Lower Thames Crossing

6.1 Environmental Statement Chapter 15 – Climate

APFP Regulation 5(2)(a)

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

Volume 6

DATE: October 2022

Planning Inspectorate Scheme Ref: TR010032
Application Document Ref: TR010032/APP/6.1

VERSION: 1.0

Lower Thames Crossing

6.1 Environmental Statement
Chapter 15 – Climate

List of contents

Page number

List of tables

Page number

List of plates

Page number

15 Climate

15.1 Introduction

15.1.1 This chapter presents an assessment of the likely significant effects of the A122 Lower Thames Crossing (the Project) on climate during construction and operation.

15.1.2 The assessment follows the methodology set out in the Design Manual for Roads and Bridges (DMRB) LA 114 Climate (Highways England, 2021), which requires the assessment, reporting and management of effects of the Project on the climate, along with the effects of climate on the Project.

15.1.3 This chapter is supported by additional information contained in the following appendices (Application Document 6.3):

a. Appendix 15.1: Climate Legislation and Policy

b. Appendix 15.2: Climate Resilience Baseline

c. Appendix 15.3: Climate Resilience Impacts and Effects

15.1.4 In addition to the supporting appendices, a number of other documents are closely linked to the climate assessment, namely:

a. Chapter 14: Road Drainage and the Water Environment

b. Appendix 14.6: Flood Risk Assessment (FRA) (Application Document 6.3)

c. Carbon and Energy Management Plan (Application Document 7.19)

15.1.5 The chapter uses the term ‘carbon’ as shorthand for greenhouse gases.

15.2 Legislative and policy framework

15.2.1 This assessment has been undertaken in accordance with relevant legislation and having regard to national and local plans and policies.

15.2.2 Appendix 15.1 sets out how the Applicant has considered and addressed those policies in the NPSs which relate to the assessment of effects considered in this chapter of the Environmental Statement. Policies in the NPSs which relate to decision making in relation to matters of relevance to this topic of the ES are addressed in the Planning Statement (Application Document 7.2).

Legislative requirements

15.2.3 Relevant international treaties and national legislative requirements that have been considered during the assessment are presented and described in Table 1.1 of Appendix 15.1 (Application Document 6.3), together with the related Project response. This includes the Climate Change Act 2008 (CCA), which sets a statutory framework for the UK to reduce GHG emissions and build capacity to adapt and strengthen resilience to climate risks.

National policy

National Policy Statements

15.2.4 Nationally Significant Infrastructure Projects (NSIPs) are determined in accordance with the decision-making framework in the Planning Act 2008 (as amended) and relevant National Policy Statements (NPSs), as well as any other matters that are both important and relevant (which may include the National Planning Policy Framework (NPPF)) (Ministry of Housing, Communities and Local Government 2021). The relevant NPS requirements, related to both GHG emission reduction and climate adaptation and resilience, are described in Table 1.2 of Appendix 15.1 (Application Document 6.3), together with the related Project response. A summary is presented in this section.

15.2.5 The National Policy Statement for National Networks (NPSNN) (DfT, 2014) sets out the Government's policies to deliver NSIPs on the national road and rail networks in England.

15.2.6 Diversions of major energy infrastructure are also required to deliver the Project, some of which constitute NSIPs in their own right, and therefore the Project will also be assessed against the following national policy statements, in addition to the NNNPS:

a. Overarching National Policy Statement for Energy (EN-1) (Department for Energy and Climate Change, 2011a),

b. National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) (Department for Energy and Climate Change, 2011b)

c. National Policy Statement for Electricity Networks Infrastructure (EN-5) (Department for Energy and Climate Change, 2011c).

15.2.7 However, the NPSNN forms the 'case-making' basis for the Project, and the need for nationally significant utilities diversions arises solely from the need for the road element of the Project.

15.2.8 National Highways has taken these policy requirements into account during the development and design of the Project and the preparation of this ES.

15.2.9 The National Planning Policy Framework (NPPF) sets out the Government's planning policies. It provides a framework within which locally prepared plans for housing and other development can be produced.

15.2.10 The NPPF does not contain specific policies for NSIPs. However, the NPPF advises that local authorities' planning policies should take into account NSIPs which are located within their local areas. Paragraph 1.17 of the NPSNN states that the NPS and NPPF are consistent, and paragraph 1.18 explains that the NPPF is an important and relevant consideration, 'but only to the extent relevant to [the] project'.

15.2.11 Table 1.2 of Appendix 15.1: Climate Legislation and Policy (Application Document 6.3) lists the planning policies at a national level and the Project response.

15.2.12 Further information on the how the application has responded to national planning policies is available in the Planning Statement (Application Document 7.2).

Plans and strategies supporting the UK's net zero commitments

15.2.13 A number of plans and strategies have been published to set out measures to achieve a low-carbon economy, following the UK's commitment to achieve net zero emissions by 2050 through the CCA (as amended) (refer to Table 1.1 of Appendix 15.1 (Application Document 6.3) for a description of the CCA). The relevant plans and strategies are set out in Table 1.3 of Appendix 15.1. The most relevant plans and strategies are also introduced and described below.

Net Zero Strategy: Build Back Greener (HM Government, 2021)

15.2.14 The Net Zero Strategy ('the Strategy') dated October 2021 was presented to Parliament pursuant to Section 14 of the CCA. The Strategy describes policies and proposals, including budget allocations, for the following:

a. Reducing emissions across the economy, with selected targets and details as follows:

   i. Power – power system fully decarbonised by 2035

   ii. Fuel supply and hydrogen – deliver 5GW of low carbon hydrogen production capacity by 2030 whilst halving the emissions from oil and gas

   iii. Industry – deliver four carbon capture usage and storage (CCUS) clusters, capturing 20-30 MtCO2e across the economy, including 6 MtCO2e of industrial emissions, per year by 2030

   iv. Transport – start to mobilise additional public and private investment of around £220 billion in line with the 2037 delivery pathway, remove all emissions at the tailpipe and kickstart zero emissions international travel

   v. Natural resources, waste and fluorinated gases – treble woodland creation rates in England, contributing to the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of this Parliament

   vi. Greenhouse Gas Removals (GGR) – an ambition to deploy at least 5 MtCO2e / year of engineered GGRs by 2030 (Direct Air Capture and other technologies)

b. Supporting the transition across the economy:

   i. Innovation for net zero

   ii. Green investment

   iii. Green jobs, skills, and industries

   iv. Embedding net zero in Government

v. Local climate action

vi. Empowering the public and business to make green choices

vii. International leadership and collaboration

15.2.15 Some selected key commitments for the transport sector are:

a. An additional £620 million for zero-emission vehicle grants and electric vehicles infrastructure

b. Allocating £350 million of the up to £1 billion Automotive Transformation Fund (ATF) to facilitate electrification of UK vehicles and support their supply chains

c. Trials of three zero-emission Heavy Goods Vehicle (HGV) technologies at scale on UK roads to determine their operational benefits, as well as their infrastructure needs

d. £2 billion investment to help enable half of journeys in towns and cities to be cycled or walked by 2030

e. £3 billion to create integrated bus networks, more frequent services and bus lanes to speed journeys

