

A47 Blofield to North Burlingham Dualling

Scheme Number: TR010040

Volume 6 **6.1 Environmental Statement** **Chapter 14 – Climate**

APFP Regulation 5(2)(a)

Planning Act 2008

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

December 2020

Infrastructure Planning

Planning Act 2008

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

**A47 Blofield to North Burlingham
Development Consent Order 202[x]**

**CHAPTER 14
CLIMATE**

Regulation Number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010040
Application Document Reference	6.1
BIM Document Reference	PCF STAGE 3 HE551490-GTY-EAC-000-RP-LC-30001
Author:	A47 Blofield to North Burlingham Dualling Project Team, Highways England

Version	Date	Status of Version
Rev 0	December / 2020	Application Issue

Table of contents

14.	Climate	1
14.1.	Introduction	1
14.2.	Competent expert evidence	1
14.3.	Legislation and policy framework	2
14.4.	Assessment Methodology	6
14.5.	Assumptions and limitations	9
14.6.	Study Area	10
14.7.	Baseline conditions	11
14.8.	Potential impacts	13
14.9.	Design interventions and mitigation	20
14.10.	Assessment of likely significant effects	21
14.11.	Monitoring	21
14.12.	Summary	22
14.13.	References	22

Tables

Table 14-1	: UK carbon budgets and scheme appraisal period	7
Table 14-2	: Likelihood categories	8
Table 14-3	: Measure of consequence	8
Table 14-4	: Significance matrix	9
Table 14-5	: Affected road network baseline emissions (Do-Minimum Scenario)	12
Table 14-6	: Climate baseline for Eastern England (1981 to 2010)	12
Table 14-7	: Future climate projection data for East of England (2080s; RCP8.5)	13
Table 14-8	: Change in tCO _{2e} associated with Proposed Scheme end user traffic emissions by carbon budget period	14
Table 14-9	: Potential Impact of Proposed Scheme on carbon emissions (including ARN) compared against relevant UK Government carbon budgets	15
Table 14-10	: Summary of the net change in emissions against relevant carbon budgets	15
Table 14-11	: Vulnerability of Proposed Scheme assets to climate change – Summary of Effects and Mitigation	18

14. Climate

14.1. Introduction

14.1.1. As part of the Environmental Impact Assessment (EIA) process, this Environmental Statement (ES) chapter reports the potential significant effects for Climate as a result of the Proposed Scheme. This assessment includes a review of the existing baseline conditions, consideration of the potential impacts and identification of proportionate mitigation. This comprises a review of the existing climate information and identification of the potential climate impacts associated with the Proposed Scheme and also its vulnerability to climate change.

14.1.2. The approach to this assessment follows the methodology presented in the Scoping Report (February 2018) and subsequently agreed Scoping Opinion (March 2018) for the Proposed Scheme in combination with recent guidance in the Design Manual for Roads and Bridges LA 114 Climate (DMRB LA 114). To align with the requirements of the Infrastructure Planning EIA Regulations 2017, the National Networks National Policy Statement (NNNPS) 2014, and DMRB LA 114, this chapter covers two separate aspects:

- **Effects on climate** - impacts on climate from carbon emissions arising from the Proposed Scheme, including whether the Proposed Scheme may affect the ability of the UK Government to meet its carbon reduction targets (in accordance with the NNNPS (Department for Transport, 2014)).
- **Vulnerability of the Proposed Scheme to climate change** - the ability of the Proposed Scheme to operate as intended despite climate change impacts and associated weather effects, including how the Proposed Scheme will take account of the projected climate change (in accordance with NNNPS and the Infrastructure Planning EIA Regulations 2017).

14.1.3. The term 'carbon' is used as shorthand to refer to all relevant greenhouse gas (GHG) emissions.

14.1.4. The main chapter text is supported by Appendix 15.1 (Embodied Carbon Report)(TR04004/APP/6.2), based on the Proposed Scheme. The appendix contains further details of the carbon assessment as outlined in the Effects on Climate sections of this chapter.

14.2. Competent expert evidence

14.2.1. The climate competent expert, with over 20 years' experience, is a Fellow of the Institution of Civil Engineers, a Member of the Chartered Institution of Water and Environmental Management, a Chartered Engineer and a Chartered Environmentalist.

14.3. Legislation and policy framework

14.3.1. The legislative and planning context for the assessment of the effects of the Proposed Scheme on climate is outlined below.

National legislation

Climate Change Act 2008

14.3.2. The Climate Change Act 2008 is central to the UK Government's plan to reduce carbon emissions, committing the UK to a reduction of 80% against 1990 levels by 2050. On 1 May 2019, the UK Government declared a climate emergency, leading to updating the commitments in the 2008 Act to target net zero carbon emissions by 2050 under the Climate Change Act (2050 Target Amendment) Order 2019.

14.3.3. A key provision of the Act with respect to climate change **mitigation** is a requirement for the government to set legally binding carbon budgets limiting the amount of carbon emitted in the UK over a five-year period. These budgets currently cover the period to 2032 and were issued prior to the revision to the 2050 target in the Climate Change Act. The next (sixth) Carbon Budget is due to be published by April 2021 and will be the first budget to take account of the UK Government's 2050 net zero target.

14.3.4. Key provisions of the Act with respect to climate change **adaptation** include:

- a requirement for the government to report, at least every six years, on climate change risks to the UK, and to publish a programme setting out how these will be addressed
- an Adaptation Sub-Committee of the Committee on Climate Change, to both advise and critically review the government's adaptation work.

