Great Yarmouth Third River Crossing

Application for Development Consent Order

Document 6.2: Environmental Statement Volume II: Technical Appendix 13A: Legislation, Policy and Guidance

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended) ("APFP")

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Tables

1 Legislation, Policy and Guidance

1.1.1 Table 1.1 to 1.3 summarises the applicable legislation, policy and guidance to Chapter 13: Climate Change.

Table 1.1: Summary of Legislation

Legislation	Summary	Chapter Reference
United Nations Framework Convention on Climate Change (UNFCCC)	The UK is a member of the UNFCCC which drives international action on climate change. The UK has pledged to reduce GHG emissions under the Paris Agreement, as a part of a joint pledge by members of the EU. This provides an overarching commitment by the UK.	Not directly applicable to this chapter. Legislation included to provide an overview of UK commitment to climate change.
Directive 2014/52/EU on the assessment of the effects of certain public and private projects on the environment (the EIA Directive)	The Directive requires EIA to identify, describe and assess the direct and indirect significant effects of a project on climate (Article 3). It also stipulates that the information to be included within the ES should include *"the impact of the project on climate (for example the nature and magnitude of greenhouse gas emissions) and the vulnerability of the project to climate change"*.	Chapter 13 (document reference 6.1) and the associated appendices 13 A, 13B and 13C (document reference 6.2) fulfils the climate assessment requirements of the EIA Directive. The nature and magnitude of greenhouse gas emission are presented in Section 13.5 of Chapter 13 (document reference 6.1). The vulnerability of the project is assessed, as presented in Section 13.6 of Chapter 13 (document reference 6.1) and accompanying appendices (Appendix 13B and Appendix 13C

Legislation	Summary	Chapter Reference
		(document reference 6.2)).
UK Climate Change Act 2008	The Climate Change Act established a legal requirement for an 80% reduction in the GHG emissions of the UK economy by 2050 in comparison to the 1990 baseline. The Climate Change Act also created the Committee on Climate Change, with responsibility for setting 5-year Carbon Budgets covering successive periods of emissions reduction to 2050. The Act includes a requirement for Government to report, at least every five years, on the risks to the UK of climate change, and to publish a programme setting out how these will be addressed. The Act also introduced powers for Government to require public bodies and statutory undertakers to carry out their own risk assessment and make plans to address those risks.	This chapter uses the carbon budgets to compare the schemes estimated GHG emissions in line with IEMA guidance and professional judgement. See Table 13.12 of Chapter 13 (document reference 6.1). Whilst not directly applicable to the climate resilience assessment, the identification of mitigation measures undertaken as part of EIA for infrastructure projects such as this Scheme will contribute to the UK's overall level of preparedness for climate change which is one of the key objectives of the Act.

Table 1.2: Summary of Policy

Policy	Summary	Chapter Reference
National Policy Statement for National Networks (2014)	The NPS NN sets out Government policy on national networks and identifies that the transport sector will play an important part in meeting the Government's carbon targets through technological innovation (paragraph 3.14) and sustainable modes of transport (paragraph 3.15 and 3.16). In relation to climate change adaptation, the policy states that *"New national networks infrastructure… will need to remain operational over many decades. Consequently, applicants must consider the impacts of climate change"* (paragraph 4.40), through the application of *"…the UK climate projections"* using the *"…high emissions scenarios…against the 2080 projections at the 50% probability level"* (paragraph 4.41). The policy states that it should be demonstrated *"…that there are no critical features of the design of new national networks infrastructure which may be seriously*	The chapter has considered the impacts of carbon (GHG emissions) from the Scheme (see Section 13.5 of Chapter 13 (document reference 6.1)). Section 13.6 (and the accompanying appendices (Appendix 13B and 13C (document reference 6.2)) reviews the impacts of climate change and assesses climate resilience of the Scheme. The climate resilience assessment uses the UK Climate Projections 2018 (UKCP18) (Appendix 13B (document reference 6.2)) as part of the vulnerability assessment. UKCP18 data is the most up-to-date projections and represents the best current understanding of how climate in the UK will change over the 21st century. The vulnerability assessment uses the high emissions scenarios (termed RCP8.5 in UKCP18) for the 2080s using the 50% percentile projections. The vulnerability assessment includes extreme climate change

Policy	Summary	Chapter Reference
	affected by more radical changes to the climate, beyond that projected in…UK climate projections. Any potential critical features should be assessed taking account of the latest credible scientific evidence…and on the basis, that necessary action can be taken to ensure the operation of the infrastructure over its estimated lifetime through potential further mitigation or adaptation" (paragraph 4.43). Chapter 5: Generic Impacts (Carbon emissions paragraph 5.16 to 5.19) sets out Government policy on climate change and outlines the importance of reducing carbon emissions, stating that the Government has a legally binding commitment to reduce greenhouse gas emissions by *"at least 80% by 2050"* and to conform to Carbon Budgets outlined in the *"Carbon Plan 2011"*. The policy states that *"Carbon impacts will be considered as part of the appraisal of scheme options (in the business case), prior to the submission of an*	scenarios (Appendix 13B (document reference 6.2)). The findings of the climate resilience assessment (Table 13.24 in Chapter 13 (document reference 6.1)) provides a resilience rating of the Scheme components to climate change and also present a significance assessment. The GHG emissions chapter, (section 13.5 in Chapter 13 (document reference 6.1)) considers the carbon impacts of the Scheme. Table 13.8, Table 13.9 and Table 13.12 in Chapter 13 (document reference 6.1) compares the calculated GHG emissions from the Scheme with the UK Government Carbon Budgets.

Policy	Summary	Chapter Reference
	application for DCO" (paragraph 5.17) and that *"any Environmental Statement will need to describe an assessment of any likely significant climate factors in accordance with the requirements in the EIA Directive"* (paragraph 5.17). However, it goes on to say 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. However, road projects applicants should provide evidence of the carbon impact of the project and an assessment against the Government's Carbon Budgets"* (paragraph 5.17). The policy also states that *"an increase in carbon emissions is not a reason to refuse development consent, unless the increase in carbon emissions resulting from the proposed Project are so significant that it would have a material impact on the ability of Government to meet its carbon reduction targets"*. The Policy states that the Government's Carbon	

Policy	Summary	Chapter Reference
	Plan 2011 *"…includes a range of non-planning policies which will…ensure that any carbon increases from road development do not compromise its overall carbon reduction commitments". "Therefore, any increase in carbon emissions is not a reason to refuse development consent, unless the increase…is so significant it would have a material impact on the ability of the Government to meet its carbon reduction targets"* (paragraph 5.18). Evidence of mitigation measures should be presented for the Secretary of State to consider the effectiveness of such mitigation to ensure that the carbon footprint is not unnecessarily high. In relation to climate resilience, Chapter 5 sets out key considerations for infrastructure projects that are proposed on or near the coast. Developments in these areas are required to *"undertake an assessment of the vulnerability of the proposed development to coastal change, taking account of climate*	Embedded mitigation measures are presented in Chapter 13 (document reference 6.1), paragraphs 13.5.25 and Table 13.23. The vulnerability assessment (presented in Appendix 13B (document reference 6.2)) includes variables associated with coastal locations (sea level change, storm surge) and other climate change variables consistent with the Scheme and its operational life. Variables assessed as medium or high vulnerability are taken forward for further risk assessment (Appendix 13B (document reference 6.2)). The final steps of the climate resilience assessment takes account of embedded mitigation measures (Table 13.23) to determine the resilience rating of the Scheme components. Climate change in relation to flood risk is considered further in the Chapter 12: Flood Risk (document reference 6.1).

	change, during the project's operational life" (paragraph 5.71). With regards to the decision-making process, the policy states that *"the applicant must demonstrate that a full account has been taken of the policy on assessment and mitigation…taking account of the potential effects of climate change on these risks"* (paragraph 5.78). Chapter 5 also acknowledges the fact that climate change will likely lead to an *"increased flood risk in areas susceptible to flooding, and to an increased risk of flooding in some areas which are not currently thought of as being at risk"*. It also states that an applicant's assessment should *"identify and assess the risks of all forms of flooding to and from the Scheme and demonstrate how these flood risks will be managed, taking climate change into account"* (paragraph 5.93) by taking *"the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made"* (paragraph 5.94)	

Policy	Summary	Chapter Reference
	when preparing the Flood Risk Assessment.	
National Policy Statement for Ports (2012)	The NPS for Ports, in relation to greenhouse gases, states that *"new port infrastructure should…minimise the emissions of greenhouse gases from port related development"* (paragraph 3.3.3). It is recognised that *"Port developments may have an effect on greenhouse gases, particularly through their impact on sea and road transport"* and that impact may be positive if there is a shift from road to shipping or rail transport (paragraph 4.12.1). The policy states that *"Given the international nature of shopping and the difficulties in estimating and attributing GHGs…measures to address emissions from ships on international journeys are…not included in the national targets recommended by the Committee on Climate Change"* (paragraph 4.12.2). Paragraph 4.12.5 discusses inland transport and states that *"where the development will lead to significant increases in inland transport needs, the estimated impact on*	The chapter has considered the impacts of carbon (GHG emissions) from the Scheme in relation to inland transport needs (see Section 13.5 of Chapter 13 (document reference 6.1)). Section 13.6 of Chapter 13 (document reference 6.1) (and the accompanying appendices (Appendix 13B and 13C (document reference 6.2)) assesses climate resilience of the Scheme. The GHG assessment (Section 13.5 in Chapter 13 (document reference 6.1)) includes an assessment from end - user traffic emissions (regional traffic flows). The vulnerability assessment (presented in Appendix 13B (document reference 6.2)) includes variables associated with coastal locations (sea level change, storm surge) and other climate change variables consistent with the Scheme and its operational life. The vulnerability assessment

Policy	Summary	Chapter Reference
	CO_2, and other greenhouse gases if significant, will need to be covered in the Environmental Statement". In reference to climate adaptation, the policy states that *"… applicants must consider the impacts of climate change when planning the location, design, build and operation of new port infrastructure"* (paragraph 4.13.6). The policy also states that "… *the decision-maker should satisfy itself that there are not critical features of the design…which may be seriously affected by more radical changes to the climate beyond that projected in the…UK Climate Projections"* (paragraph 4.13.11).	includes extreme climate change scenarios (Appendix 13B (document reference 6.2)). The findings of the climate resilience assessment (Table 13.24 in Chapter 13 (document reference 6.1)) provides a resilience rating of the Scheme components to climate change and also present a significance assessment.
National Planning Policy Framework (2019)	Paragraph 8 of the NPPF includes in the definition of the environmental objective *"mitigating and adapting to climate change, including moving to a low carbon economy"*. Chapter 9: Promoting Sustainable Transport, encourages the pursuit of *"…opportunities to promote walking, cycling and public transport…and offer a choice of genuine*	Not directly applicable to the Chapter. Appendix 13A (document reference 6.2) provides a summary of applicable legislation in order to provide an overview of the UK commitment to climate change and requirements to consider climate change impacts on development and infrastructure.

Policy	Summary	Chapter Reference
	transportation modes" (paragraphs 102 and 103). Chapter 14: Meeting the Challenge of Climate Change, Flooding and Coastal Change, establishes that Local Planning Authorities *"should take a proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk, coastal change, water supply, biodiversity and landscapes, and the risk of overheating from rising temperatures. Policies should support appropriate measures to ensure the future resilience of communities and infrastructure to climate change impacts, such as providing space for physical protection measures, or making provision for the possible future relocation of vulnerable development and infrastructure"* (paragraph 149).	Climate change in relation to flood risk is considered further in the Chapter 12: Flood Risk (document reference 6.1).
Infrastructure Carbon Review (2013)	In 2013, the UK government published the Infrastructure Carbon Review, aiming to *"… release the value of lower carbon solutions and to make carbon reduction part of the DNA of*	The chapter fulfils the need to assess GHG emissions early in the lifecycle of an infrastructure project. See Section 13.5 of Chapter 13 (document reference 6.1).

Policy	Summary	Chapter Reference
	infrastructure in the UK". Major infrastructure owners, operators and developers were invited to endorse, become signatories and make commitments under the review. The review provided increased emphasis on 'capital carbon' (GHG emissions associated with raw materials, activities and transport for construction, repairs, replacement, refurbishment and de-construction of infrastructure) while acknowledging that 'operational carbon' (associated with energy consumption for the operation and use of infrastructure) will continue to dominate overall emission to 2050 and beyond. The Infrastructure Carbon Review highlighted the need to assess GHG emissions early in the lifecycle of an infrastructure project when there is the greatest carbon reduction potential. It also led to the publication of a Publicly Available Specification on infrastructure carbon	

Policy	Summary	Chapter Reference
	management; PAS2080:2016.	
Great Yarmouth Borough Council Local Plan: Core Strategy 2013-2030	The Core Strategy contains a number of core policies which make reference to climate change: Policy CS1: Focusing on a Sustainable Future recognises that climate change is one of the greatest future challenges, but planning can support the transition of a low carbon economy and provide resilience to climate change impacts. It also states that policies in the Core Strategy will focus on ways to minimise greenhouse gas emissions, the risk of flooding and encourage the use of renewable energy. Policy CS12: Utilising Natural Resources identifies an aim, where feasible, to reduce carbon dioxide emissions (over the requirements set by Building Regulations) by 10% through enhanced energy efficiency measures or the installation of renewable or low carbon sources in all major development. Policy CS14: Securing essential new	The assessment within the climate chapter (chapter 13 (document reference 6.1)), demonstrates the resilience of the Scheme to climate change impacts through embedded mitigation (Table 13.23) and minimising GHG emissions through embedded mitigation measures (from paragraph 13.5.25).

Policy	Summary	Chapter Reference
	infrastructure makes reference to having positive impacts on climate changes as the effect of the policy is to reduce reliance upon car use and therefore GHG emissions, by creating improvements to public transport, highways, footpaths and cycleways. The policy does note that positive impacts are reliant upon individual travel choices which are difficult to change.	
Tomorrow's Norfolk, Today's Challenge – Summary of the County Climate Change Strategy (2008)	'Tomorrow's Norfolk, Today's Challenge' is the climate change strategy for Norfolk, produced and endorsed by the county's eight local authorities. It is a key element of Norfolk's Sustainable Communities Strategy. It recognises the need for climate change adaptation and states that an adaptation plan will be developed following a comprehensive risk assessment.	The Transport Analysis Guidance has been utilised to quantify traffic data for the operational phase end-user GHG emissions specifically. This quantitative assessment forms the basis of the EIA assessment of this emissions source by providing emissions magnitude. This then enables the significance of emissions to be determined.