15.2.16 It is noted that the Strategy does not provide a full implementation plan up to 2050, when net zero is required to be achieved. In the Executive Summary its status is clarified as follows: *'Whilst there are a range of ways in which net zero could be achieved in the UK, we set out a delivery pathway showing indicative emissions reductions across sectors to meet our targets up to the sixth carbon budget (2033 – 2037). This is based on our current understanding of each sector's potential, and a whole system view of where abatement is most effective. But we must be adaptable over time, as innovation will increase our understanding of the challenges, bring forward new technologies and drive down the costs of existing ones.'*

15.2.17 In a judgment handed down on 18 July 2022, the High Court ruled that the Strategy breached the Government's obligations under sections 13 and 14 CCA and was therefore unlawful. The Strategy was not quashed, pursuant to the court's ruling, however the Government is required to publish a report which addresses the matters identified by the court and to lay it before Parliament by no later than 31 March 2023.

Decarbonising Transport: A Better, Greener Britain (DfT, 2021a)

15.2.18 The Transport Decarbonisation Plan (DfT, 2021a) communicated the plan to align road, rail, maritime and air transport with the UK's net zero commitments. The plan sets out a number of commitments which aim to help reduce the transport sector's contribution to the UK's domestic carbon emissions, which it notes was responsible for 27%, or 122.5 million tonnes of carbon dioxide equivalent (tCO_2e), in 2019. The plan builds on 'Decarbonising Transport: Setting the Challenge' (DfT, 2020a).

15.2.19 The Transport Decarbonisation Plan (DfT, 2021a) identifies six strategic priorities building on the themes noted in 'Decarbonising Transport: Setting the Challenge' (DfT, 2020a), as follows:

a. Accelerating modal shift to public and active transport

b. Decarbonising road transport

c. Decarbonising the freight and logistics sector

d. Encouraging green transport technology and innovation in the UK

e. Finding place-based (local level) solutions to reduce emissions

f. Reducing carbon in a global economy

15.2.20 Key commitments noted within the plan in relation to road transport include the following:

a. Increasing cycling and walking, by investing in improved infrastructure to reduce the contribution of GHG emissions from local car journeys, with the aim of half of journeys in towns and cities being cycled or walked by 2030

b. Improving the bus and coach industry by modernising bus services, delivering zero-emission buses, and phasing out non-zero-emission buses and coaches

c. Transitioning to a zero-emission fleet of cars, vans, motorcycles, and scooters, including commitments in relation to the Government car fleet, the development of action and delivery plans (such as Transitioning to Zero Emission Cars and Vans: 2035 Delivery Plan (HM Government, 2021c)) as well as investment in the charging infrastructure and road signalling to improve traffic flows

d. Transitioning to a zero-emissions freight and logistics sector, consulting on the phase-out date for the sale of new non-zero-emission HGVs, encouraging a modal shift from road freight and transforming ‘last mile deliveries

e. Investing in innovation and technologies around sustainable, low-carbon fuels such as hydrogen

Net zero highways: our 2030/2040/2050 plan (National Highways, 2021a)

15.2.21 National Highways published its plan for achieving a net zero future for the strategic road network which is consistent with the UK's net zero obligations under the CCA.

15.2.22 The plan sets out National Highways’ commitment to achieving net zero greenhouse gas emissions by taking fast action in three areas:

a. Corporate emissions: To be net zero by 2030

b. Maintenance and construction emissions: To be net zero by 2040

c. Road-user emissions: To be net zero by 2050

15.2.23 Key actions to reach net zero corporate emissions by 2030 include the following:

a. Buying 100% of electricity from certified renewables (already implemented since 2020)

b. Replacing 70% of road lighting with LEDs by 2027

c. Supplying 10% of National Highways' electricity requirement from renewable sources on or near its own sites by 2030

d. Non-traffic officer vehicles to be 100% electric by 2027 and traffic officer vehicles by 2030

e. Planting at least three million trees by 2030

f. Following a trajectory of 75% reduction of emissions by 2025 when compared to a 2017/2018 baseline

15.2.24 Key actions within the plan in relation to reducing emissions from maintenance and construction activities to net zero by 2040 include both the embodied carbon of material assets as well as their transportation, and include the following:

a. Launching a zero-carbon construction innovation programme focusing on asphalt, cement, concrete and steel, being the core construction products, with National Highways taking the lead to create more transparency in the industry

b. Developing a near-zero plan for each procurement category by the end of 2022

c. Strategic partnerships with other infrastructure owners and suppliers in place (2022)

d. Providing clarity to the supply chain on what materials will be needed, including carbon content, and working with them to develop and agree on a roadmap to net zero for key construction products

e. Specifications (Manual of Contracts Documents for Highway Works (MCHW)) and Standards (DMRB) have integrated net zero thinking by 2022 and 2025 respectively

f. Working with and supporting manufacturers and Government on Carbon Capture and Storage (CCS) solutions. Providing market surety for CCS versions of cement and steel

g. Designing and building the first net zero major road enhancement scheme, open by 2035

h. Finalising in 2021 (issued meanwhile) and rolling out the Digital Roads vision by which capacity of existing roads will be increased thus reducing new construction

i. Following a trajectory of 0-10% reduction in emissions by 2025, 40-50% by 2030, 70 – 80% by 2035 and net zero by 2040 against the 2020 baseline

15.2.25 The plan identifies the Lower Thames Crossing as a key project to test low-carbon innovation and approaches. Further details on how the Project would be required to adopt this approach is provided in the Carbon and Energy Management Plan (Application Document 7.19).