National policy

National Networks National Policy Statement (2014)

14.3.5. The NNNPS covers delivery of Nationally Significant Infrastructure Projects (NSIPs) and contains a section on climate change **adaptation** (paragraph 4.40) which sets out how the effects of climate change should be considered when developing infrastructure, a section on the assessment of carbon emissions (paragraph 5.17) and a section on climate change **mitigation** of carbon emissions (paragraph 5.19).

14.3.6. NNNPS includes relevant guidance, stating that the latest UK climate projections should be used to assess the potential impacts of climate change and to influence **adaptation** measures, covering the estimated lifetime of the new infrastructure. The current UK climate projections, produced by the Met Office, are referred to as UKCP18, which were updated in 2018 from UKCP09.

14.3.7. Regarding climate change **mitigation**, the NNNPS notes that carbon emissions should be considered as part of an application for Development Consent Order (DCO) and assessed against the Government's carbon budgets (paragraph 5.17). It notes that significant emissions would be those that would have a material effect on the ability of the UK Government to meet its carbon reduction targets (paragraph 5.18), although a definition of 'material impact' is not given. It subsequently requires evidence of any mitigation efforts (e.g. use of materials or value engineering) be presented (paragraph 5.19).

The Road to Zero (2018)

14.3.8. With a focus on climate change **mitigation**, the Road to Zero strategy (Department for Transport, 2018) outlines plans to enable expansion of green infrastructure across the UK, reduce the emissions from vehicles already being driven on the roads and encourage uptake of zero emissions vehicles. The UK Government has since updated its ambitions for the uptake of electric vehicles and has brought forward the date for banning the sale of new petrol, diesel and hybrid cars from 2040 to 2035 (this target date is expected to shortly be brought forward further to 2030).

National Planning Policy Framework (2019)

14.3.9. The National Planning Policy Framework (NPPF) sets out the government's planning policies for England and how these are to be applied. Chapter 14 ('Meeting the challenge of climate change, flooding and coastal change'), published by the Ministry of Housing, Communities and Local Government (2019) includes the requirement for local authorities to adopt proactive strategies to **mitigate** and **adapt** to climate change. This is in line with the objectives and provisions of the Climate Change Act 2008 and takes into account water supply and demand considerations, flood risk and coastal change.

UK Climate Change Risk Assessment (2017)

14.3.10. Focusing on climate change **adaptation**, the UK Climate Change Risk Assessment (HM Government, 2017), which replaced its predecessor published in 2012, fulfils the Climate Change Act requirement for the government to report on climate change risks to the UK every five years.

14.3.11. The assessment identified six priority areas of risks and opportunities. One of the six priority areas relevant to the Proposed Scheme is '*Flooding and coastal change risks to communities, business and infrastructure*'.

National Adaptation Programme

14.3.12. The National **Adaptation** Programme (HM Government, 2013a) 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.

14.3.13. The programme contains the following objectives relevant to the Proposed 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.

14.3.14. The National **Adaptation** Programme was updated in 2018 (HM Government, 2018), as well as building on the first programme this sets out the strategy until 2023 focusing on actions to address the most urgent risks from the second UK Climate Change Risk Assessment (2017). Key actions include:

- Flooding and coastal change risks to communities, businesses and infrastructure:
- Make sure that decisions on land use, including development, reflect the level of current and future flood risk
- Boost the long-term resilience of our homes, businesses and infrastructure
- Include flood risk as a key feature of adaptation reporting from infrastructure reporting organisations.
- Risks to health, well-being and productivity from high temperatures
- Work with infrastructure operators included in the third cycle of adaptation reporting to outline risks posed to their productivity from climate impacts

Local policy

14.3.15. The Joint Core Strategy for Broadland, Norwich and South Norfolk, adopted in January 2014, outlines the objectives for growth in the region with respect to the economy, housing and infrastructure until 2026.

14.3.16. The strategy contains the following climate change objectives and policies relevant to the Proposed Scheme:

- Spatial Planning Objective 1: To minimise the contributors to climate change and address its impact.
- Area-wide Policy 1: Addressing climate change and protecting environmental assets, specifically:
- To address climate change and promote sustainability, all development will be located and designed to use resources efficiently, minimise greenhouse gas emissions and be adapted to a changing climate and more extreme weather.

Highways England requirements

Highways England License

14.3.17. The Highways England License (Department for Transport, 2015) 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 should:

- (e) *“Calculate and consider the carbon impact of road projects and factor carbon into design decisions, and seek to minimise carbon emissions and other greenhouse gases from its operations [mitigation];*
- (f) *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 [adaptation];*
- (g) *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;*
- (h) *Take opportunities to influence road users to reduce the greenhouse gas emissions from their journey choices.”*

Industry Guidance

DMRB LA 114 Climate

14.3.18. The DMRB guidance for Climate, LA 114, sets out the requirements for assessing and reporting the vulnerability of a Proposed Scheme to climate change (**adaptation**) and the effect on climate of greenhouse gas emissions (**mitigation**) from construction, operation and maintenance of projects. The guidance details how to scope, assess and monitor both carbon emissions reduction and resilience assessments as well as outlining the principles and purpose of both assessments. The guidance states significant effects shall only

be identified where emissions will have a 'material impact' on the UK Government meeting its carbon reduction target.

DMRB GG 103 Introduction and general requirements for sustainable development and design

14.3.19. The DMRB guidance for sustainable development and design (GG 103) outlines the general requirements for sustainable development and design to be aligned with designing motorways and all-purpose trunk roads. The guidance details the goals of sustainable development and the principles of good road design, as well as outlining the importance of legal, environmental, economic, social and cultural factors in sustainable development and design as well as how to address the opportunities and risks.