Table 0.3: Summary of Guidance

Guidance	Summary	Chapter Reference
PAS 2080:2016 Carbon Management in Infrastructure	PAS 2080:2016 provides a common framework for all infrastructure sectors and value chain members on how to manage whole life carbon when delivering infrastructure assets and programmes of work.	The GHG assessment (Section 13.5 of Chapter 13 (document reference 6.1) has been produced in line with the guidance document. The document provides a standard for assessing whole life carbon emission from infrastructure projects and has been used throughout the GHG assessment. Specifically, the standard has been used to identify the construction and operational lifecycle emission sources (Tables 13.4 and 13.5 in Chapter 13).
IEMA (2015), Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation	The guidance document provides a framework for the effective consideration of climate changes resilience and adaptation in EIA, in line with the 2014 amendment to the EU EIA Directive (2014/52/EU). The guidance document covers legislation and policy setting, identifying future climate, building climate resilience into the project, and integration climate change adaptation into the EIA.	The climate resilience assessment (Section 13.6 of Chapter 13 (document reference 6.1) has been produced in line with the guidance document. The guidance sets out principles for including climate vulnerability assessment within EIAs.
European Commission (2013), Guidance on Integrating Climate Change and	The guidance aims to help Member States improve the way in which climate change and	The guidance document has been considered in the developing the assessment methodology

Guidance	Summary	Chapter Reference
Biodiversity into Environmental Impact Assessment	biodiversity are integrated in EIAs carried out across the EU. The guidance provides the following advice in terms of assessing the effects of climate change in EIA: • Consider climate change scenarios at the outset • Analyse the evolving environmental baseline trends • Consider the impact that predicted changes in climate and biodiversity will have on the proposed project, potentially over a long timescale, and the project's resilience and capacity to cope. Base your recommendations on the precautionary principle and acknowledge assumptions and the limitations of current knowledge	and in completion of the assessment (see Section 13.6 of Chapter 13 (document reference 6.1)). Climate projections for the long-term (2080s) have been used in the assessment and a precautionary approach has been applied through choice of a high emissions scenario (RCP8.5). The Scheme's 'capacity to cope' with climate change has been assessed through consideration of pre-mitigation risks and incorporated mitigation measures which reduce the vulnerability of the Scheme to climate-related risks.
European Commission (2016), Climate Change and Major Projects	The guidance document outlies the process for the Climate Change Vulnerability and Risk	The climate resilience assessment (Section 13.6 of Chapter 13 (document reference 6.1) has been

Guidance	Summary	Chapter Reference
	Assessment and the process of managing climate adaptation issues in order to improve the project's resilience to climate change. The process described by the document involves identifying which climate hazards the project is vulnerable to, assessing the level of risk, and considering adaptation measures to reduce that risk to an acceptable level. Vulnerability is considered to be a product of sensitivity and exposure of a project to hazards associated with change in climate variables. Risk is considered to be a product of the likelihood and impact of those hazards occurring.	produced in line with the guidance document. The vulnerability assessment (Appendix 13B (document reference 6.2)) follows the approach set out in the guidance, i.e. identifying vulnerabilities based on the sensitivity and exposure of the Scheme to climate variables. The risk assessment (from paragraph 13.6.21 in Chapter 13 (document reference 6.1) and Appendix 13C (document reference 6.2)) follows the approach set out in the guidance, i.e. assessing risk in terms of the likelihood and consequence of climate risks to the Scheme.
European Commission (undated), Non-Paper Guidelines for Project Managers: Making Vulnerable Investments Climate Resilient	The objective of the guidelines is to help developers of physical assets and infrastructure incorporate resilience to current climate variability and future climate change within their projects. The guidelines explain when and how to apply various steps in order to identify how a project is vulnerable to climate	The vulnerability assessment (Appendix 13B (document reference 6.2)) follows the approach set out in the guidance, i.e. identifying vulnerabilities based on the sensitivity and exposure of the Scheme to climate variables. The risk assessment (from paragraph 13.6.21

Guidance	Summary	Chapter Reference
	variability and change and assess current and future climate risks to the success of the project. Steps include: • Identify climate sensitivities of the project to a range of climate variables • Evaluate exposure to climate change • Assess vulnerability • Assess risks through likelihood and severity of occurrence	in Chapter 13 (document reference 6.1) and Appendix 13C (document reference 6.2)) follows the approach set out in the guidance, i.e. assessing risk in terms of the likelihood and consequence of climate risks to the Scheme.

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1 Vulnerability Assessment

1.1 Vulnerability Assessment Findings

1.1.1 The assessment of the vulnerability of the Scheme to the impacts of climate change has been informed by regional scale information on historic and projected change in climate variables. The vulnerability of the Scheme to climate change has been assessed against the UK Climate Projections 2018 (Ref 1.10) (UKCP18) for the 2080s for the East of England region for a high emissions ('worst-case') scenario (termed Representative Concentration pathway (RCP) 8.5).

1.1.2 In line with published guidance (primarily IEMA (2015), Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation (Ref 1.13) and European Commission (2016), Climate Change and Major Projects (Ref 1.14), the assessment of climate vulnerability and risk in the EIA process consists of five steps:

- **Step 1**: Identify receptors and analyse policy context;
- **Step 2**: Climate vulnerability assessment;
- **Step 3**: Risk assessment;
- **Step 4**: Adaptation measures and
- **Step 5:** Determination of significance.

1.1.3 This Appendix presents the detailed assessment and findings of Step 1 (identify receptors) and Step 2 climate vulnerability assessment. The analysis of policy context element (review of relent legislation and policy) of Step 1 is presented in Appendix 13A. The assessment methodology for the assessment can be found in Chapter 13: Climate Change (document reference 6.1), Section 13.6.

Step 1: Identify Receptors and Analyse Policy Context

1.1.4 During this stage, relevant receptors which may be affected by climate change are identified, whilst considering the impact of extreme weather and changes in climate on the Scheme over its lifetime. These receptors may comprise both known (i.e. receptors affected by historic weather events) and unknown (new) receptors. This stage includes a definition of the policy context (presented in Appendix 13A).

Step 2: Climate Vulnerability Assessment

1.1.5 This stage comprises an assessment of the vulnerability of the receptors identified in Step 1 to projected climate change and extreme weather

variables. The vulnerability of a receptor to extreme weather and climate change is a function of:

- The typical **sensitivity** of the receptor to climate variables – based on literature review and professional judgement from knowledge of similar schemes; and
- The **exposure** of the receptor to projected change in climate variables, based on information on observed climate and projected climate. UKCP18 provides probabilistic projections of future climate for a range of emissions scenarios. However, future GHG emissions and the resultant effects on climate is uncertain. As such, a precautionary approach has been adopted by selecting the High emissions ('worst-case') scenarios for the longest term timeslice (2080s), which offer the longest-term projections into the Scheme timescale.

1.1.6 For each element of the vulnerability assessment (i.e. sensitivity and exposure), a category is assigned to each climate variable relative to each receptor based on the following scale:

- High: High climate sensitivity or exposure;
- Medium: Moderate climate sensitivity or exposure; and
- Low: No significant climate sensitivity or exposure.

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

1.1.8 The vulnerability of receptors to climate variables is determined from the combination of the sensitivity and exposure categorisation, using the matrix shown in Table 1.1. At this point 'Low' vulnerabilities are scoped out of further assessment, whilst 'High' and 'Medium' vulnerabilities are taken forward to Steps 3 and 4.

Table 1.1: Vulnerability Rating

Sensitivity	Exposure		
	Low	Medium	High
Low	Low Vulnerability	Low Vulnerability	Low Vulnerability
Medium	Low Vulnerability	Medium Vulnerability	Medium Vulnerability
High	Low Vulnerability	Medium Vulnerability	High Vulnerability

Step 1: Identify Receptors

1.1.9 Receptors associated with the Scheme are as follows:

- Dual carriageway road;
- Double-leaf bascule bridge and associated substructure and knuckle walls (design life 120 years);
- Five-arm roundabout;
- Single span bridge over Southtown Road;
- Reinforced earth embankments;
- Signalised junction;
- Cycle and pedestrian provision; and
- Signage.

1.1.10 The Scheme receptors are summarised below in terms of key Scheme elements. The terms 'road', 'bridge' and 'cycle and footway' are used throughout this Appendix, Chapter 13: Climate Change (document reference 6.1) and Appendix 13C:

- The 'road' including the new dual carriageway road, five-arm roundabout signalised junction junctions and reinforced earth embankments;
- 'Bridges' including the new double-leaf bascule bridge and associated substructure and 'knuckle' walls and associated control tower, plant room control equipment, and single span bridge over Southtown Road; and
- The 'cycle and footway' comprising the cycle and pedestrian provision.

Step 2: Climate Vulnerability Assessment

Sensitivity

1.1.11 Based on relevant guidance (Ref 1.1) and professional judgement, the climate variables which the Scheme elements are typically vulnerable to are shown in Table 1.2. Australian guidance (Ref 1.1) is used in lieu of any UK guidance to assess the vulnerability Scheme elements.

1.1.12 'Crossed' grey shaded cells in the table indicate where the climate variable or climate-related hazard is not relevant to the Scheme elements; these climate variables and climate-related hazards have then been excluded from the forthcoming analyses. Further justification is provided in Table 1.3.

Table 1.2: Climate Variables and Climate Related Hazards: Transport

Scheme Element	Variable																	
	Sea				Precipitation			Temperature			Wind		Relative Humidity		Soils			
	Sea level rise	Storm surge and storm tide	Surface temperature	Currents and waves	Change in annual average	Drought	Extreme precipitation events (flooding)	Changes in annual average	Extreme temperature events	Solar radiation	Gales and extreme wind events	Storms (snow, lightning, hail)	Changes in annual average	Evaporation	Soil moisture	Salinity/pH	Runoff	Soil stability
Roads	✓	✓	X	X	✓	✓	✓	X	✓	✓	✓	✓	X	X	✓	✓	✓	✓
Bridges	✓	✓	X	X	X	X	✓	X	✓	✓	✓	✓	X	X	X	✓	X	✓
Cycle and footway	✓	✓	X	X	✓	✓	✓	X	✓	✓	✓	✓	X	X	✓	✓	✓	✓

Table 1.3: Justification for Excluding Climate Variables from Further Analysis

Scheme Element	Climate Variables Excluded from Further Analysis	Justification
Roads, cycle and footway	Sea surface temperature	The roads, cycle and footway elements are sensitive to the presence of water (flooding) rather than water temperature.
	Currents and waves	The main sensitivity of the road, cycle and footway elements is flooding which is picked up through the sea level rise and storm surge variables.
	Changes in annual average temperature	The road, cycle and footway elements are sensitive to extreme temperatures (heatwaves) but not highly sensitive to long term changes in average temperatures.
	Changes in annual average relative humidity	Evaporation has little direct effect on the road, cycle and footway elements
	Evaporation	Evaporation has little direct effect on the road, cycle and footway element
Bridges	Sea surface temperature	Bridges are sensitive to the presence of water (flooding) rather than water temperature
	Currents and waves	The main sensitivity of the bridge element is flooding which is picked up through the sea level rise and storm surge variables.
	Changes in annual average rainfall	Bridges are sensitive to extreme precipitation events but not highly sensitive to long term changes in average precipitation.
	Drought	Bridges are not directly affected by dry conditions. Effects of dry conditions on soil stability which may affect bridges is picked up through the soil stability variable.
	Changes in annual average temperature	Bridges are sensitive to extreme temperatures (heatwaves) but not

Scheme Element	Climate Variables Excluded from Further Analysis	Justification
		highly sensitive to long term changes in average temperatures.
	Changes in annual average relative humidity	Humidity levels have little direct effect on bridges
	Evaporation	Evaporation has little direct effect on bridges
	Soil moisture	Effects of changes to soil stability on bridges is picked up through the soil stability variable.
	Runoff	The bridge element is not thought to be sensitive to changes in soil runoff.

Sea

1.1.13 Road, cycle and footways and bridges located near the coast or in estuarine locations is sensitive to changes in sea level and storm surges. An increase in sea level or increased storm surges could lead to coastal flooding which could cause damage to roads, cycle and footways, bridges and associated structures (e.g. earthworks, control buildings and equipment). Coastal flooding could lead to temporary closure of roads, cycle and footways and bridges as well as deterioration of materials.

Precipitation

1.1.14 Roads, cycle and footways and bridges are sensitive to high rainfall. An average increase in winter rainfall may cause roads, cycle and footways to become flooded due to flooding of local watercourses (fluvial flooding) or surface water flooding (pluvial flooding). Flooding may mean that roads, cycle and footways are impassable. Flooding may also cause damage to paved surfaces (leading to increased maintenance requirements). Roads, bridges, cycle and footways are also sensitive to extreme rainfall events which, in addition to flooding, may also lead to destabilisation of soils and earthworks, potentially leading to temporary or permanent loss of amenity. Any electronic control equipment associated with the bridge will also be sensitive to flooding.

1.1.15 Roads, cycle and footways are also sensitive to low rainfall or drought. Prolonged dry periods may lead to drying out and cracking of earthworks and soils.

Temperature

1.1.16 Roads, bridges, cycle and footways are sensitive to extreme temperatures. High temperatures may cause damage to paved surfaces, including potential melting and deformation. An increase in solar radiation can also cause more rapid deterioration of materials and associated infrastructure such as signage. Bridges are sensitive to high temperatures which affect thermal expansion joints and increase earth pressures.

Wind

1.1.17 Bridges are sensitive to high winds which increase wind loading on the structure. High winds and storms can affect the stability of above-ground infrastructure and hasten material degradation. High winds can also cause wind-driven rain infiltration into building materials and surfaces which can increase maintenance costs and operational disruption. High winds also increase risk to bridge users (particularly high sided vehicles) and may lead to temporary closure. Road, cycle and footway users may also be sensitive to high winds. Associated infrastructure such as signage or signals could also be damaged by high winds.