15.2.26 Key actions to contribute to net zero road-user emissions by 2050 include the following:

a. Publishing the approach to zero carbon HGV trials by the end of 2022

b. Publishing a blueprint for electric vehicle (EV) charging services on the National Highways road network by 2023

c. Integrating a strong modal shift programme in Road Period 3 (RP3)

d. Delivering £950 million of charging infrastructure by 2023, aiming at providing at least six 150-350kW charge points at each motorway service area

e. Investment plan for HGV charging / fuelling by 2028 for RP4

f. Finalising in 2021 (issued meanwhile) and rolling out the Digital Roads vision by which capacity of existing roads will be increased (Digital Roads was published in 2021, refer to brief description below)

g. Planning for a trajectory of road-user emissions of 31-26 MtCO2e by 2025, 25-15 MtCO2e by 2030, 20-7 MtCO2e by 2035, 8-3 MtCO2e by 2040, 5-1 MtCO2e by 2045 and net zero by 2050 against a 2020 baseline of 33 MtCO2e

Digital Roads

15.2.27 Digital Roads (National Highways, 2021b) describes how the Applicant intends to improve the way roads are designed, built, operated, and used, with resulting GHG emission reduction opportunities for the Project's construction and operational phases (refer to Section 15.5 and Section 15.6 of this chapter and the Project response column in Table 1.3 of Appendix 15.1 (Application Document 6.3)). Digital Roads presents the 2025 ambitions around three themes:

a. Digital design and construction. This includes digitally enabled design, off-site fabrication, and modular and automated construction.

b. Digital operations. This includes intelligent asset management focusing on pre-emptive interventions that improve asset resilience and increase asset life.

c. Digital for customers. This includes providing customers with real-time information on travel times, which will reduce congestion.

15.2.28 The key benefits of the 2025 ambitions include carbon emission reductions, clarified in Digital Roads as follows:

a. '*The use of digital design tools will ensure that we get designs right the first time, reducing the need to make changes at later stages. The use of modular and offsite fabrication will reduce carbon emissions, shorten road closures and enable smoother customer journeys.*'

b. '*Digital design tools will enable us to consider the environmental impact of our schemes and minimise carbon emissions where possible. Offsite fabrication and modular construction will also reduce waste and minimise carbon emissions.*'

15.2.29 Among other key focus areas that drive improved environmental outcomes towards the 2050 vision, are the following:

a. Digital twin: digital representation of each physical entity enabling improvement in their design, construction, maintenance, and operation

b. Connected services: enabling smoother-flowing traffic and reduced congestion

c. Autonomous vehicles: enabling smoother-flowing traffic and reduced congestion

Further national policies, plans and assessments

15.2.30 Further relevant policies, plans, assessments and documents are listed below, and a description is provided in Table 1.3 of Appendix 15.1 (Application Document 6.3).

a. Industrial Decarbonisation Strategy (HM Government, 2021a)

b. Transitioning to Zero Emission Cars and Vans: 2035 Delivery Plan (HM Government, 2021c)

c. Ten Point Plan for a Green Industrial Revolution (HM Government, 2020)

d. The Energy White Paper – Powering our Net Zero Future (BEIS, 2020)

e. The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting. (Defra, 2018).

f. UK Climate Projections 2018 (UKCP18) (Met Office, 2018).

g. Independent Assessment of UK Climate Risk – Advice to Government for the UK's third Climate Change Risk Assessment (CCRA3) (Committee on Climate Change (CCC), 2021)

h. UK Climate Change Risk Assessment 2022 (HM Government, 2022)

i. Preparing for Climate Change on the Strategic Road Network – Third Adaptation Report under the Climate Change Act (National Highways, 2022)

Local policy framework

15.2.31 Consideration has been given to county policies within Kent, Essex, the updated London Plan and local policies relating to climate in the following local authorities within the study area: Maidstone, Tonbridge and Malling, Gravesham, Thurrock, Havering, and Brentwood. These are outlined in Table 1.4 of Appendix 15.1: Climate Legislation and Policy (Application Document 6.3) and are considered further within the Planning Statement (Application Document 7.2).

15.2.32 The local policy framework includes various local strategic flood risk assessments/strategies that have been prepared by local authorities. A description of the assessments/strategies and aspects taken into account in the Project design is provided in Part 2 of Appendix 14.6: FRA (Application Document 6.3). These are not repeated in this chapter or Appendix 15.1.

15.3 Assessment methodology

Standards and guidance

15.3.1 The following standards and guidance documents have been used in devising the methodology for data collection and assessment of climate impacts:

a. DMRB LA 114 Climate (Highways England, 2021)

b. DMRB LA 104 Environmental Assessment and Monitoring (Highways England, 2020a)

c. DMRB GG 103 Introduction and General Requirements for Sustainable Development and Design (Highways England, 2019a)

d. 2021 Government Greenhouse Gas Conversion Factors for Company Reporting (BEIS, 2021)

e. PAS 2080: 2016: Carbon Management in Infrastructure (‘PAS 2080’, herein) (British Standards Institution (BSI), 2016a)

f. GHG Protocol (World Resources Institute and World Business Council for Sustainable Development, 2015)

g. Transport Analysis Guidance (TAG) GHG Workbook (DfT, 2022a)

h. Appraisal and Modelling Strategy: A route map for updating TAG during uncertain times (DfT, 2020b)

i. Inventory of Carbon and Energy (ICE Database) v3.0 (Circular Ecology, 2019)

j. Flood risk assessments: climate change allowances (Environment Agency, 2022a)

Use of the River Thames

15.3.2 Based on the predicted vessel movements associated with the construction of the Project, as outlined in Chapter 2: Project Description, this chapter considers the related GHG emissions in the carbon model.

15.3.3 Vessel movements on the River Thames are not relevant to the assessment of vulnerability of the Project to climate change. This is because vessel movements associated with the construction of the Project would be through established facilities, that would mitigate potential climate change effects themselves. Use of the river is therefore excluded from the scope of this part of the chapter.

Scoping Opinion

15.3.4 A Scoping Report (Highways England, 2017) was submitted to the Planning Inspectorate on 2 November 2017, setting out the proposed approach to this Environmental Impact Assessment (EIA). A Scoping Opinion (Planning Inspectorate, 2017) was received from the Secretary of State on 13 December 2017, which included comments on the scope of assessment from the Planning Inspectorate and Statutory Environmental Bodies. These comments have been taken into account in the preparation of this chapter, and the Project response is set out in Appendix 4.1: The Inspectorate's Scoping Opinion and National Highways' Responses (Application Document 6.3).