14.4. Assessment Methodology

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

Update to guidance and scope of assessment

14.4.2. Following a review of the updates to DMRB LA 114, introduced in 2019, the scope presented in the Scoping Report for the Proposed Scheme (2018) is still valid and no change is required.

Consultation

14.4.3. No additional consultation specific to climate has been required beyond the Scoping Opinion (2018) and Preliminary Environmental Information Report (2018) for the Proposed Scheme.

Assessment criteria

Effects on Climate

14.4.4. The EIA Directive (2014/52/EU) and subsequent updates to UK EIA regulations includes a requirement to assess the impacts of projects on climate and their vulnerability to climate change.

14.4.5. The Climate Change Act (2050 Target Amendment) Order 2019 sets legally binding targets for reducing the UK's carbon emissions to net zero by 2050.

14.4.6. A key provision of the UK Climate Change Act (2050 Target Amendment) Order 2019 is a requirement for the government to set legally binding carbon budgets limiting the amount of carbon emitted in the UK over a five-year period.

- 14.4.7. There is currently no definitive EIA guidance on the determination of significance based on quantified carbon emissions. However, DMRB LA 114 guidance (paragraph 3.20) states “*The assessment of projects on climate shall only report significant effects where increases in [carbon] emissions will have a material impact on the ability of Government to meet its carbon reduction targets.*”
- 14.4.8. Assessors are required to determine whether the carbon emissions resulting from a scheme are likely to materially affect the UK in reaching the carbon budgets outlined in Table 14-1. These carbon budgets predate the Paris Agreement and at the time of writing do not consider the Climate Change Act (2050 Target Amendment) Order 2019. However it is expected that the sixth carbon budget, and all subsequent carbon budgets, will accommodate both the Paris Agreement and the UK Government’s commitment to net zero carbon emissions by 2050.

Table 14-1 : UK carbon budgets and scheme appraisal period

Budget & Period	Carbon Limit	Reduction below 1990 levels	Scheme Appraisal Period
Third (2018 to 2022)	2,544MtCO ₂ e	37% by 2020	2025 to 2085
Fourth (2023 to 2027)	1,950MtCO ₂ e	50% by 2025	
Fifth (2028 to 2032)	1,725MtCO ₂ e	57% by 2030	
Sixth to 16 th (2033 to 2087)	Not yet set	Towards net zero	

- 14.4.9. The assessment of the effects of the Proposed Scheme on climate has included:
- Estimation of the carbon emissions associated with Proposed Scheme construction using the Highways England Carbon Tool v2.3.
 - Estimation of the carbon emissions associated with Proposed Scheme operational energy, principally lighting, using the Highways England Carbon Tool v2.3.
 - Estimation of the end user (vehicle) carbon emissions associated with Proposed Scheme.
 - Comparison between estimated carbon emissions arising from the Proposed Scheme and UK carbon budgets.
 - Opportunities for mitigation in the Proposed Scheme design.

Vulnerability of the Proposed Scheme to climate change

- 14.4.10. The Proposed Scheme may be subject to weather extremes during construction. However, it is not anticipated that verifiable climate change (as opposed to extreme weather events) will occur between the time of design assessment and the end of the construction period (approximately 18 months). Construction works are therefore not considered to be vulnerable to climate change, thus no associated mitigation, other than what will be reasonable site practice (e.g. reviewing weather conditions before commencing work, providing appropriate

Personal Protective Equipment, provision of shade and water on site, etc) at the time of design finalisation, is considered to be necessary.

14.4.11. A qualitative methodology for assessing the vulnerability of Proposed Scheme assets to climate change during operation has been produced in line with DMRB LA 114. The methodology includes the following steps:

- Impacts (hazards and opportunities) for each scheme asset (e.g. Highways, Pavements, Structures) have been identified using Met Office climate projection data. The vulnerability of the Proposed Scheme to both normal weather and extreme weather-related disaster scenarios throughout the project lifecycle have been identified and reported.
- Following identification of climate change impacts (hazards and benefits), a risk assessment of those impacts on the Proposed Scheme has been undertaken using the following framework outlined in Table 14-2 (likelihood categories) and Table 14-3 (measure of consequence).

Significance of effects has been reported using

- Table 14-4 (significance matrix).

Table 14-2 : Likelihood categories

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

Notes: Proposed Scheme lifetime is considered to include construction and operational stages. The Proposed Scheme appraisal period is taken to be 60 years or above in line with the WebTAG GHG Assessment and DMRB LA 114 (Climate).

Table 14-3 : Measure of consequence

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

Table 14-4: 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	NS	NS
	Moderate	NS	NS	S	S	S
	Large	NS	NS	S	S	S
	Very large	NS	S	S	S	S

Notes: NS = Not significant, S = Significant

14.5. Assumptions and limitations

Effects on Climate

- 14.5.1. The Highways England Carbon Tool (v2.3) estimates carbon emissions associated with plant processes using direct fuel usage entered by the contractor during the construction stage. Due to uncertainty regarding construction fuel use at this stage, plant emissions have only been included for Site Clearance, Earthworks and Drainage for Stage 3. Usage of plant fuel to calculate plant carbon emissions for all items will be confirmed at Stage 5.
- 14.5.2. Maintenance, for both baseline and future carbon estimate, has been excluded from this assessment as it is not considered likely to materially affect the baseline calculations and is therefore not anticipated to alter the outcome of this assessment. However, this will be included within the carbon estimate for the Scheme at Stage 5.
- 14.5.3. Traffic data forecasts are based on multiple assumptions in accordance with DMRB LA 114 best practice and therefore the carbon emissions associated with vehicular end-users are estimates and subject to change due to changing behaviours of those using the road into the future.
- 14.5.4. Lighting operating hours have been assumed to be 4,128 hours per year with an estimated load of 22.4kW.
- 14.5.5. The UK climate policy landscape and the associated approach to gauging climate significance in EIA is evolving, with uncertainty as to how increases in emissions such as those from the Proposed Scheme may be compatible with recently introduced national net zero carbon targets. There are also currently no quantitative criteria for determining the (EIA) significance of carbon emissions. However, DMRB LA 114 in paragraph 3.20 states “*The assessment of projects on climate shall only report significant effects where increases in [carbon] emissions will have a material impact on the ability of Government to meet its*