1.1.18 Bridges are also sensitive to storms, particularly the risk of lightning strike. Electronic control equipment associated with bridges is likely to be highly sensitive to lightning strike.

Soils

1.1.19 Roads, bridges, cycle and footways are all sensitive to soil stability. Soil stability can be reduced as a result of extreme rainfall or prolonged periods of rainfall which can lead to waterlogging, as well as extreme temperatures and drought which can causes soils to dry out and crack. Earthworks and embankments associated with roads, bridges, cycle and footways are particularly sensitive to changes in soil stability. Roads, cycle and footways are also sensitive to an increase in soil runoff, increasing the amount of sediment on paved surfaces and reaching drains, potentially leading to blockages.

1.1.20 Water availability can cause a number of impacts to water quality and soils. For example, greater water volumes can increase the mobilisation of pollutants in soils whilst water scarcity can increase the accumulation of chemicals and pollutants which may cause increased salinity and acidification. Sea level rise could also lead to increasing soil salinity. More acidic soils and/or water will increase the deterioration of building materials. Bridge foundations may be sensitive to changes in soil chemistry

1.1.21 Based on the information described above, literature review and professional opinion, Table 1.4 outlines the climate sensitivity of the Scheme.

Table 1.4: Sensitivity Assessment

Climate Variable		Sensitivity of Scheme Components		
		Road	Bridges	Cycle and Footway
Sea	Sea level rise	Medium	Medium	Medium
	Storm surge and storm tide	High	High	Medium
Precipitation	Changes in annual average	Medium	n/a	Low
	Drought	Medium	n/a	Medium
	Extreme precipitation events	High	High	Medium
Temperature	Extreme temperature events	High	High	Medium
	Solar radiation	Medium	Low	Low
Wind	Gales and high winds	Medium	High	Low
	Storms	Low	High	Low
Soils	Soil moisture	Medium	n/a	Medium
	Soil salinity	Low	Medium	Low
	Runoff	Medium	n/a	Medium
	Soil stability	Medium	High	Medium

Exposure

1.1.22 This section considers the exposure of the Scheme to current climate and climate change/changes in extreme weather.

Current Climate

1.1.23 The Scheme is located in the East of England which has a warm, dry climate, compared to UK average. Information on long term average observed climate variables over the period 1981 – 2010 is presented below. This information is taken from The Climate of the United Kingdom and Observed Trends (Ref 1.2), Met Office regional climate profile for Eastern

England (Ref 1.3) and Met Office Weather Station data (Ref 1.11). The date range (1981-2010) is the most up to date long term average data available.

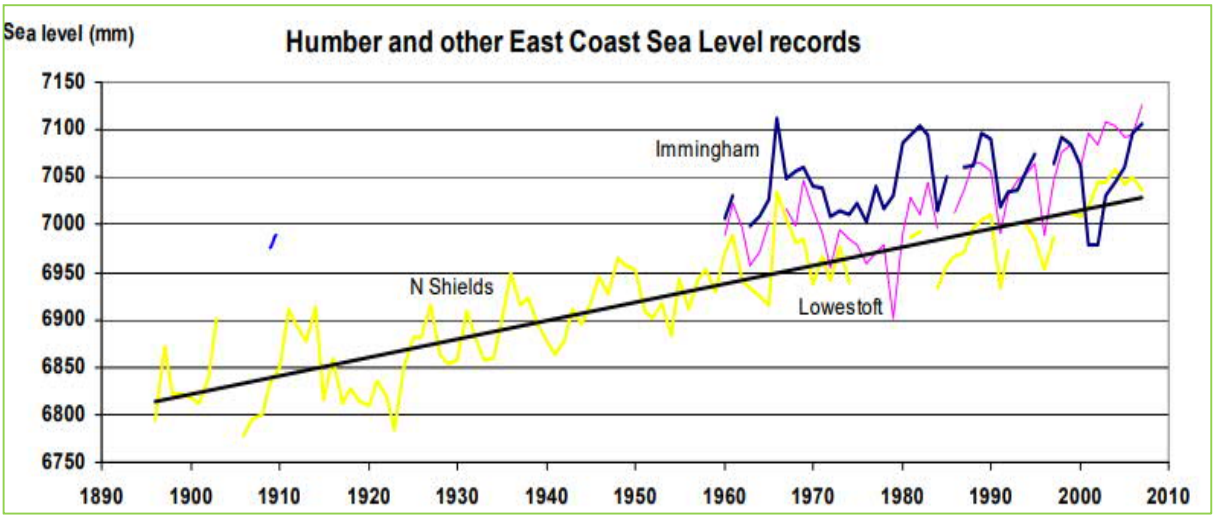
Sea Level

1.1.24 Sea level change is controlled by two main factors: eustatic (changes related to the expansion and contraction of sea water plus changes in the volume of water stored on land as ice sheets/glaciers) and isostatic (changes related to movement of the land in responses to the effect of glaciers on the Earth's crust). Recent and future sea level change in the region is dominated by the eustatic component resulting from global warming. Local changes (i.e. in geomorphology), modify these broader changes and can have a significant effect on the actual sea level rise experienced along the region's coastline.

1.1.25 Sea level around the UK rose by about 1mm/yr in the 20th century, corrected for land movement (Ref 1.2). At Lowestoft (the nearest tide gauge site to the Scheme), mean sea level increased by 2.01 (+/- 0.42) mm per year over the period 1960-1996 (Ref 1.6).

1.1.26 Plate 1.1 shows sea level records on the east coast. Lowestoft is the nearest recording station to the Scheme.

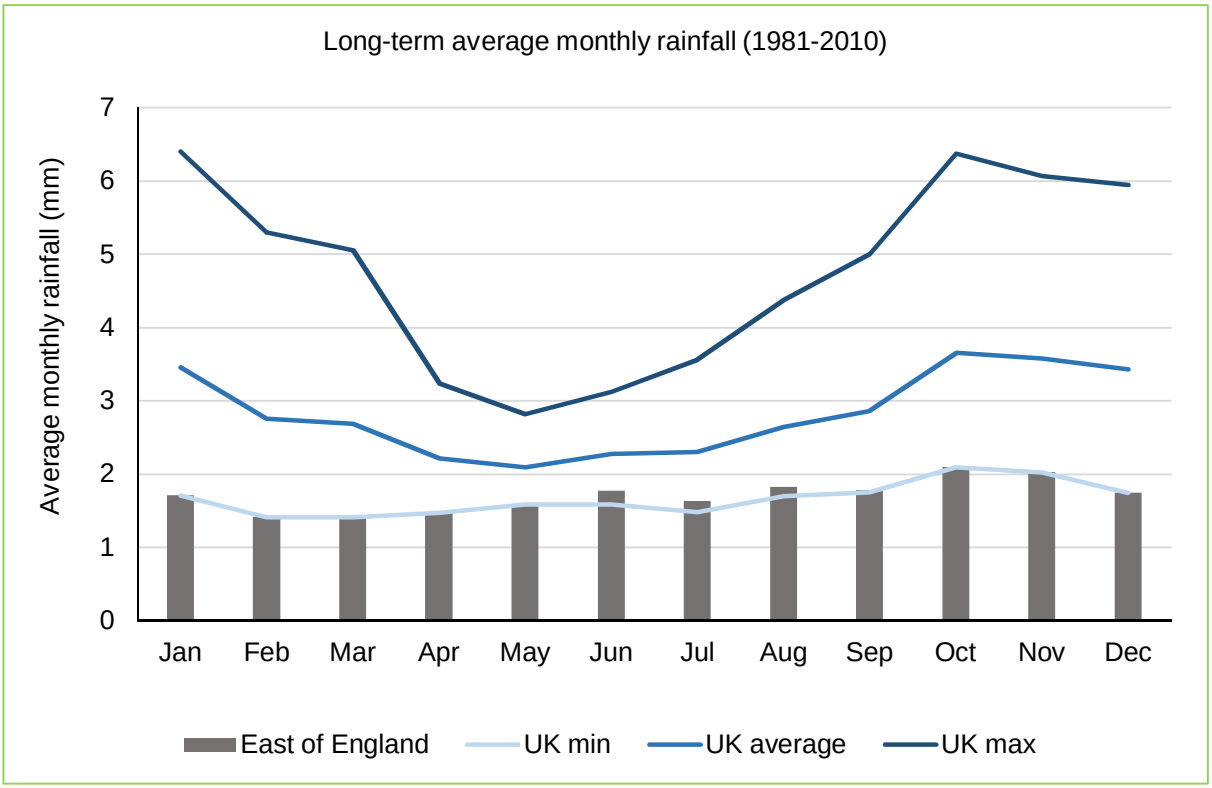
Plate 1.1: East Coast Sea Level Records



Precipitation

1.1.27 Plate 1.2 shows the long-term average monthly rainfall for the East of England region between 1981 and 2010 (Ref 1.2). Across most of the region there are, on average, about 30 rain days (rainfall greater than 1 mm) in winter (December to February) and less than 25 days in summer (June to August) with the highest averages being at the higher altitude of the Lincolnshire Wolds (Ref 1.3).

Plate 1.2: Long Term Average Monthly Mean Rainfall



1.1.28 Average summer (June, July and August) and winter (December, January and February) rainfall at Hemsby Weather Station (the nearest weather station to the Scheme situated approximately 11km to the north east) for the period 1981-2010 is summarised in Table 1.5 (Ref 1.11).

Table 1.5: Long Term Average Mean Rainfall (mm) at Hemsby Weather Station (1981 – 2010)

Period	Mean Rainfall (mm)
Summer	57.7
Winter	58.6
Annual	636.4

1.1.29

1.1.30 Table 1.6 shows the average number of days per year (in the period 1981 – 2010 where rainfall exceeded 10mm per day in the East of England region (Ref 1.2).

Table 1.6: Long Term Average of Total Number of Days where Rainfall Exceeded 10mm for the Baseline Period (1981 – 2010) in the East of England Region

Period	Average Number of Days Rainfall >10mm (1981-2010)
Summer	1.4
Winter	0.9
Annual	1.2

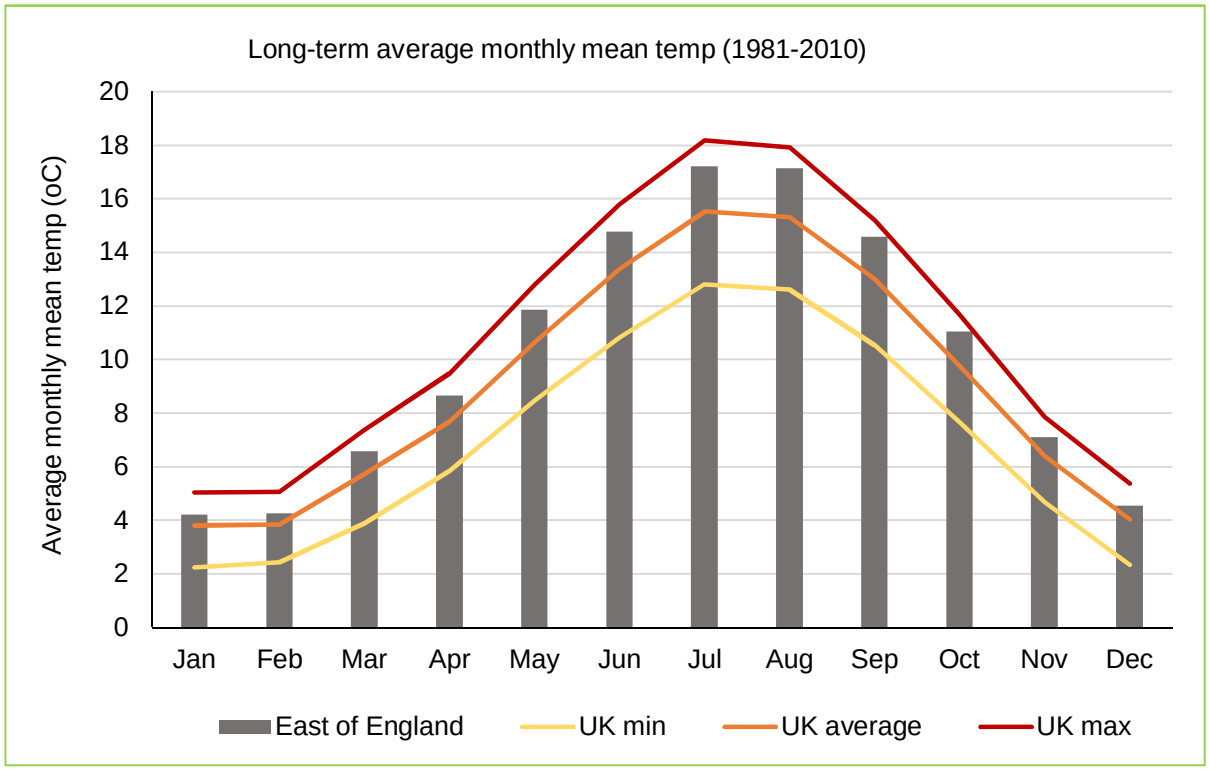
1.1.31 Although rainfall is generally low in the East of England, there have been some noteworthy severe storms. These include (Ref 1.3):

- 25 to 26 August 1912 - over 100 mm was recorded in Norfolk causing damage to roads and bridges
- 1 September 1994 - 147 mm was recorded in only a few hours in Suffolk, causing transport disruption and significant flooding.

Temperature

1.1.32 Plate 1.3 shows the long-term average mean monthly temperature for the East of England region between 1981 and 2010 (Ref 1.2). The mean annual temperature over the region varies from around 9.5°C to just over 10.5°C (Ref 1.3).

Plate 1.3: Long Term Average Monthly Temperature



1.1.33 The long-term average of maximum mean summer (June, July and August) temperature and minimum mean winter (December, January and February) temperature at Hemsby Weather Station for the baseline period is presented in Table 1.7 below (Ref 1.11).