15.3.5 It should be noted that since the publication of the Scoping Report the climate assessment methodology was updated to follow the requirements of DMRB LA 114 Climate (Highways England, 2021), which provides the latest guidance for assessing and reporting the effects of climate on highways (climate change resilience and adaptation), and the effect on climate due to greenhouse gas emissions resulting from the construction, operation and maintenance on highways projects. DMRB LA 114 Climate provides a defined methodology and makes provision for the requirements outlined within European Union (EU) Directive 2011/92/EU as amended by EU Directive 2014/52/EU and the CCA. The DMRB approach remains consistent with the scope of assessment confirmed in the Scoping Opinion.

15.3.6 The quantification of GHG emissions, based on PAS 2080:2016, has been extensively reported in the Carbon and Energy Management Plan (Application Document 7.19). This includes a presentation of which PAS 2080:2016 modules are included and provides an explanation of those that have been excluded. GHG emissions from the consumption of water during the operational phase and other operational processes (management of operational water and waste) have been scoped out of the assessment on the basis that each would be generating less than 1% of total estimated GHG emissions from the Project. This is in line with the Scoping Opinion – see Section 4.10 of Table 1.2 in Appendix 4.1: The Inspectorate's Scoping Opinion and National Highways' Responses (Application Document 6.3).

15.3.7 In addition, it is highly unlikely that the Project would be decommissioned before the end of the 60-year appraisal period, as the Project road would have become an integral part of the strategic road network. However, if the Project did need to be decommissioned within the appraisal period, this would conform to the statutory process at that time, and an EIA or similar assessment would be

undertaken in line with regulatory requirements at that future point in time. For example, the tunnels are likely to have an operational life well in excess of the 60-year appraisal period, as evidenced by the number of historic tunnels still in use.

15.3.8 The flexibility of future deconstruction of the highways elements was a key consideration during the Project design and would allow materials to be easily recovered and recycled when they need to be replaced. The repair and replacement of elements of the Project (e.g., resurfacing, electrical equipment) is included as part of the operation and maintenance life cycle sub-stage of the GHG assessment and has therefore been included within the assessment.

Consultation

Project consultation

15.3.9 Statutory Consultation under Section 42 of the Planning Act 2008 was undertaken on the Project from 10 October 2018 to 20 December 2018. This provided an opportunity for consultees to comment on the Preliminary Environmental Information Report (PEIR) (Highways England, 2018). A summary of the responses to the Statutory Consultation can be found in the Consultation Report (Application Document 5.1). Consultees comprised prescribed bodies, local authorities, people with an interest in land affected by the Project, and local communities.

15.3.10 The Project design continued to be developed, which included changes to the Project. These formed the basis for the Supplementary Consultation, which was undertaken from 29 January 2020 to 2 April 2020. A Design Refinement Consultation was then undertaken from 14 July 2020 to 12 August 2020.

15.3.11 A Community Impacts Consultation was undertaken from 14 July 2021 to 8 September 2021. This sought feedback on the impacts of the Project at a local ward level, as well as the mitigation proposed for those impacts. Changes to the Project since the Design Refinement Consultation were also presented, along with a summary of how feedback to earlier consultations had shaped the development of the Project.

15.3.12 Prior to the submission of this DCO application, the Local Refinement Consultation was held between 12 May 2022 and 20 June 2022. This provided local communities with the opportunity to comment on a number of proposed refinements to the Project.

15.3.13 Information about the environmental impacts associated with the refinements was presented at all stages of consultation. A summary of the responses to these consultation stages can also be found in the Consultation Report (Application Document 5.1).

Stakeholder engagement

15.3.14 A summary of stakeholder engagement specific to climate is shown in Table 15.1. Engagement in relation to climate change allowances for Appendix 14.6: FRA (Application Document 6.3) and operational surface water drainage design, is detailed within Chapter 14: Road Drainage and the Water Environment.

Table 15.1 Stakeholder engagement

Stakeholder	Date of meeting / communication	Summary of discussions
Kent County Council, Essex County Council, London Borough of Havering, Gravesham Borough Council, Medway Council and Thurrock Council	December 2017 and August 2018 – email communication	A request for confirmation of the relevant policies that should be considered as part of the Project climate assessment was issued to the county councils and local authorities via email correspondence. The communication also included a request for baseline information relating to GHG emissions and climate change targets. Although no response was received, the assessment proceeded with publicly available policy information and data. The methodology and data sources to be used in the assessment were presented and confirmed via a meeting held with all local authorities on 21 and 22 April 2020.
Kent County Council, Essex County Council, London Borough of Havering, Gravesham Borough Council, Medway Council and Thurrock Council	21 and 22 April 2020	A meeting was held to outline the updated DMRB LA 114 Climate methodology (Highways England, 2021) to be used in the assessment. This meeting confirmed the policy and data sources used in the ES and presented the preliminary finding and mitigation of the environmental assessments. No objections to the approach adopted for the climate assessment were raised during the meeting.
Kent County Council, Essex County Council, London Borough of Havering, Gravesham Borough Council, Medway Council and Thurrock Council	2 August 2022	Follow up of the Community Impact Public Health Advisory Group meeting of 31 March 2022. Presentation on the way in which National Highways is aiming for the Project to be the greenest road ever built, supported by information on the carbon model and DCO commitments. Feedback and questions on the Project's approach to carbon were taken from attendees and responses provided as part of a follow up engagement.
Community Impact Public Health Advisory Group	31 March 2022	Presentation of the Project's climate resilience (brief) and carbon model, including description and breakdown of the construction phase carbon emissions. In the meeting it was agreed that a carbon roadshow would be undertaken to update the local authorities on the matter.
Thurrock Council	23 September 2020	Meeting to discuss issues raised by Thurrock Council within the Statement of Common Ground (Application Document 5.4.4.12). The Project team presented the scope of the climate assessment, study areas and confirmation of the information sources used within the assessment. No objections were raised during the meeting.

Stakeholder	Date of meeting / communication	Summary of discussions
	01 September 2021	Meeting to discuss approach to the climate assessment and Project sustainability following Thurrock Council's review of this draft chapter and Sustainability Statement. Thurrock Council provided feedback for consideration within the finalised assessment.
Environment Agency	16 May 2019	Meeting to agree flood modelling climate change scenarios, and to discuss strategies for managing residual flood risks. Details of agreed climate change allowances and strategies for managing residual flood risk are provided in Part 6 of Appendix 14.6: FRA (Application Document 6.3).
Environment Agency	18 March 2021	Meeting to discuss the West Tilbury Main and Mardyke flood modelling, including breach modelling and adoption of the guidance on climate change allowances for flood risk assessments applicable at that time from the Environment Agency. The next steps for model reviews and sign-off were agreed.
Environment Agency	04 May 2022	Meeting to discuss latest hydraulic flood models with Environment Agency technical flood specialists. The upcoming revised climate change allowances for peak rainfall were discussed and it was agreed the departure of +/- 5% from the updated guidance would be acceptable for the Project's design.