carbon reduction targets.” This chapter therefore follows DMRB LA 114, whereby predicted increases in emissions have been compared with published carbon budgets, which at the moment can be undertaken up to and including the end of the fifth carbon budget (2032).

Vulnerability of the Proposed Scheme to climate change

- 14.5.6. Climate projections are not predictions or forecasts but simulations of potential scenarios of future climate, under a range of hypothetical emissions scenarios and assumptions. Climate modelling results cannot be treated as exact or factual, but projection options, and their reliability differs between climate variables. 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.

14.6. Study Area

Effects on Climate

- 14.6.1. The assessment of effects on climate considers the extent to which carbon emissions resulting from the Proposed Scheme may impact the global climate and contribute towards climate change.
- 14.6.2. The study area considered for the **construction** phase comprises the physical infrastructure assets associated with Proposed Scheme and therefore includes the embodied carbon of Proposed Scheme materials and emissions associated with construction activities. These are defined in terms of lifecycle stages, detailed in Section 7 of Publicly Available Specification (PAS) 2080:2016, Carbon Management in Infrastructure, as follows:
- Products and materials (A1-3) - use of materials for temporary and permanent construction activities
 - Transport to works site (A4) – the transportation of materials to the Proposed Scheme site, e.g. by HGV
 - Construction and installation processes (A5) - construction plant use
- 14.6.3. The study area to be considered for the **operational** phase includes the operational energy requirements of the Proposed Scheme (i.e. road lighting), and the Affected Road Network (ARN) for road user carbon (vehicle emissions). These elements are also defined in terms of life cycle stages, as detailed in Section 7 of PAS 2080:2016 as follows:
- Operational energy use (B6) - operational lighting emissions
 - User utilisation of infrastructure (B9) – end user traffic emissions

Vulnerability of the Proposed Scheme to climate change

- 14.6.4. For the purposes of the climate change vulnerability assessment, the study area is considered to be the physical infrastructure assets associated with the Proposed Scheme. The Proposed Scheme appraisal period is taken to be 60 years or above in line with the WebTAG GHG Assessment and DMRB LA 114.
- 14.6.5. The vulnerability assessment considers climate change effects on the Proposed Scheme assets such as pavements, drainage and geotechnical (e.g. earthworks, piles, etc) receptors. A list of key receptors considered in this assessment is included in Table 14-11.
- 14.6.6. To establish a climate baseline and future climate projections, the latest Met Office regional climate data pertinent to the Proposed Scheme area has been used (i.e. UKCP18 for the Eastern England region) (Met Office, 2016 and 2018).

14.7. Baseline conditions

Effects on Climate

- 14.7.1. The carbon baseline has been taken as the current situation in which no proposed additional infrastructure is built, considering existing travel and traffic patterns. Potential impacts from emissions associated with the construction and operation of the road infrastructure have been assessed against this baseline.

Existing scheme emissions

- 14.7.2. The baseline against which the Proposed Scheme has been compared with is the Do-Minimum scenario, the future baseline without the Proposed Scheme in place. In the Do-Minimum scenario, typical carbon emission sources include maintenance works (e.g. the embodied carbon of materials used for resurfacing), operational energy (e.g. lighting) and end-user emissions (i.e. emissions from vehicles using the road). However, maintenance has been excluded at this stage as it is unlikely to materially affect baseline conditions. This will be included within the Stage 5 carbon calculations.
- 14.7.3. Baseline end-user carbon emissions have been estimated based on outputs from an appropriate validated traffic model for the existing road and wider network, collectively referred to as the affected road network (ARN). These comprise emissions from the ARN over three key years: base year (2015), opening year (2025) and design year (2040).
- 14.7.4. Design year emissions have been extrapolated to provide a baseline estimate for the 60-year appraisal period. These emissions are summarised in Table 14-5, in which the effect of a predicted increase in electric vehicles can be seen to result in a reduction in vehicular emissions in this baseline scenario.

Table 14-5 : Affected road network baseline emissions (Do-Minimum Scenario)

Year	End-user emissions (tCO ₂ e)
Baseline (2015)	1,072,458
Opening Year (2025)	1,065,487
Design Year (2040)	978,328
Whole Appraisal Period (60 years - cumulative)	59,396,960

Vulnerability of the Proposed Scheme to climate change

14.7.5. As per DMRB LA 114, a current climate baseline for the wider region has been compiled using Met Office (2016) historical regional climate data. High-level climate observations over a 30-year averaging period (1981 to 2010) are presented in Table 14-6 for Eastern England, which comprises the counties of Bedfordshire, Cambridgeshire, Norfolk, Suffolk, Lincolnshire, the East Riding of Yorkshire and parts of Essex and Hertfordshire. This information has been used by the Design Team as a baseline against which to determine the potential vulnerability of the proposed scheme when subjected to the climate change projected by the Met office (see below).