Table 1.7: Long Term Average Mean Monthly Temperature

Variable	Temperature °C
Maximum mean summer temperature (°C) (1981 – 2010)	19.7
Minimum mean winter temperature (°C) (1981 – 2010)	2.1

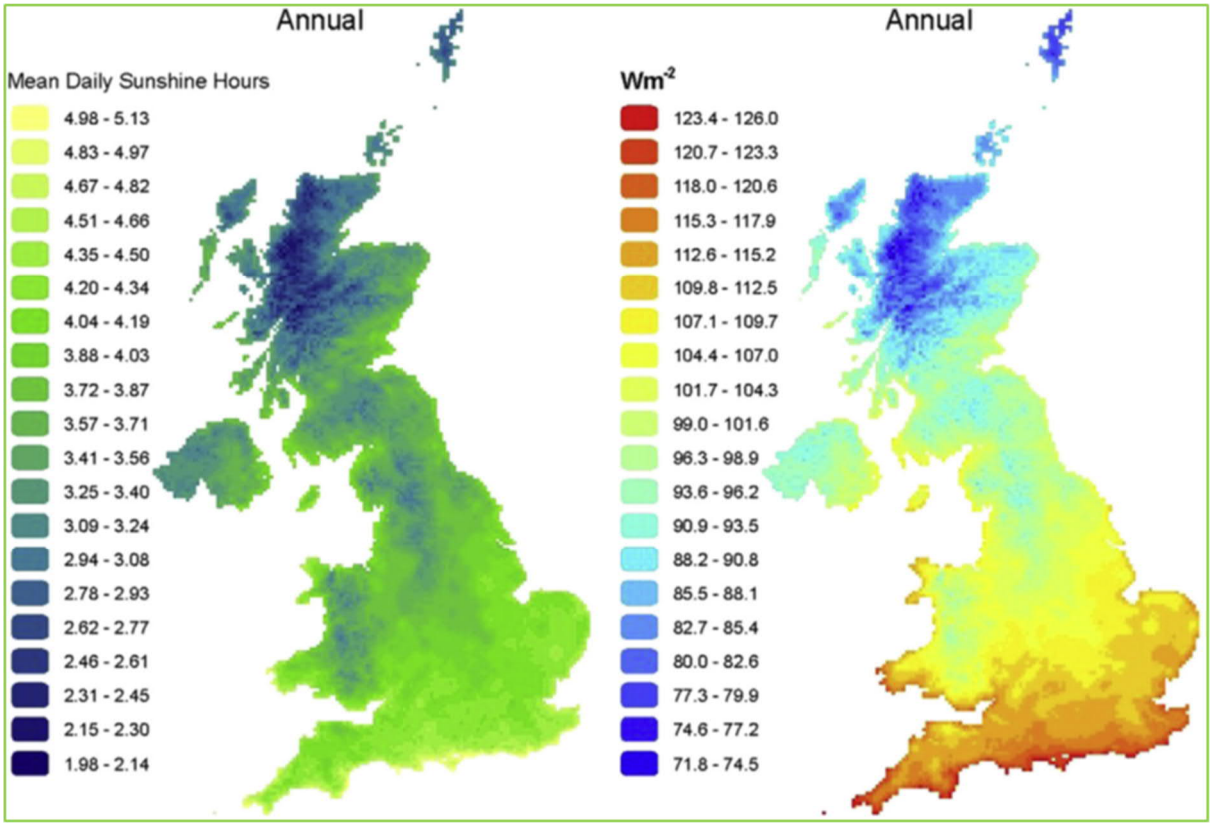
1.1.34 The highest known temperature recorded in the region was 37.3°Cat Cavendish on 10 August 2003 (Ref 1.3).

1.1.35 Sea temperatures off the coast of eastern England vary from 5-6°C in February and early March to 15-16°C in August (Ref 1.3). The temperature is governed by the influx of warm water associated with the Gulf Stream.

Solar Radiation

1.1.36 The Met Office has developed UK gridded observed sunshine duration data sets which are based on observations from weather stations. Sunshine duration data can be converted to solar radiation data. Plate 1.4 shows average daily annual sunshine hours and converted solar irradiance over the period 1961 – 1990 across the UK (Ref 1.4). Average daily solar irradiance at Great Yarmouth over this period is in the region of 110 watts per meter squared (Wm^{-2}).

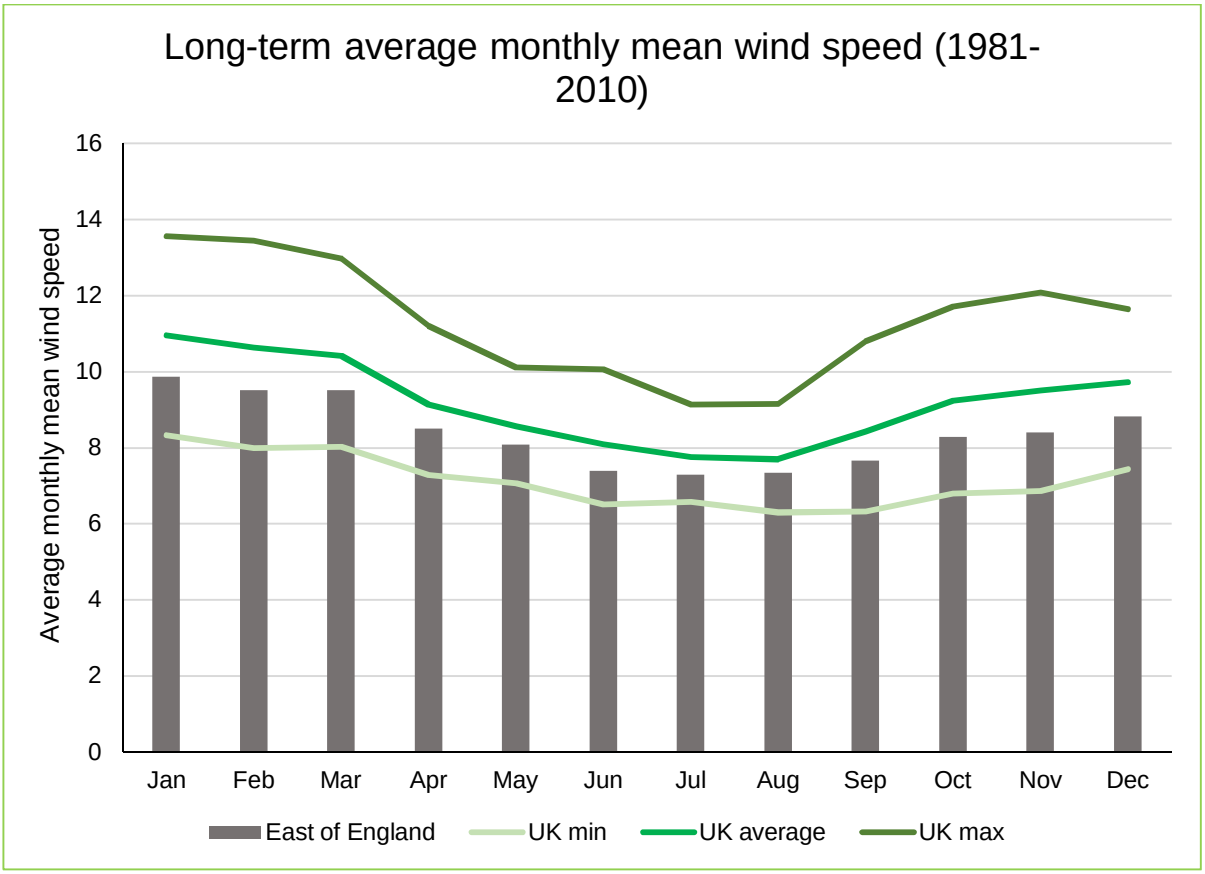
Plate 1.4: Long Term Average Daily Solar Irradiance



Wind

1.1.37 Plate 1.5 shows the long-term average monthly mean wind speed in the East of England region between 1981 and 2010 (Ref 1.2). Eastern England is one of the more sheltered parts of the UK and the strongest winds are associated with the passage of deep depressions across or close to the UK. In coastal areas sea breezes are an important feature of the weather in late spring and summer when the land is warming up and the sea still relatively cool (Ref 1.3).

Plate 1.5: Long Term Average Monthly Mean Windspeed



1.1.38 The long-term average of mean summer and winter wind speed at 10m at the Hemsby Weather Station (Ref 1.11) for the baseline period is presented in Table 1.8 below.

Table 1.8: Long Term Average of Mean Summer and Winter Wind Speed for the Baseline Period (1981 – 2010), Hemsby Weather Station

Variable	Wind speed (knots)
Mean summer wind speed (knots) (1981 – 2010)	8.6
Mean winter wind speed (knots) (1981 – 2010)	11.7
Annual	10.2

1.1.39 A day of gale is defined as a day on which the wind speed attains a mean value of 34 knots or more over any period of 10 minutes. Much of East Anglia and Lincolnshire has no more than two days of gale each year, but exposed coasts average about five gales each year. Two particularly noteworthy gale events have occurred in the region (Ref 1.3):

- 2 January 1976 - a depression moved across Scotland to the North Sea causing storm force winds that particularly affected the north, east and Midland areas of England. Gusts exceeding 90 knots were reported in East Anglia and sea walls were breached at Walcott in Norfolk and Cleethorpes on Humberside causing extensive damage.
- The 'Great Storm' of 15-16 October 1987 caused widespread damage across south-east England. The strongest gust recorded in Eastern England was 87 knots at Shoeburyness (Landwick) in Essex.

Projected Climate

1.1.40 Information on projected climate is taken from the UK Climate Projections 2018 (UKCP18) (Ref 1.10). The UKCP18 are the most up-to-date projections of climate change for the UK. UKCP18 includes probabilistic projections of a range of climate variables for different emissions scenarios (Representative Concentration Pathways RCPs[1]) and for a range of timeslices[2] to the end of the 21st Century. The projections are presented using a central estimate (50th percentile) projections for the 2080s high emissions scenarios (RCP8.5) for the East of England administrative region.

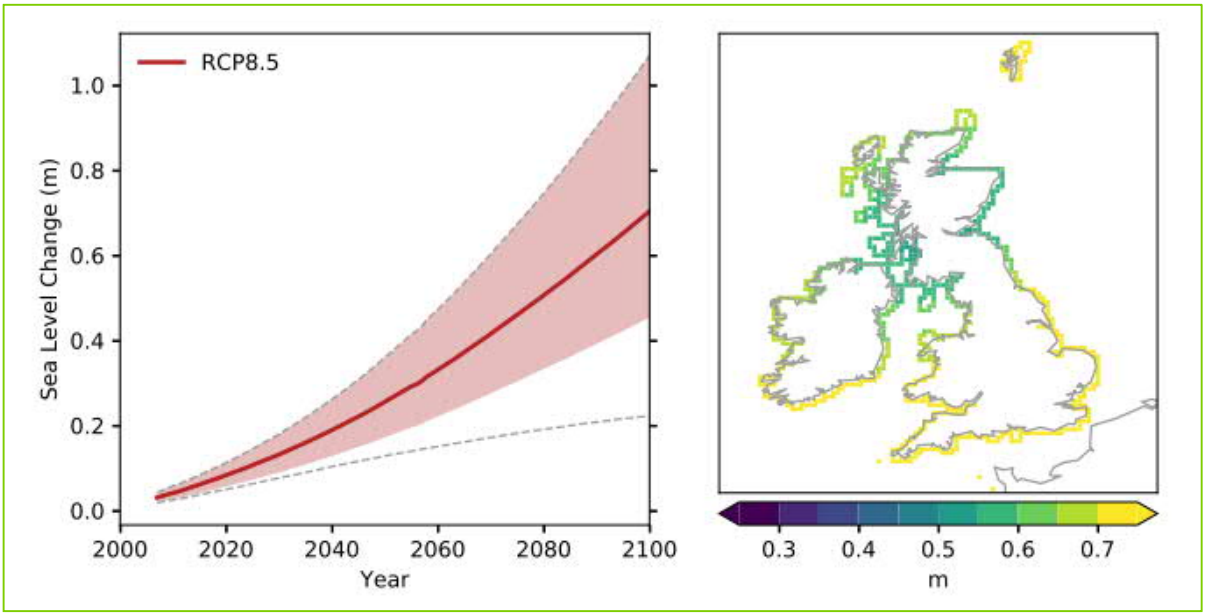
Sea Level

1.1.41 UKCP18 projections provide predictions for four cities across the UK of which London is the most applicable here. Under RCP8.5, UKCP18 suggests that seal level change will be between 0.53m (5th percentile) and 1.15 (95th percentile). Plate 1.6, shows the UK average sea level change under the RCP8.5 emission scenario and the pattern of change around the UK coastline in the year 2100 (Ref 1.15).

[1] Representative Concentration Pathways specify the concentrations of greenhouse gases that would result in target amounts of radiative forcing at the top of the atmosphere by 2100, relative to preindustrial levels. Four forcing levels have been set: 2.6, 4.5, 6.0 and 8.5 W/m^2. These create four RCPs that are used in UKCP18; RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5.

[2] UKCP18 projections are given for seven overlapping 30-year time periods. Each period steps forward by a decade, with the first-time period being 2010-2039. For simplicity, these time periods are referred to by the middle decade, starting with the 2020s (2010-2039) and ending with the 2080s (2070-2099).