Scope of the assessment

15.3.15 The scope of this chapter is in line with DMRB LA 114 Climate (Highways England, 2021) and considers the impacts of the Project on climate through its GHG emissions and the vulnerability of the Project to climate change. This comprises two assessments:

a. Impact of the Project on climate (GHG emissions) – The likely significant effects of the Project on the environment measured through the consideration of changes in GHG emissions arising from the main stages of the project life cycle, as identified by LA 114. Evidence of the Project's impact against the Government's carbon budgets is also provided.

b. Vulnerability of the Project to climate change – The Project's resilience to the effects of climate change through the application of adaptation measures within the design.

15.3.16 No aspects have been scoped out from the assessment.

15.3.17 In each section of this chapter, the GHG emissions impact assessment is described first, followed by the vulnerability of the Project to climate change.

15.3.18 This assessment also informs the assessment of major accidents and disasters, summarised in Chapter 4: EIA Methodology and set out in full in Appendix 4.2: Major Accidents and Disasters Long List; and Appendix 4.3: Major Accidents and Disasters Short List (Application Document 6.3), by providing the likelihood and consequence of potential major climate events.

Impact assessment methodology

15.3.19 The assessment follows the general approach described in Chapter 4: EIA Methodology. This section provides topic-specific information regarding the methodology used for establishing the baseline, and the methods used for the construction and operational phase assessments.

GHG emissions impact assessment

Study area

Construction phase

15.3.20 The Project has not defined a geographical spatial boundary for the GHG emissions impact assessment for the construction phase as it includes emissions irrespective of the geographic location in which they occur. Instead, the study area has been aligned to the life cycle stage modules presented within PAS 2080 (BSI, 2016a) and therefore addresses GHG emissions associated with the Project's construction activities and material usage within the Order Limits as well as the emissions associated with material production and transportation, and staff transportation outside the Order Limits.

15.3.21 Table 15.2 is adapted from DMRB LA 114 Climate (Highways England, 2021) to align with the PAS 2080 (BSI, 2016a) life cycle modules and presents the main stages of the Project's life cycle that have been included within the construction phase assessment.

Operational phase

15.3.22 As with the construction phase assessment, there is no spatial boundary for the carbon emissions arising from the maintenance, repair and replacement of the Project during its operation. The sources of carbon emissions related to this life cycle stage are detailed in Table 15.2 and are in alignment with the approach set out in PAS 2080 (BSI, 2016a).

15.3.23 The study area for the road-user GHG emissions is the fully modelled area of the Project's transport model as set out in the Combined Modelling and Appraisal Report (ComMA) (Application Document 7.7). This study area is appropriate as it captures the user emissions from the Project, those arising from the outlying road network, and vehicle movements that would be indirectly influenced by the Project (positively and negatively).

Table 15.2 Life cycle stages included within the Project GHG emissions assessment

DMRB Main stage of Project life cycle	PAS 2080 (BSI, 2016a) Sub-stage of life cycle and module	Sources of GHG emissions	Activity data
PAS 2080 Before use stage			
Construction stage (construction phase)	A-0 Pre-construction	• Preliminary studies and works such as strategy and brief development, architecture, design efforts, EIA and cost planning. These functions are largely office-based.	• Staff travel estimates • Actual data and analysis
	Product stage A-1 Raw material supply A-2 Transport A-3 Manufacture	• Embodied GHG emissions associated with the raw material assets required to construct the Project.	• Estimation of the quantity (tonnes) or volume (m^3) of material assets including both temporary and permanent works.
	Construction process stage A-4 Transport of materials to and from works site A-5 Construction / Installation processes	• Transport of construction material assets and equipment from point of purchase to the works site • Transport of workers • Transport of materials and equipment onsite • Emissions associated with construction and installation processes (including fuel and electricity consumption) of the temporary works, ground works, landscaping and permanent works • Materials storage and any energy or otherwise need to maintain necessary environmental conditions • Emissions associated with site water demand, including water treatment • Waste management activities (transport, processing, final disposal) associated with waste arising from the Project • Potential identified scenarios that may materialise during construction activities that may result in a carbon impact	• Estimation of the quantity (tonnes) or volume (m3) of material assets, including both temporary and permanent works • Type of material assets required (e.g., concrete) • Transport distances (km) of material assets • Transport distances (km) of Project staff to the work site • Volume (m^3) of waste generated (both construction and demolition)

DMRB Main stage of Project life cycle	PAS 2080 (BSI, 2016a) Sub-stage of life cycle and module	Sources of GHG emissions	Activity data
			• Water usage (m^3) • Fuel and energy usage associated with plant, equipment, site operations and processes • Project-specific calculation of emissions per million pounds of spend (tCO_2e/£)
	Land use change (additional to PAS 2080), including the 60-year appraisal period	• GHG emissions mobilised from vegetation or soil loss during the construction stage in addition to GHG emissions associated with land use change – representing the influence of land use change through the Project's planting proposals and ongoing sequestration of carbon each year during the construction and operation phase.	• Baseline habitat mapping (ES Chapter 8: Terrestrial Biodiversity) • Post development design models and information such as engineering and landscape plans. These identify the areas moving from one land use category to another. Land use change emission factors derived from Emissions and Removals Greenhouse Gases from Land Use, Land Use Change and Forestry for England, Scotland, Wales and Northern Ireland: 1990-2012 Report (NAEI, 2014) are applied to the relevant land use change.

DMRB Main stage of Project life cycle	PAS 2080 (BSI, 2016a) Sub-stage of life cycle and module	Sources of GHG emissions	Activity data
PAS 2080 Use stage			
Operation 'use' stage (to extend 60 years from the Project opening year in line with appraisal period) (operational phase)	B-9 Use of the infrastructure by road users	• Vehicles using the highways infrastructure.	• Transport emissions
	B-1, B-2, B-3, B-4 and B-5 Operation and maintenance, including repair, replacement and refurbishment	• This sub-stage includes the following aspects: • Energy – represents the GHG emissions resulting from the fuel and electricity used by the Project's infrastructure (e.g., lighting, signals, technology, pumps) and activities conducted as part of routine maintenance. • Raw materials – represents the GHG emissions resulting from providing the material assets required by the Project so that it can operate and deliver its service, for example material assets used for maintenance, repair and cleaning.	• Fuel and energy usage associated with the Project's infrastructure • Water usage (m3) • Estimation of the quantity (tonnes) or volume (m3) of material assets required for maintenance and cleaning • Volume (m3) of waste generated (both maintenance and cleaning)

Temporal scope

15.3.24 The environmental assessment uses defined temporal scales for the assessment period and characterises the duration of potential effects.

