to be used on the scheme would be selected based on their relative environmental performance taken from a technical specification.

13.9.13 Construction works would be carried out in accordance with the best practicable means, as described in Section 79 (9) of the *Environmental Protection Act (EPA) 1990*, to reduce fumes or emissions. This would include all vehicle engines and plant motors to be switched off when not in use.

Vulnerability to climate change

13.9.14 Mitigation measures would ensure that the construction of the scheme allows for adaptation to impacts of changes in climate, such as ensuring construction materials are covered when stored and pro-active planning to minimise adverse effects.

13.9.15 Plan for remedial work after long, dry periods. The consideration of permeable pavements where appropriate has been undertaken on the scheme.

13.9.16 After periods of extreme weather inspections and potential maintenance of ADS, road markings and vehicle restraint systems needs to be undertaken.

13.10 Assessment of likely significant effects

Effects on climate

Construction

13.10.1 The carbon assessment from the Mott MacDonald Carbon Portal tool has indicated that the scheme would result in emissions of approximately 10,414tCO_2e for construction- lifecycle stages A1-3 and A5. See Appendix 13.1 Carbon Assessment Report (Volume 6.3) for greater detail. This makes up 0.0004% of the 4th Carbon Budget (2,544MtCO_2e). Therefore, it is concluded that the construction of the scheme would not have a substantial adverse effect or impact the government's ability in achieving the budget.

13.10.2 The carbon output specifically from the materials (lifecycle stages A1 - 3) are estimated to be 9,013tCO_2e. When compared to the 10% contribution from construction materials to the annual UK emissions, this only contributes 0.02% (refer to paragraph 13.6.3 for further detail).[22]

13.10.3 Emissions at the A5 lifecycle stage of 1,376tCO_2e would be produced due to construction plant throughout the construction process. This would be reduced by implementing the early engagement with the contractor to avoid double handling during earthworks.

13.10.4 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 as explored in paragraphs 13.10.1 and 13.7.1.

Operational

13.10.5 Emissions from operation energy (lifecycle stage B6) created by the lighting columns installed for the scheme result in 4.2tCO_2e per annum. This is assuming, on average, 87W per column and that the columns run for 12 hours per day.

13.10.6 During operation (lifecycle stage B9), as per the results of webTAG Unit A3 Chapter 4, the scheme is estimated to cause an increase of 625,195tCO_2e in

[22] Note that the annual UK emissions are in CO_2 and the scheme emissions in CO_2e.

non-traded emissions and increase by 5,972tCO_2e in traded emissions over 60 years.

Assessment of scheme emissions against UK carbon budgets

13.10.7 The change in CO_2e by carbon budget is detailed in Table 13.9, from the GHG Workbook - Worksheet 1. This shows the traded and non-traded emissions that would contribute to emissions within the current carbon budget (4th).

Table 13.9: Change in CO_2e by carbon budget

	Carbon budget 1	Carbon budget 2	Carbon budget 3	Carbon budget 4
Traded sector	0.00	0.00	0.00	273.35
Non-traded sector	0.00	0.00	0.00	49,591.54

13.10.8 This increase of 625,195tCO_2e in non-traded emissions an increase by 5,972tCO_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.

13.10.9 Table 13.10 summarises the assessment of scheme emissions against the carbon budgets.

Table 13.10: Summary of project emissions against carbon budgets

Stage	Net tCO_2e	Relevant carbon budgets
Construction	10,414	3rd carbon budget period
Operation	631,167	3rd, 4th & 5th carbon budget period

Vulnerability of the scheme to climate

13.10.10 The scheme's vulnerability to climate during operation is assessed based on the varied assets which make up the scheme, 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.

13.10.11 An assessment of the effects of the projected changes in climate, as outlined in Table 13.7, on the scheme assets during operation is presented in Table 13.10. Significance has been assigned in line with the likelihood and measure of consequence outlined in Tables 13.2 and 13.3 and in line with DMRB Volume 11 Section 2 Part 5, Table 2.4. Design and mitigation measures are detailed in Section 13.8.

13.10.12 Considering the sensitivity of scheme assets outlined in Table 13.10, it is considered that changes in climate would have a Not Significant effect on the scheme assets.