Plate 1.6: UK Average Sea Level Change under the RCP8.5 Emission Scenario and the Pattern of Change around the UK Coastline in the Year 2100



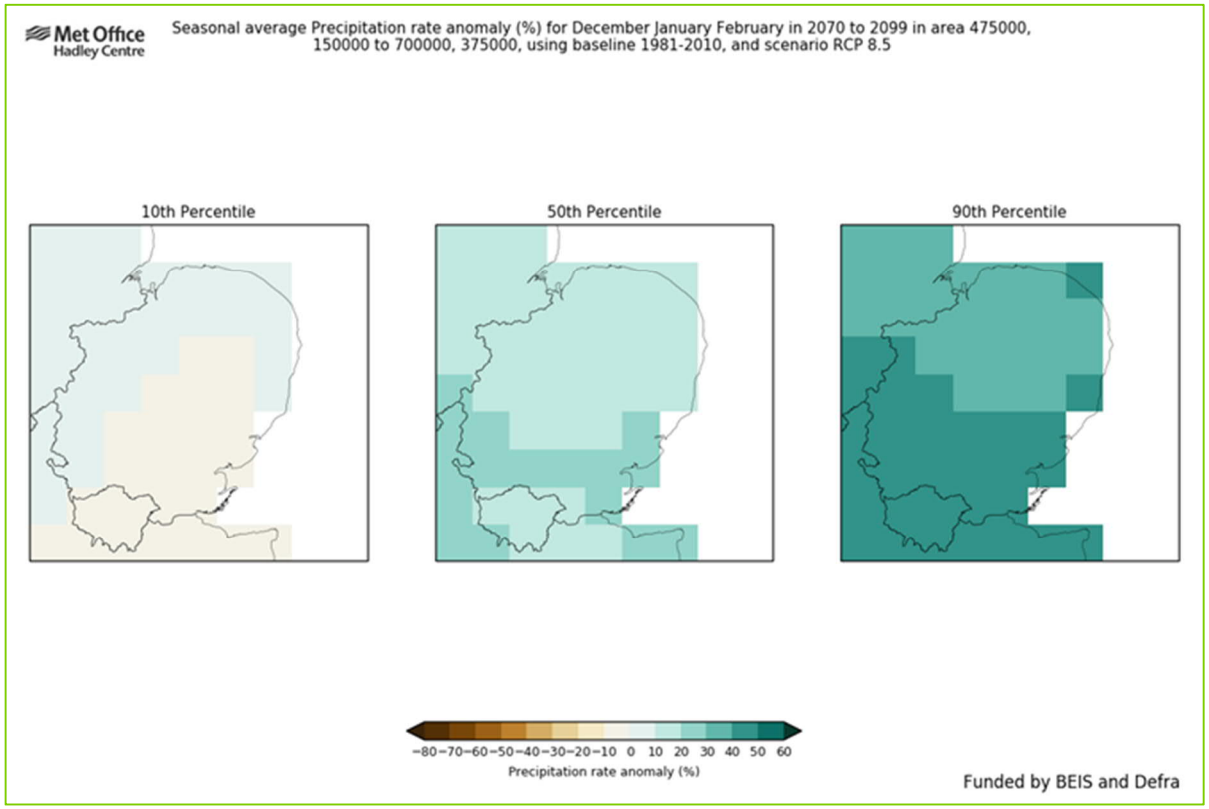
Precipitation

1.1.42 Over land, UKCP18 projects that general trends of climate changes in the 21st century will move towards warmer, wetter winters and hotter, drier summers. However, natural variations mean that some cold winters, some dry winters, some cool summers and some wet summers will still occur.

1.1.43 UKCP18 suggests that by the 2080s in the East of England region, mean winter precipitation is expected to increase by up to 20% in the north and central areas of the region and up to 20% in the south of the region (50th percentile) under RCP 8.5.

1.1.44 Plate 1.7 summarises changes in mean winter precipitation for the 2080s under UKCP18 emission scenarios RCP8.5 (Ref 1.10).

Plate 1.7: Mean Winter Precipitation in the East of England Region for the 2080s under UKCP18 RCP8.5 Emission Scenario

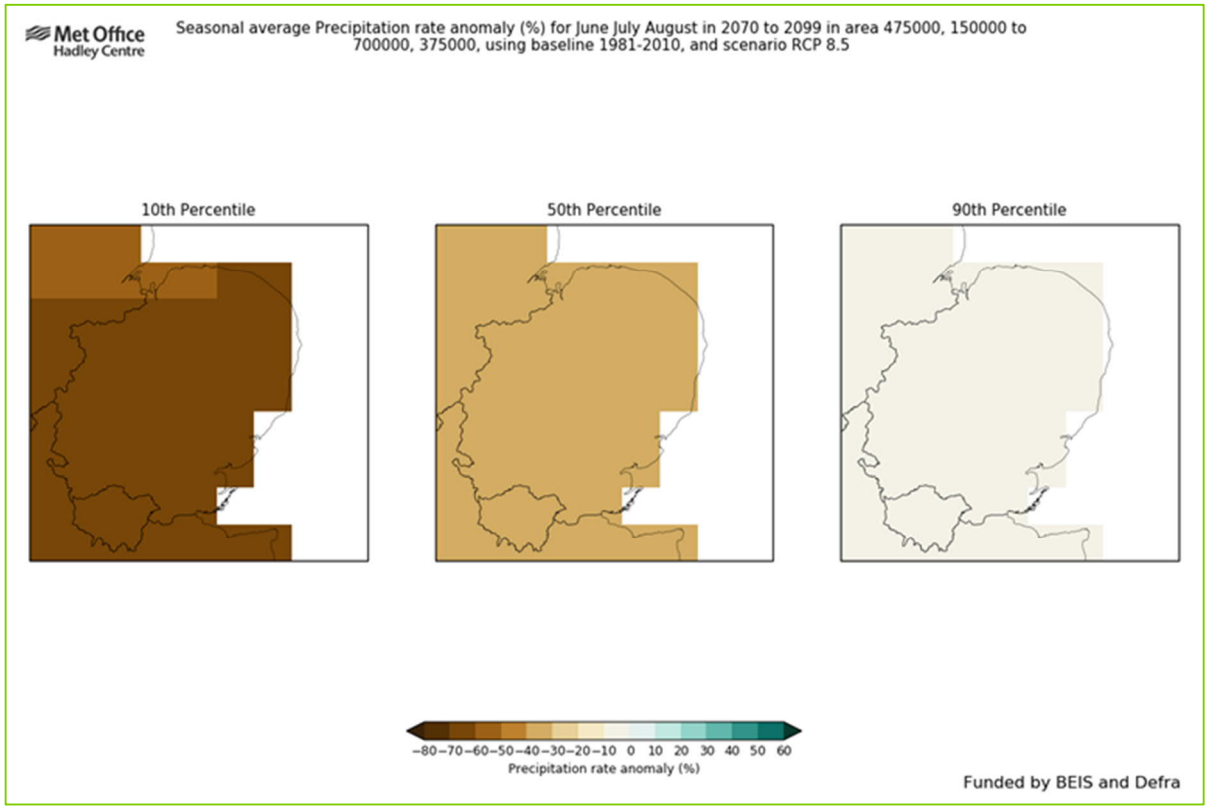


1.1.45 Snowfall is closely linked with temperature, with falls rarely occurring if the temperature is higher than 4 °C. For snow to lie for any length of time, the temperature normally has to be lower than this. With regards to future changes, rising winter temperatures are likely to reduce the amount of precipitation that falls as snow in winter. UKCP18 data (at time of writing) does not have data on snowfall, however UKCP09 (Ref 1.12) projects a reduction of mean snowfall, the number of days when snow falls and heavy snow events by the end of the 21st century. UKCP09 does not provide projections for the nearer-term for snow.

1.1.46 For the summer, by the 2080s in the East of England region, mean summer precipitation is expected to decrease by up to 40% (50th percentiles) under RCP8.5.

1.1.47 Plate 1.8 summarises changes in mean summer precipitation for the 2080s under UKCP18 emission scenario RCP8.5 (Ref 1.10).

Plate 1.8: Mean Summer Precipitation in the East of England Region for the 2080s under UKCP18 RCP8.5 Emission Scenario



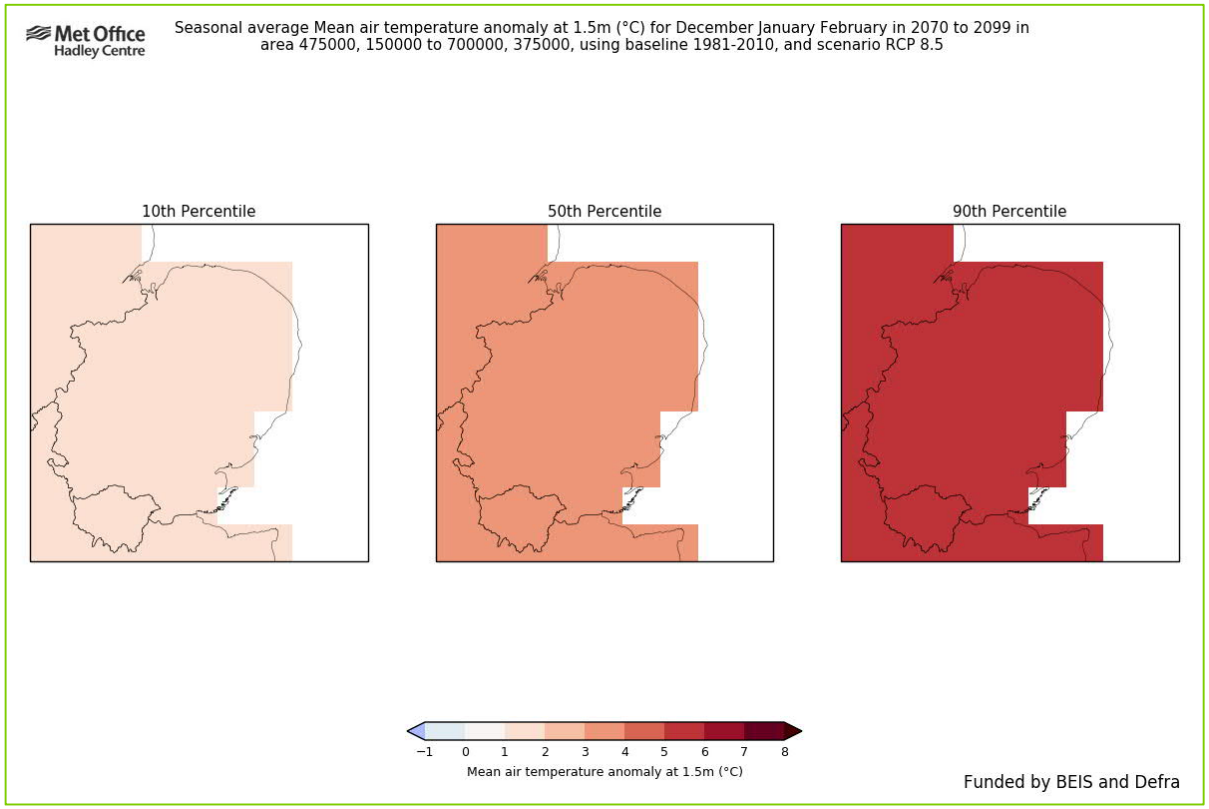
Temperature

1.1.48 Climate change is projected to lead to hotter summers and warmer winters. The probabilistic projections show that there is more warming in the summer than in the winter. Additionally, in summer there is a pronounced north / south contrast at the scale of the UK, with greater increases in maximum summer temperatures over the southern UK compared to northern Scotland.

1.1.49 UKCP18 suggests that by the 2080s, mean winter temperature in the region is expected to increase by up to 4°C (50th percentile) under RCP8.5.

1.1.50 Plate 1.9 summarises changes in mean winter temperature for the 2080s under UKCP18 emission scenario RCP8.5 (Ref 1.10).

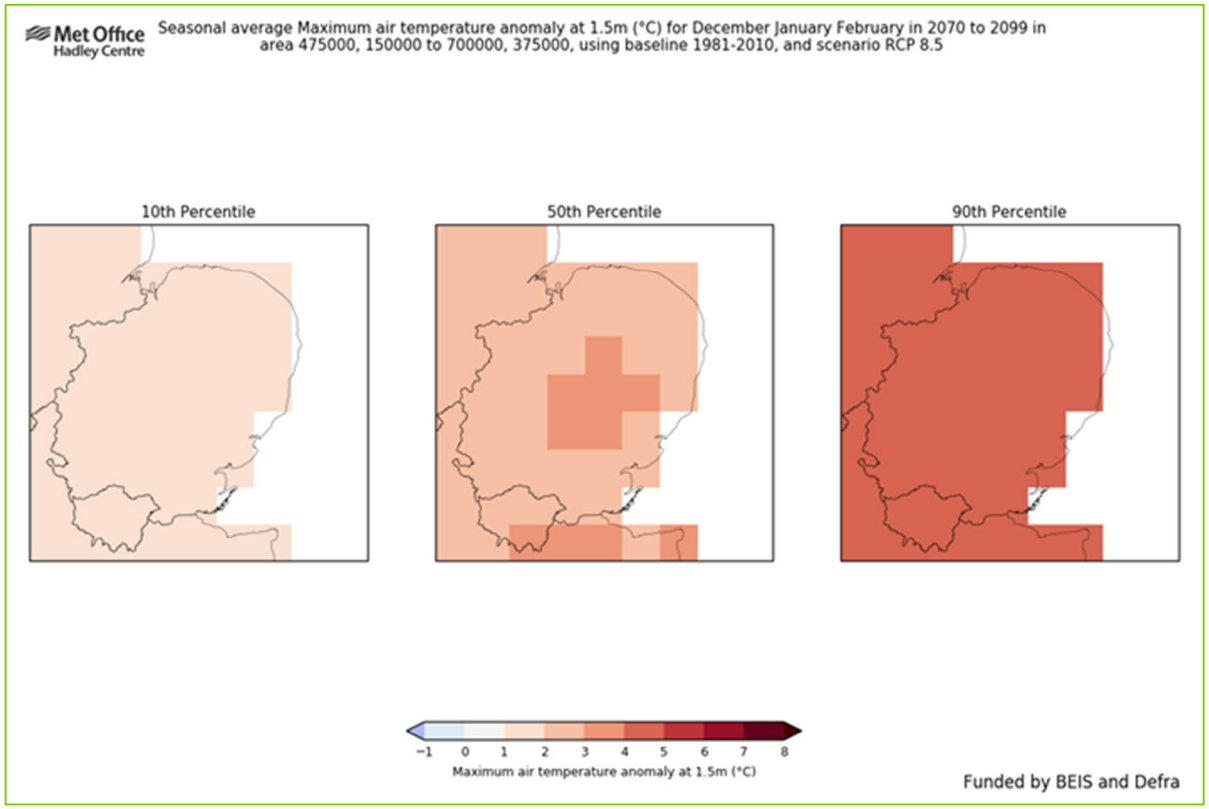
Plate 1.9: Mean Winter Temperature in the East of England Region for the 2080s under UKCP18 RCP8.5 Emission Scenario



1.1.51 UKCP18 suggests that by the 2080s, mean daily maximum winter temperature in the region is expected to increase by up to 3°C in the coastal and western area of the region and up to 4°C in the central areas of the region (50th percentile) under RCP8.5.