15.3.25 The temporal scope of the assessment includes the following:

a. The complete construction phase (estimated at six years)

b. A sixty-year operational phase, in line with the sixty-year appraisal period adopted in DMRB LA 114 Climate (Highways England, 2021) and set out in the Transport Analysis Guidance (TAG) Unit A.1.1 Cost-Benefit Analysis (DfT, 2021b)

15.3.26 The temporal scope of the assessment for the operational phase (60 years) covers a longer period than presented in the Scoping Report (40 years for roads and 120 years for the tunnel), in response to DMRB LA 114 Climate (Highways England, 2021), published after the Scoping Report had been issued.

15.3.27 The appraisal also presents GHG emissions for the opening year (2030) and design year (2045) scenarios, in line with DMRB LA 114 (Highways England, 2021).

15.3.28 The GHG emissions contribute to increased GHG concentration levels in the atmosphere leading to further global warming and resulting in (adverse) climate change effects. This is a long-term continuous effect for both construction and operational phase GHG emissions.

15.3.29 In line with DMRB LA 114 Climate, paragraph 3.20 (Highways England, 2021) the significance of effects is determined based on the following requirement: '*The assessment of projects on climate shall only report significant effects where increases in GHG emissions will have a material impact on the ability of the Government to meet its carbon reduction targets*'. The UK's carbon reduction targets are linked to the 4th, 5th, and 6th carbon budgets (covering 2023-2027, 2028-2032, 2033-2037 respectively). The duration of potential effects on these targets are considered long-term.

Limits of deviation and Rochdale Envelope

15.3.30 The Project's application of the Rochdale Envelope is summarised in Chapter 2: Project Description. The limits of deviation (LOD) for the Project (defined in the draft DCO (Application Document 3.1)) represent an 'envelope' within which the Project would be constructed and have informed the reasonable worst-case approach to assessment for the purposes of this chapter.

15.3.31 The Carbon and Energy Management Plan (Application Document 7.19) stipulates the maximum level of construction phase emissions in delivering the Project. Appendix D of the Carbon and Energy Management Plan identifies possible GHG emission reduction measures to meet this requirement, representing one of numerous possible pathways to achieve this maximum level of emissions. The actual route will be determined by the Contractors[1] and

[1] In this document, Contractors refers to the Contractors providing the main works (Roads North, Tunnels and Approaches and Kent Roads)

their designers but whichever pathway they select, Contractors must at least match this maximum level of construction phase emissions. This is considered a worst-case, reflecting the Rochdale Envelope. The worst-case scenario represents current best-practice and results because it can only be delivered by incorporating an extensive range of commercially available, low carbon technologies and approaches.

15.3.32 The applied Rochdale Envelope and the Government's net zero policies would provide opportunities for further construction phase carbon emission reductions during the development of the detailed design, construction methodologies, procurement strategy and during the construction phase itself, through implementation mechanisms set out in the Carbon and Energy Management Plan (Application Document 7.19) and summarised in Section 15.5 of this chapter.

Method of establishing existing baseline conditions

15.3.33 The existing (road-user GHG emissions) baseline was established using data collection from published sources and the outputs of the transport modelling completed for the Project.

15.3.34 The existing baseline for the GHG emissions impact assessment is a 'Do Minimum' scenario, which presents the GHG emissions of the road network without the Project. The 'Do Minimum' scenario has been based on information obtained from the Project's transport model as set out in the ComMA (Application Document 7.7).

15.3.35 The baseline year for the GHG emissions impact assessment is 2016 in line with the Project's validated transport model base year as detailed in Appendix B: Transport Model Package, of the ComMA (Application Document 7.7). Using the outputs of the Project's transport model, the baseline year GHG emissions (2016) were estimated using the National Highways speed band emission factors (set out in DMRB LA 105).

15.3.36 The base year (2016) GHG emissions are used for comparison with GHG emissions in the opening year (2030) and design year (2045) to determine the trend.

Forecasting the future baseline ('Without Scheme' scenario)

15.3.37 The future (road-user GHG emissions) baseline is the 'Do Minimum' scenario in which the Project does not go ahead. This provides the basis for comparison against which net changes in GHG emissions can be established. Under this scenario, the GHG emissions associated with the future use of the existing road network were estimated, through outputs from the Project's transport model as detailed within the ComMA (Application Document 7.7). The Project's transport model was the basis for forecasting emissions from the road network considering forecast increases in traffic and associated congestion, presenting the GHG emissions for the Project's 2030 opening year, for 2045 (the design year) and for the 60-year appraisal period of the Project.

15.3.38 It should be noted that the National End Trip Model (NTEM) Version 7.2 (DfT, 2017) was used in which 2051 is the final year of the DfT traffic growth forecasts. Therefore, GHG emissions are at a level rate from 2051 to 2089 for