Table 14-6 : Climate baseline for Eastern England (1981 to 2010)

Climate variables	Climate observations
Temperature	Mean daily minimum temperatures can range from 0°C to 2°C in winter, whilst summer daily maximum temperatures are in the region of 22°C.
Rainfall	Eastern England includes some of the driest areas in the country, with the majority of the region receiving less than 700mm of rainfall annually, distributed fairly evenly throughout the year. On average, the region experiences approximately 30 rain days during the winter months (December to February) and under 25 days during the summer period (June to August). Despite generally low levels of precipitation, the area has encountered a number of severe storms which can contribute significantly to total annual rainfall and may also result in the occurrence of hail.
Wind	Eastern England is one of the more sheltered parts of the UK, however the winter months are when the strongest winds are experienced. Wind direction is fairly consistent across the region; speeds are generally greater in coastal locations than inland, and gusts exceeding 167 km/h have been recorded in East Anglia. The frequency of tornadoes is greatest in Eastern England relative to other parts of the UK, nevertheless, the intensity of these events remains minor.
Sunshine	Average annual sunshine in the wider region ranges from approximately 1,450 hours over Lincolnshire and East Yorkshire, to over 1,600hrs in east Norfolk, Suffolk and Essex.
Air Frost	The average number of days with air frost ranges from less than 30 (coastal) to 55 (inland) per year.

Source: Met Office (2016) Regional Climate Data

Climate Projections

14.7.6. The UK Climate Projections (UKCP18) provide regional climate projection information, within the East of England Administrative Region (within which the Proposed Scheme is located). The East of England region is predicted to experience changes in temperature, rainfall, and increase in frequency of extreme weather events as a consequence of climate change. These changes

are predicted to occur under all emissions scenarios (i.e. low, medium and high levels of carbon emissions), which are incorporated into the climate change models used by the Inter-governmental Panel on Climate Change (IPCC). The general trend for the region is warmer, drier summers and milder, wetter winters.

- 14.7.7. Under the most conservative, highest impact emissions scenario (RCP8.5) for the 2080s (2070 to 2099), estimated changes in climatic conditions are as outlined in Table 14-7.

Table 14-7 : Future climate projection data for East of England (2080s; RCP8.5)

Climate variables	Climate projections
Temperature	The average summer temperature is projected to increase by 6-7°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 projected to decrease by 30-40%, whereas the average winter rainfall rate is estimated to increase by 20-30% (in the 50th percentile or central estimate for both).
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: UKCP18 UK Climate Projections

- 14.7.8. Climate projection data corresponding to the 2080s (2070 to 2099) under a high emissions scenario have been selected in line with NNNPS (2014) paragraph 4.41, which states:

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

- 14.7.9. Since 2014, when the NNNPS was written, the UKCP09 projections referred to in the above statement have been updated to UKCP18 projections (published November 2018). The most recent projections (UKCP18) have been used in this assessment (as outlined in Table 14-7).

14.8. Potential impacts

Effects on climate

- 14.8.1. The following sub-section presents the results of the carbon emissions assessment associated with Proposed Scheme. It also addresses impacts on climate, including how the Proposed Scheme may affect the ability of the UK

Government to meet its carbon reduction budgets (in accordance with NNNPS (2014) paragraph 5.18).

Construction

- 14.8.2. The proposed construction duration for the Proposed Scheme is anticipated to be approximately 18 months. Embodied carbon emissions from construction materials are the main contributor to climate change during this period, with additional emissions arising from the direct use of plant and transport of materials.
- 14.8.3. A carbon assessment using the Highways England Carbon Tool (v2.3) has estimated emissions of approximately **25,765 tCO₂e** in association with Proposed Scheme construction. Further information on the derivation of this value is contained within Appendix 14.1 (Embodied Carbon Assessment)(TR04004/APP/6.2).

Operation

- 14.8.4. The Highways England Carbon Tool (v2.3 published in 2019) predicts emissions associated with operational energy for the Proposed Scheme to be approximately 22 tCO₂e per annum, based on the annual kWh electricity demand of lighting columns, i.e. **1,320 tCO₂e** over the 60-year appraisal period.
- 14.8.5. For end user traffic emissions, a comparison of Do-Minimum (without the Proposed Scheme) and Do-Something (with the Proposed Scheme in place) scenarios has been undertaken based on the Proposed Scheme opening year (2025) and Design year (2040). Table 14-8 shows estimated changes in vehicle emissions associated with Proposed Scheme in relation to the relevant UK carbon budget period as required in DMRB LA 114.

Table 14-8 : Change in tCO₂e associated with Proposed Scheme end user traffic emissions by carbon budget period

	Third (2018 to 2022)	Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth to 16th (2033 to 2087)
Carbon budget (tCO₂e)	2,544,000,000	1,950,000,000	1,725,000,000	Not yet set
Change in traded emissions (tCO₂e)	0	+ 227	+ 319	+1,853
Change in non-traded emissions (tCO₂e)	0	+ 9,194	+ 13,816	+106,608

Notes: Traded emissions are those associated with electric vehicles whilst non-traded emissions are those associated with both petrol and diesel vehicles.

- 14.8.6. The total increase in vehicle carbon emissions associated with the Proposed Scheme (comparison of Do Minimum and Do Something scenarios) over the 60-

year appraisal period (2025 to 2085) is estimated to be **132,017 tCO₂e**, the total of the change in emissions in Table 14-8.

Summary

14.8.7. Construction and operational emissions predicted to result from the Proposed Scheme are presented in Table 14-9 against each relevant carbon budget period by comparing the Affected Road Network (ARN) baseline (Do Minimum) emissions with those predicted to result from the Proposed Scheme (Do Something). As construction is not planned to start until 2023, the third carbon budget (accounting for 2018-2022) is not relevant in this assessment.