1.1.52 Plate 1.10 summarises change in mean daily maximum temperature in the winter for the 2080s under RCP8.5 (Ref 1.10).

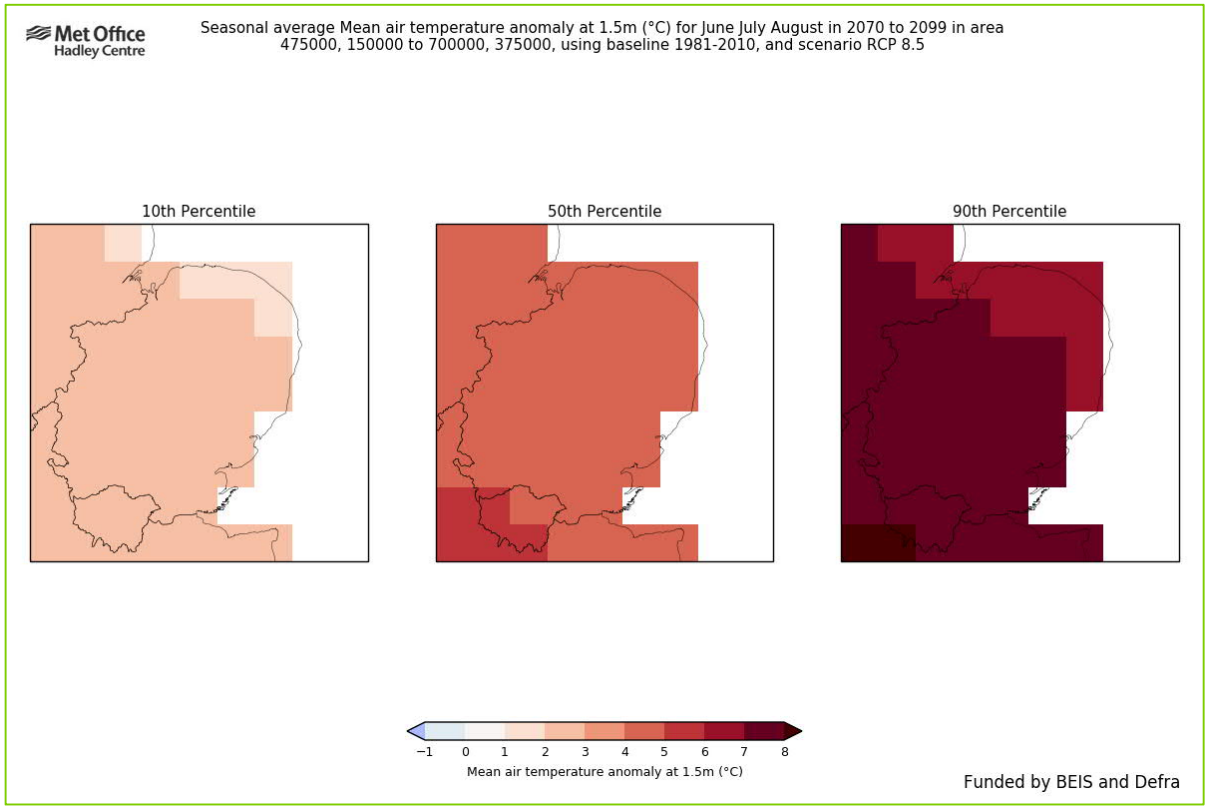
Plate 1.10: Mean Daily Maximum Winter Temperature in the East of England Region for the 2080s under UKCP18 RCP8.5 Emission Scenario



1.1.53 For the summer, by the 2080s, mean summer temperature is expected to increase by up to 5°C (50th percentile) under RCP8.5.

1.1.54 Plate 1.11 Summarises changes in mean summer temperature for the 2080s under RCP8.5 (Ref 1.10).

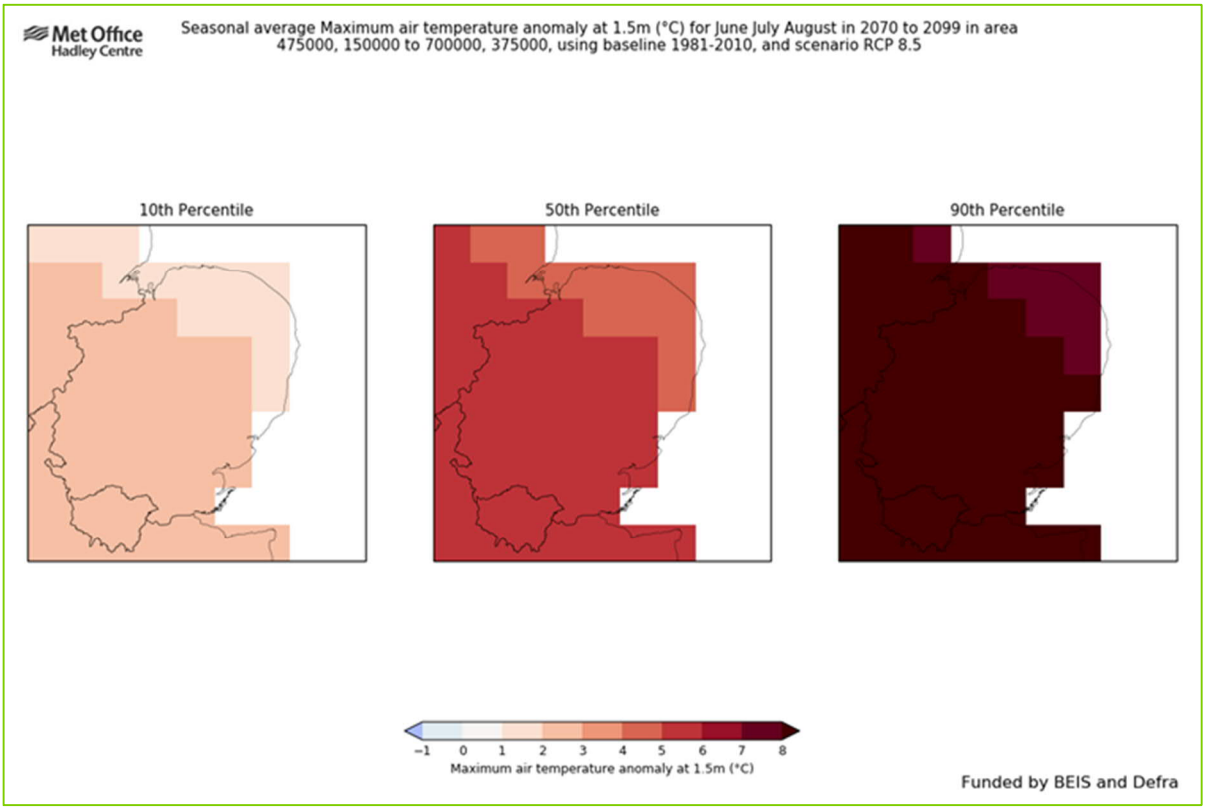
Plate 1.11: Mean Summer Temperature in the East of England Region for the 2080s under UKCP18 RCP8.5 Emission Scenario



1.1.55 For the summer by the 2080s, mean daily maximum summer temperature is expected to increase by up to 6°C in the majority of the region and by 5°C in the north east of the region (50th percentile) under RCP 8.5.

1.1.56 Plate 1.12 summarises changes in the mean daily maximum temperature in the summer for the 2080s under RCP8.5 (Ref 1.10).

Plate 1.12: Mean Daily Maximum Summer Temperature in the East of England Region for the 2080s under UKCP18 RCP8.5 Emission Scenario



1.1.57 In addition to changes in seasonal average temperatures, it is likely that there will be more extreme temperature events. With regard to heat waves, research published by the Met Office Hadley Centre suggests the European summer heat wave in 2003 could become a normal event by the 2040s. By the 2060s, such a summer would be considered cool according to some climate models. It is very likely (confidence level >90%) that human influence has at least doubled the risk of a heatwave exceeding mean summer temperatures experienced in 2003 (Ref 1.4).

Solar Radiation

1.1.58 A recent (regional) study suggests that the England South region (including the East of England administrative region), is likely to see an increase in annual solar radiation by the 2050s of 5.6 Watts per square meter (Wm-2) (Low), 5.3Wm-2 (Medium) or 6.2Wm-2 (High) under the central (50th percentile) estimate. By the 2080s, increases of 6.2 Wm-2 (Low), 6.8 Wm-2 (Medium) or 8.0 Wm-2 (High) under the central (50th percentile) estimate are projected (Ref 1.4). All regions of the UK are likely to have increased cloud cover (although there is large uncertainty around future projections of cloud cover) and therefore slightly less solar radiation during the winter.

Wind

1.1.59 The UKCP18 global projections over the UK show an increase in near surface wind speeds over the UK for the second half of the 21st century for the winter season when more significant impacts of wind are experienced. This is accompanied by an increase in frequency of winter storms over the UK.

1.1.60 There is large uncertainty in projected changes in circulation over the UK and natural climate variability contributes much of this uncertainty (Ref 1.7). It is therefore difficult to represent regional wind extreme winds and gusts within regional climate models (Ref 1.8).

1.1.61 Central estimates of change in mean wind speed for the 2050s are small in all ensemble runs (<0.2ms-1). A wind speed of 0.2 ms−1 (~0.4 knots) is small compared with the typical magnitude of summer mean wind speed of about 3.6–5.1 ms-1 (7–10 knots) over much of England (Ref 1.2). Seasonal changes at individual locations across the UK lie within the range of –15% to +10%. Results suggest that there could be a future reduction in the summer westerly wind flows over the southern half of the UK. There may be an increase in westerly flows in the north during summer and also an increase in southerly flows over the UK in winter (Ref 1.11).

Relative Humidity

1.1.62 Relative Humidity is the most common measure of humidity. It measures how close the air is to being saturated. UKCP18 does not currently have projections for humidity, therefore data from UKCO09 has been used.

1.1.63 By the 2050s, projections for winter mean relative humidity in the East of England region suggest a decrease of up to 5% under the high emissions scenario (central estimate). By the 2080s, winter mean relative humidity could increase by up to 5% (high emissions scenario, central estimate). The projection for summer mean humidity in the 2050s under the high emissions scenario is a decrease of up to 5% (central estimate). By the 2080s the decrease could be as much as 10% (high emissions scenario, central estimate) (Ref 1.12).

Extreme Climate Change Scenarios

1.1.64 A range of ‘extreme’ climate change scenarios (produced by Wade et al., 2015 (Ref 1.9) have also been reviewed. These scenarios provide a high-impact, low-likelihood event to compare against more likely outcomes. Wade et al., (2015) considered a range of climate variables including heatwaves, cold snaps, low and high rainfall, droughts, floods and windstorms. The H++ scenarios fall outside the ‘likely’ range of UK climate projections and represent scenarios beyond the lower and upper (10th to

90th) percentile range of the 2080s UKCP09 High emissions scenario as presented in the UKCP09 projections and reported here.

1.1.65 The H++ scenarios suggest that average summer maximum temperatures will exceed 30°C across most of the UK, with temperatures of the hottest days are also likely to exceed 40°C (Ref 1.9). The H++ scenarios for heavy daily and sub-daily rainfall suggest that, for the same period, there is a 60% to 80% increase in rainfall for summer or winter events based on a consideration of new high-resolution modelling and physical processes. This is within the UKCP09 distribution range for the 2080s High emissions "wettest day of the winter" variable but higher than uplifts previously considered for summer.

Exposure Rating

1.1.66 As detailed under paragraphs 1.1.5 to 1.1.8, the exposure of the receptor to projected change in climate variables (base in information on observed climate and projected climate) is assessed. Based on the climate change projections for the East of England region, Table 1.9 indicates the level of exposure of the Scheme to changes in climate variables.

Table 1.9: Exposure Assessment

Climate Variable		Scheme Element Exposure Rating		
		Road	Bridges	Cycle and Footway
Sea	Sea Level Rise	High		
	Storm Surge and Storm Tide	High		
Precipitation	Changes in Annual Average	Medium		
	Drought	High		
	Extreme Precipitation Events	High		
Temperature	Extreme Temperature Events	High		
	Solar Radiation	Medium		
Wind	Gales and High Winds	Medium		

Climate Variable		Scheme Element Exposure Rating		
		Road	Bridges	Cycle and Footway
	Storms	Medium		
Soils	Soil Moisture	High		
	Soil Salinity	High		
	Runoff	Medium		
	Soil Stability	High		

Vulnerability Rating

1.1.67 As described under paragraphs 1.1.5 to 1.1.8, the sensitivity and exposure analyses are combined to provide an overall assessment of vulnerability of the Scheme. Table 1.10, Table 1.11, Table 1.12 present the overall assessment of vulnerability for the road, bridge and cycle and footway elements of the Scheme respectively.

Table 1.10: Vulnerability Rating Assessment for Road Elements of the Scheme

Climate Variable		Sensitivity	Exposure	Vulnerability
Sea	Sea Level Rise	Medium	High	Medium
	Storm Surge	High	High	High
Precipitation	Changes in Annual Average	Medium	Medium	Medium
	Drought	Medium	High	Medium
	Extreme Events	High	High	High
Temperature	Extreme Temperature Events	High	High	High
	Solar Radiation	Medium	Medium	Medium
Wind	Gales and High Winds	Medium	Medium	Medium

Climate Variable		Sensitivity	Exposure	Vulnerability
	Storms	Low	Medium	Low
Soils	Soil Moisture	Medium	High	Medium
	Soil Salinity	Low	High	Low
	Runoff	Medium	Medium	Medium
	Soil Stability	Medium	High	Medium

Table 1.11: Vulnerability Rating Assessment for Bridge Elements of the Scheme

Climate Variable		Sensitivity	Exposure	Vulnerability
Sea	Sea Level Rise	Medium	High	Medium
	Storm Surge	High	High	High
Precipitation	Extreme Events	High	High	High
Temperature	Extreme Temperature Events	High	High	High
	Solar Radiation	Low	Medium	Low
Wind	Gales and High Winds	High	Medium	Medium
	Storms	High	Medium	Medium
Soils	Soil Stability	High	High	High
	Soil Salinity	Medium	High	Medium

Table 1.12: Vulnerability Rating Assessment for Cycle and Footway Elements of the Scheme

Climate Variable		Sensitivity	Exposure	Vulnerability
Sea	Sea Level Rise	Medium	High	Medium
	Storm Surge	Medium	High	Medium
Precipitation	Changes in Annual Average	Low	Medium	Low

Climate Variable		Sensitivity	Exposure	Vulnerability
	Drought	Medium	High	Medium
	Extreme Events	Medium	High	Medium
Temperature	Extreme Temperature Events	Medium	High	Medium
	Solar Radiation	Low	Medium	Low
Wind	Gales and High Winds	Low	Medium	Low
	Storms	Low	Medium	Low
Soils	Soil Moisture	Medium	High	Medium
	Soil Salinity	Low	High	Low
	Runoff	Medium	Medium	Medium
	Soil Stability	Medium	High	Medium

1.2 References

Ref 1.1: Standards Australia (2013) Climate Change Adaptation for settlements and infrastructure – a risk-based approach. SAI Global Limited.