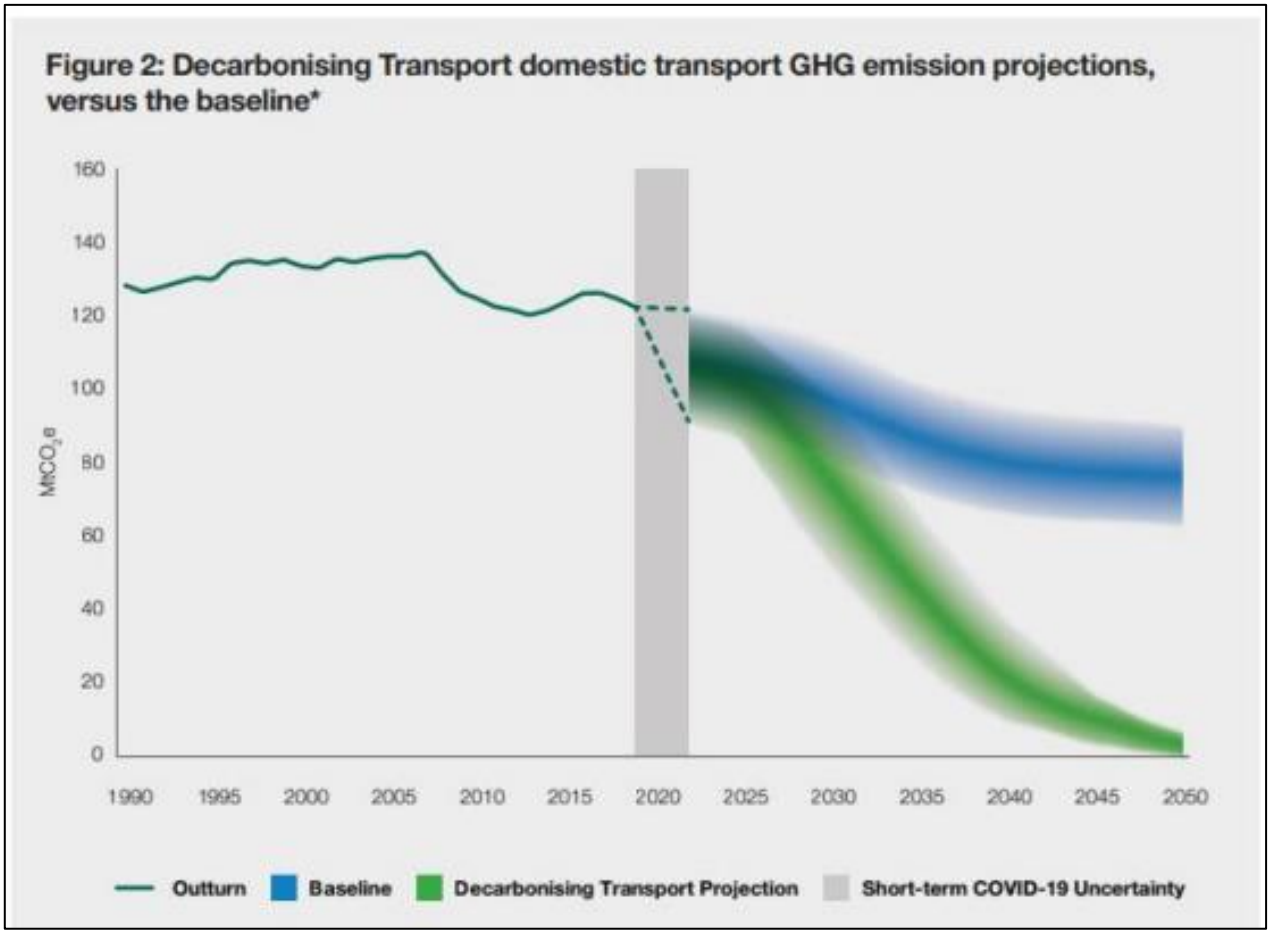
the remainder of the 60-year operational assessment, ignoring further increases in zero emission vehicle use beyond that point.

15.3.39 The future baseline GHG emissions were forecast using the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021), which includes forecasts of the mix of vehicles (petrol/diesel/electric) in the fleet, and engine fuel efficiency up to 2050. The uptake rates of electric vehicles in EFT v11 are aligned to the penetration rates described in worksheet A1.3.9 of the TAG Databook (DfT, 2022b). The worksheet refers to assumptions made for the road emissions component of 'Energy and Emission Projections (EEP): Net Zero Strategy Baseline' (BEIS, 2022). The Net Zero Strategy baseline does not reflect the policy commitments set out within DfT's Transport Decarbonisation Plan (DfT, 2021a). This means that the TAG Databook underestimates the proportion of the vehicle fleet that will be electric in the future.

15.3.40 It is therefore considered that using the TAG GHG Workbook (DfT, 2022a), with input from the TAG Databook (DfT, 2022b), and EFT v11 (Defra, 2021) overestimates GHG emissions.

15.3.41 To address the gap between the current assessment guidance and government policies, the DfT has approved a sensitivity test to review the potential impact that new policy measures set out within the Transport Decarbonisation Plan (DfT, 2021a) will have on the Project's road-user emissions. This is based on projections of the rate of improvement in decarbonising domestic transport stated in the Transport Decarbonisation Plan and presented on Plate 15.1. The sensitivity test was applied to CO_2e emissions calculated for the future baseline scenario (without the Project). There is uncertainty of policy success, represented by the width of the Decarbonising Transport projection in Plate 15.1, and therefore an upper and lower bound of the sensitivity test has been presented throughout this chapter to provide a more realistic representation of the GHG emissions during the operation phase.

Plate 15.1 Sensitivity test, taken from *Decarbonising Transport A Better Greener Britain* (DfT, 2021a)



Method of assessment – construction and operational phases

15.3.42 The Project has quantified its carbon emissions following the principles of PAS 2080 (British Standards Institution, 2016), as outlined in Table 15.2. A carbon model was developed and is presented in the Carbon and Energy Management Plan (Application Document 7.19).

15.3.43 Reporting GHG emissions from the Project in the form of tCO_2e allowed the emissions of the seven key GHGs from the Kyoto Protocol Reference Manual (United Nations Framework Convention on Climate Change (UNFCCC), 2008) to be accounted for: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The Paris Agreement (UNFCCC, 2015) has superseded the Kyoto Protocol, however, the Kyoto Protocol Reference Manual is still used to define the GHGs. The tCO_2e for each greenhouse gas is calculated by multiplying the quantity of the greenhouse gas by its global warming potential. The global warming potential depends on:

a. The amount of energy the greenhouse gas can absorb

b. How long it remains active in the atmosphere

15.3.44 The assessment determined and compared two scenarios: the 'Do Minimum' scenario (future baseline) and the 'Do Something' scenario. The basis for the two scenarios is described in Table 15.3. By reviewing the difference in emissions between the two scenarios, an estimation of the net emissions resulting from the Project was determined. The net emissions were used in the environmental assessment.