Table 14-9 : Potential Impact of Proposed Scheme on carbon emissions (including ARN) compared against relevant UK Government carbon budgets

Project Stage	Carbon emissions distributed per relevant carbon budget (tCO ₂ e)			Estimated total emissions over 60-year appraisal period (tCO ₂ e)
	Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth to 16 th (2033 to 2087)	
Baseline (DM)	3,179,030	5,182,172	51,035,759	59,396,960
Construction (DS)	25,765	-	-	25,765
Operation (DS)	3,188,517	5,196,417	51,145,362	59,530,297
Total (DS)	3,214,283	5,196,417	51,145,362	59,556,062
Difference (DS-DM)	+35,253	+14,245	+109,603	+159,102

Note: The construction carbon value is representative of the Highways England Carbon Tool assessment. The operational carbon value is representative of estimated operational energy plus estimated user utilisation emissions for the ARN over the 60-year appraisal period. DM = Do Minimum, DS = Do Something

14.8.8. Table 14-10 expands upon the previous table by including the net change in emissions as a percentage of UK carbon budgets. Existing carbon budgets (one to five) predate the net zero carbon target (by 2050) legislated in 2019. The sixth carbon budget, due to be published by April 2021, is expected to require accelerated carbon reduction towards net zero carbon.

Table 14-10 : Summary of the net change in emissions against relevant carbon budgets

Project Stage	Net change in Carbon over 60-year appraisal period (tCO ₂ e) (DS vs DM)	Net change in carbon per UK carbon budget period (tCO ₂ e) (DS vs DM)			Change as % of total UK carbon budget		
		Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth - 16 th (2033 to 2087)	Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth - 16 th (2033 to 2087)
Construction	+25,765	+25,765	-	-	<0.001%	-	-
Operation	+133,337	+9,487	+14,245	+109,604	<0.001%	<0.001%	Unknown
Total	+159,102	+35,252	+14,245	+109,604	0.001%	<0.001%	Unknown

Notes: The construction carbon value is representative of the Highways England Carbon Tool assessment. The operational carbon value is representative of estimated operational energy plus estimated user utilisation emissions over the 60-year appraisal period. It is not possible to assess the change as a % of the carbon budgets beyond 2033 as they have not been set.

- 14.8.9. The increase in carbon emissions resulting from the Proposed Scheme represents up to approximately 0.001% of relevant carbon budgets, noting the following:
1. Comparison between the increase in Proposed Scheme emissions and published carbon budgets, following DMRB LA 114 guidance on gauging significance, can only be undertaken for approximately 31% of the emissions increase. The remaining 69% of the increase in carbon emissions over the 60 year appraisal period will occur after 2032 (the end of the last currently published UK carbon budget).
 2. The predicted 49,497 tCO_{2e} (31%) increase in emissions resulting from the Proposed Scheme that may be compared with currently published budgets (to 2032) may affect the government's ability to achieve its carbon reduction targets over this period, as these budgets do not include allowances for increases in road transport emissions.
 3. The predicted emissions for the remaining 60-year assessment period of the Proposed Scheme (109,102 tCO_{2e}) are the majority of emissions which cannot be assessed in accordance with DMRB LA 114 as no carbon budgets yet exist for this period.

Vulnerability of the Proposed Scheme to climate change

- 14.8.10. The Proposed Scheme's vulnerability to climate change during construction and operation has been assessed through consideration of projected climate changes.
- 14.8.11. The vulnerability of Proposed Scheme assets (e.g. Highways, Pavement, Structures) to projected climate changes (Table 14-7) was assessed through consultation with the Design Team. Table 14-11 lists the key climate change effects that could occur to various scheme assets, with corresponding likelihoods, significance and whether specific mitigation is required. This list was provided to design teams for them to use their respective knowledge and expertise in assessing the vulnerability of the scheme. Design teams were also requested to consider any other potential effects beyond those listed in Table 14-11, although no further such effects were identified.
- 14.8.12. Particular attention was paid to the potential vulnerability of Proposed Scheme drainage systems, however it was concluded that there were no increased risks caused by the climate projections. The current drainage design includes a 20%

climate change allowance to allow for changes in peak rainfall intensity. The sensitivity of the design has been checked with a 40% increase in peak rainfall intensity due to climate change, in line with the Environment Agency's upper estimates for the 2080s.

Table 14-11 : Vulnerability of Proposed Scheme assets to climate change – Summary of Effects and Mitigation

Asset	Life cycle asset aspect	Potential effect description	Likelihood Category	Consequence of Impact	Significance	Mitigation Measures
Pavements	Foundation	Increases in winter precipitation result in increased sub-surface moisture content, decreasing foundation strength.	Very low	Large adverse	Not Significant	N/A
		Changes in moisture content as a result of decreases in summer rainfall combined with increases in winter rainfall cause soil to expand and shrink, causing pavement layers to heave.	Very low	Moderate adverse	Not Significant	N/A
		Increased rainfall saturates the road sub-base or other structural granular materials, causing loss of fine material and settlement and subsequent premature pavement failure.	Very low	Moderate adverse	Not Significant	N/A
	Surface	Increased summer temperatures result in surface failure, e.g. warping of slabs, excessive movement at joints and difficulty in maintaining asphalt surface profile during compaction.	Low	Minor adverse	Not Significant	N/A
		Increases in winter precipitation result in a build-up of particulates in the road surface, which compromises the surface's skid resistance as skid resistance decreases in flooded areas.	Medium	Minor adverse	Not Significant	N/A
Structures (e.g. gantries, retaining walls)	Above Ground Structures	Increased temperatures result in joint and bearing failure.	Very low	Large adverse	Not Significant	N/A
		Increases in precipitation results in increased deterioration rates for joints and surfacing, requiring more frequent replacement and traffic disruption.	Low	Moderate adverse	Not Significant	N/A
		Increased winter precipitation results in increased groundwater levels, causing ground movements and soil settlement.	Very low	Moderate adverse	Not Significant	N/A
		Increased precipitation results in flooding and scouring around foundations.	Very low	Moderate adverse	Not Significant	N/A
		Increases in temperature and more variable precipitation result in increased frequency of maintenance painting of structural steelwork.	Low	Minor adverse	Not Significant	N/A