Ref 1.2: Jenkins, G.J., Perry, M.C., and Prior, M.J. (2008). The climate of the United Kingdom and recent trends. Met Office Hadley Centre, Exeter, UK.

Ref 1.3: Eastern England Climate, Met Office (accessed 2019). https://www.metoffice.gov.uk/climate/uk/regional-climates/ee

Ref 1.4: Burnett, D., Barbour, E. and Harrison, G.P. (2014) The UK solar energy resource and the impact of climate change. Renewable Energy, 71, 333-343

Ref 1.5: Jenkins, G.J., Perry, M.C., and Prior, M.J. (2008). The climate of the United Kingdom and recent trends. Met Office Hadley Centre, Exeter, UK.

Ref 1.6: Review of UK climate indicators, Defra. http://www.ecn.ac.uk/iccuk/indicators/9.htm.

Ref 1.7: Brown, S., Boorman, P., McDonald, R., and Murphy. J. (2012) Interpretation for use of surface wind speed projections from the 11-member Met Office Regional Climate Model ensemble. Post-launch technical documentation for UKCP09. Met Office Hadley Centre, Exeter, UK. Crown copyright.

Ref 1.8: Brown, S., Boorman, P., Buonomo, E., Burke, E., Caesar, J., Clark, R., McDonald, R. and Perry, M. (2008) A climatology of extremes for the UK: A baseline for UKCP09. Met Office Hadley Centre, Exeter.

Ref 1.9: Wade, S., Sanderson, M., Golding, N., Lowe, J., Betts, R., Reynard, N., Kay, A., Stewart, L., Prudhomme, C., Shaffrey, L., Lloyd-Hughes, B., Harvey, B. (2015). Developing H++ climate change scenarios for heat waves, droughts, floods, windstorms and cold snaps. Met Office Hadley Centre, Exeter, UK. Crown copyright.

Ref 1.10: UK Climate Projections 2018, produced by Department for Environment and Rural Affairs, Department for Business, Energy and Industrial Strategy, Met Office and Environment Agency.

Ref 1.11: Met Office Hemsby Climate https://www.metoffice.gov.uk/public/weather/climate/u135wx0y1

Ref 1.12: UK Climate Projections 2009, produced by British Atmospheric Data Centre, Environment Agency, Marine Climate Change Impacts Partnership, Met

Office, National Oceanography Centre, Newcastle University, Tyndall Centre, University of East Anglia.

Ref 1.13: IEMA (2015), Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation.

Ref 1.14: European Commission (2016), Climate Change and Major Projects.

Ref 1.15: Met Office (2018) UKCP18 Factsheet: Sea level risk and storm surge

Great Yarmouth Third River Crossing

Application for Development Consent Order

Document 6.2: Environmental Statement Volume II: Technical Appendix 13C: Climate Change Risk Assessment

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended) ("APFP")

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Planning Inspectorate Reference Number: TR010043

Author: Norfolk County Council

Document Reference: 6.2 – Technical Appendix 13C

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Date: 30 April 2019

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Tables

1 Climate Change Risk Assessment

1.1.1 In line with published guidance (primarily IEMA (2015), Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation (Ref 1.14) and European Commission (2016), Climate Change and Major Projects (Ref 1.15), the assessment of climate vulnerability and risk in the EIA process consists of five steps:

- **Step 1**: Identify receptors and analyse policy context;
- **Step 2**: Climate vulnerability assessment;
- **Step 3**: Risk assessment;
- **Step 4**: Adaptation measures and
- **Step 5:** Determination of significance.

1.1.2 This Appendix presents the detailed assessment and findings of Step 3.

Step 3: Risk Assessment

1.1.3 The full methodology for the risk assessment is presented in Chapter 13, paragraphs 13.6.11 to 13.6.14.

1.1.4 The risk assessment identifies hazardous related to the 'medium' and 'high' vulnerabilities identified in Step 2. The climate and weather-related risks affecting the Scheme receptors over the construction and operational phases associated with the medium and high vulnerabilities are presented in Table 1.1 of this Appendix.

1.1.5 Unless stated, the impacts identified in the table below are expected to impact the whole Scheme. The terms 'road', 'bridge' and 'cycle and footway' are used throughout this Appendix, Chapter 13: Climate Change (document reference 6.1) and Appendix 13B:

- The 'road' including the new dual carriageway road, five-arm roundabout signalised junction junctions and reinforced earth embankments;
- 'Bridges' including the new double-leaf bascule bridge and associated substructure and 'knuckle' walls and associated control tower, plant room control equipment, and single span bridge over Southtown Road; and
- The 'cycle and footway' comprising the cycle and pedestrian provision.

1.1.6 The risk assessment is then undertaken by considering the likelihood of climate hazards occurring and the consequences to Scheme elements through a quantitative assessment based on professional judgement. The consequence and likelihood ratings are combined to develop a climate risk rating for each element of the Scheme relative to a specific climate hazard as presented in Table 1.2.

Table 1.1: Climate Variables and Associated Hazards / Opportunities for the Scheme

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
Sea	Sea level rise (applicable to road, bridges, cycle and footway)	Damage to road, bridge, cycle and footway structures due to flooding Soil softening and erosion leading to collapse and settlement of structures Increased slope instability Soil saturation	Deformation of rigid structures (road, bridge, cycle and footway etc). Undercutting, particularly in relation to the bridge over the River Yare	Softening of subsurface materials Blockage of drains and associated assets	Greater mobilisation of pollutants in the soil/ground causing premature deterioration of materials Increase in soil salinity leading to deterioration of materials	Road, bridge, cycle and footway closure due to flooding Scour of embankments leading to increased maintenance	Health and safety risks to road, bridge, cycle and footway users from sea level rise (such as flooding, damage to structures).
	Storm surge	Damage to road, bridge,	Undercutting, particularly in	Blockage of drains and	Greater mobilisation	Road, bridge, cycle and	Health and safety risks

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
	(applicable to road, bridges, cycle and footway)	cycle and footway structures due to flooding Subsidence impacting road, bridge, cycle and footway structures	relation to the bridge over the River Yare	associated assets	of pollutants in the soil/ground causing premature deterioration of materials	footway closure due to flooding Traffic disruption and congestion	to road, bridge, cycle and footway users from storm surge (such as flooding, damage to structures).
Precipitation	Changes in annual average – drier summers (applicable to road)	Failure of earthworks due to desiccation Shrinking and cracking of soils leading to subsidence	Shrinking and cracking of soils leading to cracking of road surface	Damage and disruption from fires Die-back of vegetation	Enhanced reactions when cement stabilising and drying of concrete	Increased dust and windborne materials affecting site construction, operation and maintenance, including silting and sedimentation	Fewer construction days lost to heavy rainfall More dust

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
	Changes in annual average – wetter winters (applicable to road)	Flooding and damage due to increased run-off Soil softening and erosion leading to collapse and settlement of soil structures Increased slope instability Soil saturation	Deformation of rigid structures Damage to unpaved shoulders	Blockage / overwhelming of drains and associated assets Water accumulation in low spots and/or on impermeable surfaces Excessive vegetation growth Softening of subsurface materials	Greater mobilisation of pollutants in the soil/ground More rapid erosion of materials	Increasingly difficult working conditions, including time available to undertake works Reduced opportunities for maintenance	Movement of debris causing slip, trip and fall hazards Increased risk of aquaplaning Construction days lost to heavy rainfall

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
	Drought (applicable to road, cycle and footway)	Failure of earthworks due to desiccation, particularly impacting the road structure Shrinking and cracking of soils leading to subsidence	Drying out of construction materials and cracking Deformation of rigid structures, particularly road, cycle and footway	Damage and disruption from fires Die-back of vegetation	Enhanced reactions when cement stabilising and drying of concrete Increased rate of deterioration of materials, potentially leading to need for early replacement Shrinking and cracking	No applicable impact	More dust Evaporation of construction water
	Extreme rainfall events (applicable to road, bridges,	Damage to road, bridge, cycle and footway	Deformation of rigid structures	Drains and culverts becoming overwhelmed	Accelerated deterioration of materials	Water accumulation causing disruption to	Difficult working conditions

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
	cycle and footway)	structures due to flooding and increased run-off Soil saturation and water damage Undercutting particularly in relation to the bridge over the River Yare Increased slope instability Erosion, silting and sedimentation	Damage to unpaved shoulders	Blockages of drainage assets	Greater mobilisation of pollutants in soil/ground causing premature deterioration of materials	construction and operation Stopping of services due to asset failure Scour of embankments leading to increased maintenance Traffic disruption and congestion	Movement of debris causing slip, trip and fall hazards Health and safety risks to road users from extreme rainfall (such as flooding and standing water).

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
		Softening of subsurface materials					
Temperature	Extreme temperature events (applicable to road, bridges, cycle and footway)	Cracking and expansion, particularly impacting road, bridge, cycle and footway structures Increased risk of erosion	Damage and disruption from e.g. fires Deformation of structures and materials	Overheating of equipment, including during construction and operation (e.g. electronic signage) Failure of temperature controls	Enhanced reactions when cement is stabilising and drying of concrete UV degradation of exposed equipment e.g. cabling	Reduced working periods and delays Risks to stored equipment, including waste Reduced opportunities for maintenance Operational disruption	Difficult working conditions Increased fire risk Hot surfaces which may cause injury Health and safety risks to road users from extreme temperature events such as exposure, damaged road, bridges,

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase) Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
							cycle and footpath surfaces).
	Solar radiation (applicable to road)	No applicable impact	No applicable impact	Increased solar gain (i.e. glare and warming of exposed surfaces)	Deformation of materials UV degradation of exposed equipment e.g. cabling	Reduced opportunities for maintenance	Health and safety risks to road users and operatives from exposure to solar radiation.
Wind	Gales and high winds (applicable to road, bridges)	Risk of damage to road and bridge structures Erosion of banks and	Damage from high winds and rain-infiltration into surfaces and materials	Damage from high winds and rain-infiltration into surfaces and materials	Increased rate of deterioration of materials	Reduced opportunities for maintenance Operational disruption	Difficult working conditions Health and safety risks to road users, particularly

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase) Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
		exposed surfaces		Damage to signage and site structures			high sided vehicles from gales and high winds, debris.
	Storms (applicable to bridges)	Destabilisation due to lighting strike, particularly to the bridge and associated control tower	No applicable impact	Destabilisation due to lighting strike, particularly to the bridge and associated control tower	No applicable impact	Risk to power sources Risk to operation of the bridge and control tower through loss of power Fire risk	Difficult working conditions Health and safety risks to road users from storms, such as exposure, debris, strong winds or rain.
Soils	Soil moisture (applicable to road, cycle and footway)	Shrinking and cracking of soils leading to subsidence	Cracking of structures	Shrinking and cracking of soils leading to subsidence	Greater mobilisation of pollutants	Increased maintenance costs and	Difficult working conditions

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
		Soil softening and erosion leading to collapse and settlement of structures Increased slope instability Soil saturation			in the soil/ground	risks to operation	Risk from slope instability
	Soil Salinity (applicable to bridges)	No applicable impact	No applicable impact	No applicable impact	Increased rate of deterioration of materials, potentially leading to need for early replacement	No applicable impact	No applicable impact

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
	Runoff (applicable to road, cycle and footway)	Flooding and damage due to increased run-off Soil saturation	Damage to unpaved shoulders	Blockage / overwhelming of drains and associated assets Drains and culverts becoming overwhelmed Water accumulation in low spots and/or on impermeable surfaces	More rapid erosion of materials	Increasingly difficult working conditions, including time available to undertake works	Movement of debris causing slip, trip and fall hazards Increased risk of aquaplaning
	Soil stability (applicable to road, bridges, cycle and footway)	Subsidence impacting road, bridge, cycle and footway structures Failure of earthworks	No applicable impact	Increased rate of deterioration, potentially leading to need for early replacement	Increased rate of deterioration of materials	Increased maintenance costs and risks to operation	Movement of debris causing slip, trip and fall hazards

Climate Variable	Associated Hazards / Opportunities	Impact (construction and operational phase)					
		Structural Stability	Structural Robustness	Ancillary Equipment	Material Durability	Site Contents and Business Continuity	Health and safety (H&S of Users (operators and customers)
		due to desiccation Shrinking and cracking of soils Greater rates of soil erosion					

1.1.7 The severity of risk of the impacts described above depends on the likelihood of them occurring and the consequence if they do occur. Table 1.2 presents risk ratings for each of the identified climate risks, across both the construction and operational phases, to the Scheme based on a qualitative assessment of likelihood and consequence.