Table 13.10: Assessment of scheme receptors

Receptors	Life cycle asset aspect	Potential effects	Likelihood category	Consequence of impact	Significance
Pavements	Foundation	Pavements have a typical design life of 40 years and would therefore be affected by changes in climate. Increases in winter precipitation could result in increased sub-surface moisture content, decreasing foundation strength.	Low	Moderate Adverse	Not Significant
		Changes in moisture content as a result of decreases in summer rainfall combined with increases in winter rainfall could cause soil to expand and shrink, causing pavement layers to heave.	Very low	Moderate Adverse	Not Significant
		Increased rainfall has the potential to saturate the unbound pavement construction, causing loss of fine material and settlement and subsequent premature pavement failure.	Low	Minor Adverse	Not Significant
	Surface	Increases in summer temperature have the potential to result in increased risk of surface failure, rutting, warping of slabs, excessive movement at joints and difficulty in maintaining asphalt surface profile during compaction.	Medium	Minor Adverse	Not Significant
Structures	Superstructure	Increases in temperature have the potential to increase the risk of joint and bearing failure.	Very low	Large Adverse	Not Significant
		Increases in precipitation would increase deterioration rates for joints and surfacing, requiring more frequent replacement and traffic disruption.	Low	Moderate Adverse	Not Significant
		Increased winter precipitation could increase groundwater levels with the potential to cause large ground movements and soil settlement.	Low	Minor Adverse	Not Significant
		Increased precipitation could lead to flooding and scouring around foundations.	Low	Minor Adverse	Not Significant
		Increases in temperature and more variable precipitation may increase the frequency of maintenance painting of structural steelwork.	Low	Negligible	Not Significant
		An increase in wind speed and extreme wind events has the potential to lead to the failure of lighter structures by overturning.	Very low	Large Adverse	Not Significant
	Foundations and substructure	Increased winter precipitation could increase groundwater levels with the potential to cause large ground movements and soil settlement.	Low	Minor Adverse	Not Significant
		Increased precipitation could lead to flooding and scouring around foundations	Low	Minor Adverse	Not Significant
Drainage	Drainage system	An increase in winter precipitation would increase flood risk and the need for attenuation ponds. In addition, erosion of embankments, banks and footings.	Medium	Minor Adverse	Not Significant
		Increases in winter precipitation could result in a build-up of particulates in the road surface, which can compromise the surfaces' skid resistance. In addition, skid resistance decreases in areas that are flooded resulting in an increased aquaplaning risk.	Medium	Minor Adverse	Not Significant
Geotechnics	Earthworks	Increased precipitation could increase risk to the earthworks stability.	Low	Moderate Adverse	Not Significant
		Reductions in summer precipitation and increases in temperature would reduce soil moisture, which demands a greater compactive effort.	Low	Moderate Adverse	Not Significant

Receptors	Life cycle asset aspect	Potential effects	Likelihood category	Consequence of impact	Significance
Signs and signals	ADS	An increase in wind speed and in frequency of extreme wind events has the potential to affect the stability of ADSs, which have a design life of 15 years (Highways England, 2011).	Low	Moderate Adverse	Not Significant
	Road markings	Increases in precipitation and temperature have the potential to weather road markings.	Low	Minor Adverse	Not Significant
Soft estate	Landscape design	Increased precipitation and flooding has the potential to kill the plants in higher flood risk areas.	Medium	Negligible	Not Significant
Non-motorised User (NMU) Facilities	Underpass	Increased precipitation has the potential to lead to underpasses flooding, deterring NMUs from their journey.	Low	Minor 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 precipitation may result in an increase in rate of deterioration of vehicle restraint systems.	Low	Moderate Adverse	Not Significant
End-users	NMUs	Increases in temperature and reductions in summer rainfall have the potential to encourage a greater number of NMUs to use NMU facilities.	Medium	Negligible	Not Significant
		Increases in winter rainfall and wind events may discourage NMUs from undertaking journeys using NMU facilities.	Medium	Negligible	Not Significant
	Motorised Travellers (Commercial and members of the public)	Increases in winter rainfall could decrease the surfaces' skid risk which would impact the actual and perceived level of safety for the users.	Medium	Minor Adverse	Not Significant
		Increases in winter rainfall could reduce visibility for motorised travellers therefore travellers would reduce their speeds resulting in longer journey times.	Low	Minor Adverse	Not Significant
		Increased extreme cold weather events, including snow and ice, could discourage motorised travellers from using the roads due to safety concerns.	Medium	Negligible	Not significant

13.11 Monitoring

13.11.1 No significant adverse effects on climate are anticipated as a result of the scheme, and therefore no monitoring is required.

13.12 Conclusions

Effects on climate

13.12.1 Overall, the effects on climate are anticipated to be Not Significant during construction. At this stage, it is anticipated that due to the quantity of materials required for the scheme, a further as-built carbon assessment, including GHGs, should be undertaken post-construction.

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

Vulnerability to climate

13.12.3 During construction, no likely significant effects are anticipated for the scheme associated with the vulnerability to climate. Due to the short-term nature of construction and limited changes in climate over the 2.5 year construction period, changes in climate are not expected to affect any receptors through construction. Overall, effects would be Not Significant.

13.12.4 During operation, there is the potential for scheme assets and environmental receptors to be adversely affected by changes in climate. However, the balance of likelihood and consequence of these effects means that overall, effects would be Not Significant.

13.12.5 The evidence provided in the ES supports the accordance statement provided in the ***Case for the Scheme (document reference TR010036/APP/7.1*)**.