Asset	Life cycle asset aspect	Potential effect description	Likelihood Category	Consequence of Impact	Significance	Mitigation Measures
		Increases in wind speed and frequency of extreme wind events results in the failure of lighter structures by overturning.	Very low	Large adverse	Not Significant	N/A
	Foundations and substructure	Increased winter precipitation results in increased groundwater levels causing ground movements and soil settlement.	Very low	Moderate adverse	Not Significant	N/A
		Increased precipitation results in flooding and scouring around foundations.	Very low	Moderate adverse	Not Significant	N/A
Drainage	Drainage System	Increases in winter precipitation result in increased flood risk and the need for attenuation.	Medium	Minor Disruption	Not Significant	N/A
Geotechnics	Earthworks	Increased precipitation results in increased risk to the earthworks stability.	Low	Moderate adverse	Not Significant	N/A
		Reductions in summer precipitation and increases in temperature would reduce soil moisture, which demands a greater effort for compaction of soils.	Very Low	Moderate adverse	Not Significant	N/A
Signs and Signals	Advance Direction Sign (ADS)	Increased wind speeds and frequency of extreme wind events affect the stability of ADSs, which have a design life of 15 years (Highways England, 2011).	Very Low	Moderate adverse	Not Significant	N/A
	Road Markings	Increases in precipitation and temperature affect road markings.	Low	Minor adverse	Not Significant	N/A
Walking, cycling and horse-riding (WCH) Facilities	Underpasses	Increased precipitation results in flooding of underpasses, deterring WCHs from their journey.	Medium	Minor adverse	Not Significant	N/A
	WCH Routes	Increases in temperature and reductions in summer rainfall encourage a greater number of WCHs to use WCH facilities.	Medium	Beneficial – N/A	N/A	N/A
		Increases in winter rainfall and frequency of extreme wind events discourage WCHs from undertaking journeys using WCH facilities.	Low	Minor adverse	Not Significant	N/A
Vehicle Restraint Systems	Safety Barriers	More frequent extreme weather events and changes in temperature and precipitation result in an increased rate of deterioration of vehicle restraint systems.	Low	Moderate adverse	Not Significant	N/A

14.9. Design interventions and mitigation

Effects on climate

- 14.9.1. In accordance with the DMRB LA 114, projects shall seek to minimise carbon emissions as far as possible in all cases in order to contribute to the UK's net reduction in carbon emissions.
- 14.9.2. Carbon emissions have been calculated using the Highways England Carbon Tool (v2.3) as part of the development of the Proposed Scheme. This has allowed for the consideration of carbon in the design process, resulting in the development of a carbon baseline from which further reductions may be made.
- 14.9.3. A hierarchical approach to carbon management has been applied to the Proposed Scheme, i.e. build nothing, build less, build clever, build efficiently. Throughout the design of the project, opportunities for carbon reduction in accordance with PAS 2080 (reducing carbon in a manner that also reduces cost) have been considered.
- 14.9.4. This process identified efficiencies associated with the use of a two-span bridge design for both the Blofield and B1140 overbridges. In the case of the Blofield overbridge, selecting this option relative to a single span design reduced the bridge depth from 1.55m to 1.2m, resulting in material savings associated with reduced embankments, contributing to reduced carbon emissions as reflected in the embodied carbon results contained within this chapter.
- 14.9.5. Further opportunities for reducing carbon during the construction phase are being considered on an ongoing basis. Although beyond the direct control of the design and construction of the Proposed Scheme, it is expected that the recent UK government announcement on ending the sale of new petrol and diesel vehicles by 2030 will further reduce the proposed scheme's end user carbon emissions.
- 14.9.6. Monitoring and reporting on carbon emissions associated with energy and fuel use during the construction process is required and is included in the Environmental Management Plan (TR04004/APP/7.7).

Vulnerability of the Proposed Scheme to climate change

- 14.9.7. During the design stage, the Design Team were briefed on projected climate changes (Table 14-7) to ensure that the Proposed Scheme would be accordingly resilient.
- 14.9.8. The potential vulnerability of Proposed Scheme assets to climate change has been assessed through iterative consultation between the Design Team and the Climate Change Coordinator. Specific assets assessed are shown in Table

14-11, with design considerations detailed within individual topic chapters (e.g. Road Drainage and the Water Environment), although it is noted that no aspect of the Proposed Scheme is considered to be vulnerable to projected climate change over the appraisal period.