Table 1.2: Risk Assessment

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
Structural stability	Sea level rise (applicable to road, bridges, cycle and footway)	Damage to road, bridge, cycle and footway structures due to flooding	Moderate adverse	Low	Medium
		Soil softening and erosion leading to collapse and settlement of soil structures	Minor adverse	Low	Low
		Increased slope instability	Moderate adverse	Low	Medium
		Soil saturation	Minor adverse	Medium	Low
	Storm surge (applicable to road, bridges, cycle and footway)	Damage to road, bridge, cycle and footway structures due to flooding	Moderate adverse	Low	Medium
		Subsidence impacting road, bridge, cycle and footway structures leading to subsidence	Moderate adverse	Low	Medium
	Changes in annual average – drier summers (applicable to road)	Failure of earthworks due to desiccation	Large adverse	Low	Medium
		Shrinking and cracking of soils leading to subsidence	Minor adverse	Medium	Low
	Changes in annual average – wetter winters	Flooding and damage due to increased run-off	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	(applicable to road)	Soil softening and erosion leading to collapse and settlement of soil structures	Moderate adverse	Low	Medium
		Increased slope instability	Large adverse	Low	Medium
		Soil saturation	Minor adverse	Low	Low
	Drought (applicable to road, cycle and footway)	Failure of earthworks due to desiccation, particularly impacting the road structure	Large adverse	Low	Medium
		Shrinking and cracking of soils leading to subsidence	Moderate adverse	Medium	Medium
	Extreme rainfall events (applicable to road, bridges, cycle and footway)	Damage to road, bridge, cycle and footway structures due to flooding and increased run-off	Minor adverse	Medium	Low
		Soil saturation and water damage	Moderate adverse	Low	Medium
		Undercutting particularly in relation to the bridge over the River Yare	Large adverse	Low	Medium
		Increased slope instability	Moderate adverse	Low	Medium
		Erosion, silting and sedimentation	Minor adverse	Medium	Low
		Softening of subsurface materials	Moderate adverse	Low	Medium

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	Extreme temperature events (applicable to road, bridges, cycle and footway)	Cracking and expansion, particularly impacting road, bridge, cycle and footway structures	Moderate adverse	Medium	Medium
		Increased risk of erosion	Minor adverse	Medium	Low
	Gales and high winds (applicable to road, bridges)	Risk of damage to road and bridge structures and foundations	Moderate adverse	Low	Medium
		Erosion of banks and exposed surfaces	Minor adverse	Medium	Low
	Storms (applicable to bridges)	Destabilisation due to lighting strike, particularly to the bridge and associated control tower	Large adverse	Very low	Medium
	Soil moisture (applicable to road, cycle and footway)	Shrinking and cracking of soils leading to subsidence	Moderate adverse	Medium	Medium
		Soil softening and erosion leading to collapse and settlement of structures	Moderate adverse	Low	Medium
		Increased slope instability	Moderate adverse	Low	Medium
		Soil saturation	Minor adverse	Low	Low
	Runoff (applicable to road, cycle and footway)	Flooding and damage due to increased run-off	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
		Soil saturation	Minor adverse	Low	Low
	Soil stability (applicable to road, bridges, cycle and footway)	Subsidence impacting road, bridge, cycle and footway structures	Moderate adverse	Medium	Medium
		Failure of earthworks due to desiccation	Moderate adverse	Low	Medium
		Shrinking and cracking of soils	Moderate adverse	Medium	Medium
		Greater rates of soil erosion	Minor adverse	Medium	Low
Structural robustness	Sea level rise (applicable to road, bridges, cycle and footway)	Deformation of rigid structures (road, bridge, cycle and footway etc).	Moderate adverse	Low	Medium
		Undercutting, particularly in relation to the bridge over the River Yare	Moderate adverse	Low	Medium
	Storm surge (applicable to road, bridges, cycle and footway)	Undercutting, particularly in relation to the bridge over the River Yare	Moderate adverse	Low	Medium
	Changes in annual average – drier summers (applicable to road)	Shrinking and cracking of soils leading to cracking of road surface	Moderate adverse	Medium	Medium
	Changes in annual average – wetter winters (applicable to road)	Deformation of rigid structures	Moderate adverse	Low	Medium
		Damage to unpaved shoulders	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	Drought (applicable to road, cycle and footway)	Drying out of construction materials and cracking	Minor adverse	Medium	Low
		Deformation of rigid structures, particularly road, cycle and footway	Moderate adverse	Low	Medium
	Extreme rainfall events (applicable to road, bridges, cycle and footway)	Deformation of rigid structures	Moderate adverse	Low	Medium
		Damage to unpaved shoulders	Minor adverse	Medium	Low
	Extreme temperature events (applicable to road, bridges, cycle and footway)	Damage and disruption from fires	Minor adverse	Low	Low
		Deformation of structures and materials	Moderate adverse	Medium	Medium
	Gales and high winds (applicable to road, bridges)	Damage from high winds and rain-infiltration into surfaces and materials	Minor adverse	Medium	Low
	Soil moisture (applicable to road, cycle and footway)	Cracking of structures	Moderate adverse	Medium	Medium
	Runoff (applicable to road, cycle and footway)	Damage to unpaved shoulders	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
Ancillary equipment	Sea level rise (applicable to road, bridges, cycle and footway)	Softening of subsurface materials	Moderate adverse	Low	Medium
		Blockage of drains and associated assets	Minor adverse	High	Medium
	Storm surge (applicable to road, bridges, cycle and footway)	Blockage of drains and associated assets	Minor adverse	High	Medium
	Changes in annual average – drier summers (applicable to road)	Damage and disruption from fires	Minor adverse	Low	Low
		Die-back of vegetation	Minor adverse	Medium	Low
	Changes in annual average – wetter winters (applicable to road)	Blockage / overwhelming of drains and associated assets	Minor adverse	High	Medium
		Water accumulation in low spots and/or on impermeable surfaces	Minor adverse	Medium	Low
		Excessive vegetation growth	Minor adverse	Medium	Low
		Softening of subsurface materials	Moderate adverse	Medium	Medium
	Drought (applicable to road, cycle and footway)	Damage and disruption from fires	Minor adverse	Low	Low
		Die-back of vegetation	Minor adverse	Medium	Low
	Extreme rainfall events	Drains and culverts becoming overwhelmed	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	(applicable to road, bridges, cycle and footway)	Blockages of drainage assets	Minor adverse	High	Medium
	Extreme temperature events (applicable to road, bridges, cycle and footway)	Overheating of equipment, including during construction and operation (e.g. electronic signage)	Minor adverse	Low	Low
		Failure of temperature controls	Moderate adverse	Low	Medium
	Solar radiation (applicable to road)	Increased solar gain (i.e. glare and warming of exposed surfaces)	Minor adverse	Medium	Low
	Gales and high winds (applicable to road, bridges)	Damage from high winds and rain-infiltration into surfaces and materials	Minor adverse	Medium	Low
		Damage to signage and site structures	Minor adverse	Medium	Low
	Storms (applicable to bridges)	Destabilisation due to lighting strike, particularly to the bridge and associated control tower	Large adverse	Very low	Medium
	Soil moisture (applicable to road, cycle and footway)	Shrinking and cracking of soils leading to subsidence	Moderate adverse	Medium	Medium
	Runoff (applicable to road, cycle and footway)	Blockage / overwhelming of drains and associated assets	Minor adverse	High	Medium

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
		Drains and culverts becoming overwhelmed	Minor adverse	Medium	Low
		Water accumulation in low spots and/or on impermeable surfaces	Minor adverse	Medium	Low
	Soil stability (applicable to road, bridges, cycle and footway)	Increased rate of deterioration, potentially leading to need for early replacement	Minor adverse	Medium	Low
Material durability	Sea level rise (applicable to road, bridges, cycle and footway)	Greater mobilisation of pollutants in the soil/ground causing premature deterioration of materials	Minor adverse	Low	Low
		Increase in soil salinity leading to deterioration of materials	Minor adverse	Low	Low
	Storm surge (applicable to road, bridges, cycle and footway)	Greater mobilisation of pollutants in the soil/ground causing premature deterioration of materials	Minor adverse	Low	Low
	Changes in annual average – drier summers (applicable to road)	Enhanced reactions when cement stabilising and drying of concrete	Minor beneficial	Medium	Not applicable, beneficial effect
	Changes in annual average – wetter winters (applicable to road)	Greater mobilisation of pollutants in the soil/ground	Minor adverse	Low	Low
		More rapid erosion of materials	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	Drought (applicable to road, cycle and footway)	Enhanced reactions when cement stabilising and drying of concrete	Minor beneficial	Medium	Not applicable, beneficial effect
		Increased rate of deterioration of materials, potentially leading to need for early replacement	Minor adverse	Medium	Low
		Shrinking and cracking	Minor adverse	Medium	Low
	Extreme rainfall events (applicable to road, bridges, cycle and footway)	Accelerated deterioration of materials	Minor adverse	Medium	Low
		Greater mobilisation of pollutants in soil/ground causing premature deterioration of materials	Minor adverse	Low	Low
	Extreme temperature events (applicable to road, bridges, cycle and footway)	Enhanced reactions when cement is stabilising and drying of concrete	Minor beneficial	Medium	Not applicable, beneficial effect
		UV degradation of exposed equipment e.g. cabling	Minor adverse	Low	Low
	Solar radiation (applicable to road)	Deformation of materials	Moderate adverse	Low	Medium
		UV degradation of exposed equipment e.g. cabling	Minor adverse	Low	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	Gales and high winds (applicable to road, bridges)	Increased rate of deterioration of materials	Minor adverse	Medium	Low
	Soil moisture (applicable to road, cycle and footway)	Greater mobilisation of pollutants in the soil/ground	Minor adverse	Low	Low
	Soil Salinity (applicable to bridges)	Increased rate of deterioration of materials, potentially leading to need for early replacement	Minor adverse	Low	Low
	Runoff (applicable to road, cycle and footway)	More rapid erosion of materials	Minor adverse	Medium	Low
	Soil stability (applicable to road, bridges, cycle and footway)	Increased rate of deterioration of materials	Minor adverse	Low	Low
Site contents and business continuity	Sea level rise (applicable to road, bridges, cycle and footway)	Road, bridge, cycle and footway closure due to flooding	Moderate adverse	Low	Medium
		Scour of embankments leading to increased maintenance	Moderate adverse	Low	Medium
	Storm surge (applicable to road, bridges, cycle and footway	Road, bridge, cycle and footway closure due to flooding	Moderate adverse	Low	Medium
		Traffic disruption and congestion	Moderate adverse	Low	Medium

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	Changes in annual average – drier summers (applicable to road)	Increased dust and windborne materials affecting site construction, operation and maintenance, including silting and sedimentation	Minor adverse	Medium	Low
	Changes in annual average – wetter winters (applicable to road)	Increasingly difficult working conditions, including time available to undertake works	Minor adverse	High	Medium
		Reduced opportunities for maintenance	Minor adverse	High	Medium
	Extreme rainfall events (applicable to road, bridges, cycle and footway)	Water accumulation causing disruption to construction and operation	Minor adverse	High	Medium
		Stopping of services due to asset failure	Moderate adverse	Low	Medium
		Scour of embankments leading to increased maintenance	Moderate adverse	Medium	Medium
		Traffic disruption and congestion	Moderate adverse	Medium	Medium
	Extreme temperature events	Reduced working periods and delays	Minor adverse	High	Medium
		Risks to stored equipment, including waste	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	(applicable to road, bridges, cycle and footway)	Reduced opportunities for maintenance	Minor adverse	High	Medium
		Operational disruption	Minor adverse	Medium	Low
	Solar radiation (applicable to road)	Reduced opportunities for maintenance	Minor adverse	Medium	Low
	Gales and high winds (applicable to road, bridges)	Reduced opportunities for maintenance	Minor adverse	Medium	Low
		Operational disruption	Moderate adverse	Medium	Medium
	Storms (applicable to bridges)	Risk to power sources	Moderate adverse	Low	Medium
		Risk to operation of the bridge and control tower through loss of power	Moderate adverse	Low	Medium
		Fire risk	Moderate adverse	Low	Medium
	Soil moisture (applicable to road, cycle and footway)	Increased maintenance costs and risks to operation	Minor adverse	Low	Low
	Runoff (applicable to road, cycle and footway)	Increasingly difficult working conditions, including time available to undertake works	Minor adverse	High	Medium
	Soil stability	Increased maintenance costs and risks to operation	Minor adverse	Low	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	(applicable to road, bridges, cycle and footway)				
H&S of users (operators and customers)	Sea level rise (applicable to road, bridges, cycle and footway)	Health and safety risks to road, bridge, cycle and footway users	Minor adverse	Low	Low
	Storm surge (applicable to road, bridges, cycle and footway)	Health and safety risks to road, bridge, cycle and footway users	Minor adverse	Low	Low
	Changes in annual average – drier summers (applicable to road	Fewer construction days lost to heavy rainfall	Minor beneficial	Medium	Not applicable, beneficial effect
		More dust	Minor adverse	Medium	Low
	Changes in annual average – wetter winters (applicable to road)	Movement of debris causing slip, trip and fall hazards	Minor adverse	Medium	Low
		Increased risk of aquaplaning	Minor adverse	Medium	Low
		Construction days lost to heavy rainfall	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	Drought (applicable to road, cycle and footway)	More dust	Minor adverse	Medium	Low
		Evaporation of construction water	Minor adverse	Medium	Low
	Extreme rainfall events (applicable to road, bridges, cycle and footway)	Difficult working conditions	Minor adverse	Medium	Low
		Movement of debris causing slip, trip and fall hazards	Minor adverse	Medium	Low
		Health and safety risks to road users	Minor adverse	Medium	Low
	Extreme temperature events (applicable to road, bridges, cycle and footway)	Difficult working conditions	Minor adverse	Medium	Low
		Increased fire risk	Minor adverse	Low	Low
		Hot surfaces which may cause injury	Minor adverse	Low	Low
		Health and safety risks to road users	Minor adverse	Medium	Low
	Solar radiation (applicable to road)	Health and safety risks to road users and operatives	Minor adverse	Medium	Low
	Gales and high winds (applicable to road, bridges)	Difficult working conditions	Minor adverse	High	Medium
		Health and safety risks to road users, particularly high sided vehicles	Moderate adverse	High	Medium
	Storms (applicable to bridges)	Difficult working conditions	Minor adverse	Medium	Low
		Health and safety risks to road users	Minor adverse	Medium	Low

Component	Description of Risk Hazard	Risk	Consequence	Likelihood	Risk Rating
	Soil moisture (applicable to road, cycle and footway)	Difficult working conditions	Minor adverse	Low	Low
		Risk from slope instability	Moderate adverse	Low	Medium
	Runoff (applicable to road, cycle and footway)	Movement of debris causing slip, trip and fall hazards	Minor adverse	Medium	Low
		Increased risk of aquaplaning	Minor adverse	Medium	Low
	Soil stability (applicable to road, bridges, cycle and footway)	Movement of debris causing slip, trip and fall hazards	Minor adverse	Medium	Low