14.10. Assessment of likely significant effects

- 14.10.1. 31% of the increase in carbon emissions resulting from the Proposed Scheme can be quantitatively compared with published UK carbon budgets (to 2032) as is required by DMRB LA 114 guidance on determining significance. The remaining 69% of the increase in emissions has no carbon budget for comparison. Future carbon budgets are expected to include less emissions across all sectors, working towards the goal of net zero carbon emissions by 2050. A definitive assessment of materiality (and hence significance) against UK carbon budgets for the complete appraisal period is therefore currently not possible.
- 14.10.2. In accordance with DMRB LA 114, this has not precluded efforts to minimise carbon throughout the design and construction of the scheme, with regular recalculation of carbon emissions and ongoing review of further opportunities to minimise them. The recent UK government announcement on ending the sales of new petrol and diesel vehicles by 2030 will further reduce the proposed scheme's end user carbon emissions.
- 14.10.3. In the context of the vulnerability of the Proposed Scheme to climate change, projected climate change is not anticipated to have a significant effect.

14.11. Monitoring Effects on climate

- 14.11.1. The Proposed Scheme will result in an increase in carbon emissions. Monitoring of emissions associated with the construction of the Proposed Scheme will be undertaken as per Highways England requirements to meet their key performance indicator "Carbon dioxide equivalents (or CO₂e) in tonnes associated with the Supply Chain's activities" (Highways England 2019).

Vulnerability of the Proposed Scheme to climate change

- 14.11.2. No significant adverse effects as a result of climate have been identified therefore no monitoring is required. However, it is noted that climate change projections are likely to change within the appraisal period of the Proposed Scheme, therefore the vulnerability of the Proposed Scheme to such changes should be reviewed as and when updated projections become available.

14.12. Summary

- 14.12.1. This assessment has considered the Proposed Scheme's effect on climate (i.e. increases in carbon emissions) as well as the potential vulnerability of the Proposed Scheme to climate change (i.e. the resilience of Proposed Scheme assets to projected changes in climate).
- 14.12.2. A definitive assessment of materiality (and hence significance) against UK carbon budgets for the full appraisal period is not currently possible due to the absence of UK carbon budgets for most of the Proposed Scheme's 60 year appraisal period. However, in accordance with DMRB LA 114, this has not precluded efforts to minimise carbon throughout the design and construction of the scheme, with regular recalculation of carbon emissions and review of further opportunities to minimise them in accordance with DMRB requirements.
- 14.12.3. The vulnerability of Proposed Scheme assets to projected changes in climate during operation has been assessed, and the Proposed Scheme has been deemed resilient to the current projections. Therefore, no significant effects as a result of climate change are anticipated however this should be reviewed at an appropriate stage once updated projections are published.

14.13. References

- BSI (2016) PAS 2080:2016 Carbon Management and Infrastructure
- Broadland District Council (2014) Joint Core Strategy Adopted document [online] available at: https://www.broadland.gov.uk/downloads/file/1310/joint_core_strategy_adopted_document_2014 (last accessed May 2020)
- Climate Change Act 2008, [online] available at: <https://www.legislation.gov.uk/ukpga/2008/27/contents> (last accessed May 2020)
- Committee on Climate Change (2017) UK Climate Change Risk Assessment Synthesis Report
- Design Manual for Roads and Bridges (2019) Volume 11, Section 3, LA 114 Climate [online] available at: <https://www.standardsforhighways.co.uk/prod/attachments/87f12e4f-70f8-4eed-8aed-9e9a42e24183> (last accessed May 2020)
- Department for Business, Energy & Industrial Strategy (2019a) Greenhouse Gas Conversion Factors [online] available at: <https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting#conversion-factors-2018> (last accessed June 2018)
- Department for Business, Energy & Industrial Strategy (2019b) UK Local Authority and Regional Carbon Dioxide Emissions National Statistics: 2005-2017 Data Tables [online] available at:

<https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017> (last accessed May 2020)

- Department for Transport (2014) National Policy Statement for National Networks available at:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf (last accessed May 2020)
- Department for Transport (2019) TAG Unit A3 Environmental Impact Appraisal [online] available at:
<https://www.gov.uk/government/publications/tag-unit-a3-environmental-impact-appraisal> (last accessed May 2020)
- EIA Directive (2014/52/EU) [online] available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0052> (last accessed May 2020)
- Department for Transport (2015) Highways England: Licence [online] available at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/431389/strategic-highways-licence.pdf (last accessed May 2020)
- Highways England (2019) Highways England Operational Metrics Manual January 2019 [online] available at:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/775149/Operational_Metrics_Manual.pdf (last accessed May 2020)
- HM Government (2013a) 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 May 2020)
- HM Government (2013b) Infrastructure Carbon Review
- 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 May 2020)
- HM Government (2018) The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting [online] available at:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727252/national-adaptation-programme-2018.pdf (last accessed November 2020)
- IEMA (2017) Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance [online] available at: <https://www.iema.net/policy/ghg-in-eia-2017> (last accessed May 2020)

- Ministry of Housing, Communities and Local Government (2019) National Planning Policy Framework (NPPF) [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf (last accessed May 2020)
- Met Office (2016) Eastern England: Climate [online] available at: <https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/eastern-england-climate---met-office.pdf> (last accessed May 2020)
- Met Office (2018) UKCP18 Climate Projections: East of England Maps & Key Findings [online] available at: <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/land-projection-maps> (last accessed May 2020)
- Norwich City Council (2019) Carbon Footprint Report 2018-19 [online] available at: https://www.norwich.gov.uk/downloads/file/6665/carbon_footprint_report_2018-19 (last accessed May 2020)
- Norfolk County Council (2016) Greenhouse Gas Report 2015/16 [online] available at: <https://www.norfolk.gov.uk/-/media/norfolk/downloads/what-we-do-and-how-we-work/policy-performance-and-partnerships/performance/corporate/greenhouse-gas-report-2015-16.pdf> (last accessed May 2020)