Table 15.3 GHG assessment scenarios

Scenario		Description
'Do Minimum'	Existing baseline without the Project (2016) Future baseline without the Project: opening year (2030), design year (2045), and appraisal period (60 years from the Project opening year)	GHG emissions without the Project were identified for the existing and future baseline ('Do Minimum' scenarios). These consist of road-user emissions only. Existing baseline conditions are a business-as-usual scenario: an estimate of the GHG emissions from the Project's transport model baseline year of 2016. The future baseline is also a business-as-usual scenario estimating GHG emissions from the transport model. The future baseline accounts for traffic growth, and for traffic generated by developments (new housing and other developments such as employment, retail and leisure sites) classed as near certain or more than likely (as defined by TAG Unit M4 (DfT, 2019)) within the study area between 2030 and 2045 as well as the full 60-year appraisal period. More information is contained within Appendix C: Transport Forecasting Package of the ComMA (Application Document 7.7). This modelling includes the uptake rates of electric vehicles as described in worksheet A1.3.9 of the TAG Databook (DfT, 2022b) and reflected in the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021). The Do Minimum (future baseline) was subject to a sensitivity test to demonstrate the effectiveness of the policies attached to the Transport Decarbonisation Plan (DfT, 2021a).
'Do Something'	Project goes ahead: Construction phase, opening year (2030), design year (2045), and appraisal period (60 years from the Project opening year)	The Do Something scenario includes GHG emissions during both the construction and operational (opening year, design year and 60-year appraisal period) phases, as described in Table 15.2. GHG design and construction mitigation measures as described in the Carbon and Energy Management Plan (Application Document 7.19). The calculation for the operational phase road-user emissions included the uptake rates of electric vehicles as described in worksheet A1.3.9 of the TAG Databook (DfT, 2022b) and reflected in the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021). The Project's road-user GHG emissions within the Do Something scenario were subject to a sensitivity test to demonstrate the effectiveness of the policies attached to the Transport Decarbonisation Plan (DfT, 2021a).

15.3.45 Table 15.2 outlines the Project life cycle stages and the associated sources of GHG emission data that were quantified to develop the 'Do Something' scenario. The two life cycle stages (construction stage and operational stage) considered the level of certainty of future activity and GHG emissions, and the extent that the predicted GHG emissions would be additional to the existing GHG inventory.

15.3.46 In line with Table 3.11.1 from DMRB LA 114 (Highways England, 2021), opportunities for emission reductions during both the construction and operational phases were identified within the assessment. A description of the opportunities for emission reduction is included within the Carbon and Energy Management Plan (Application Document 7.19). Section 15.5 of this chapter sets out the low carbon technology and measures that have been included in the calculation of the maximum level of construction emissions. These measures are one of numerous possible pathways to achieve this level of emissions. The actual route will be determined by the Contractors and their designers but whichever pathway they select, Contractors must, at a minimum, not exceed this level of emissions.

15.3.47 The key assumptions and results of calculations of GHG emissions from each of the sub-stages of the life cycle presented in Table 15.2 have been described further throughout this chapter and are presented in more detail in the Carbon and Energy Management Plan (Application Document 7.19). A full description of data sources used to quantify the Project GHG emissions is included within the Carbon and Energy Management Plan.

15.3.48 Estimated GHG emissions have been assessed using the following equation, aligned with the GHG data principles (Guidance Document for PAS 2080, British Standards Institution, 2016b):

Activity data x GHG emissions factor = GHG emissions value

15.3.49 All GHG emissions reported within this assessment are in the form of tCO_2e.

Construction phase

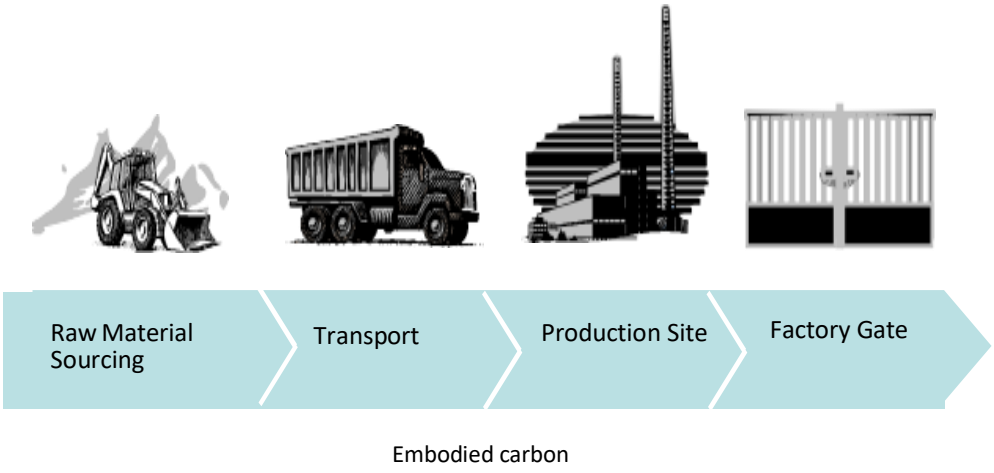
15.3.50 The tool used to calculate carbon emissions is based on the National Highways carbon tool. Specifically for the Project, it was comprehensively updated to cover additional elements of the PAS 2080 life cycle. Further details are provided in Appendix C of the Carbon and Energy Management Plan (Application Document 7.19).

15.3.51 GHG emissions arising from the construction stage of the Project, also referred to as 'construction carbon', were calculated in line with PAS 2080 (British Standards Institution, 2016a) and emission factors from the various sources presented in the Carbon and Energy Management Plan (Application Document 7.19).

15.3.52 Using the estimated material quantities and types, the embodied carbon of the construction material assets were calculated, giving their contribution to the overall construction carbon. The calculation of embodied carbon allowed the sum of the energy required in resource extraction, and any processing required before its transport to the Project for use, to be accounted for within the overall carbon model. This is presented diagrammatically in Plate 15.2. Embodied carbon covers the production stage of the PAS 2080 life cycle (modules A-1, A-

2 and A-3) (refer to Table 15.2). DMRB LA 114 Climate (Highways England, 2021) uses the same definition for embodied carbon.

Plate 15.2 Diagrammatic representation of the measure of embodied carbon in relation to material assets life cycle



15.3.53 The emissions of construction activities were also considered and quantified. These included emissions associated with waste arisings and their transportation, water use, construction site energy and fuel usage for the duration of the construction phase, and land use change.

15.3.54 The excavation and movement of materials both within and outside the Order Limits were modelled separately and included within the Project's carbon model.

15.3.55 The construction traffic represented in the Transport Assessment (Application Document 7.9) and within the assessments presented in this ES, incorporates the following elements:

a. Estimated HGV movements associated with the movement of construction materials and earthworks both on the road network and within the Order Limits

b. Staff travel to worksites

c. Temporary traffic management measures

15.3.56 Emissions estimated from construction material transport have been estimated using the transport scenarios presented in the Royal Institution of Chartered Surveyors (RICS) Whole Life Carbon Assessment for the Built Environment (RICS, 2017) which are summarised in Table 15.4.

Table 15.4 Transport scenarios used to define spatial extent of material transport GHG emissions

Transport scenario	Kilometre by road
Locally manufactured e.g., concrete, aggregate, asphalt	50
Nationally manufactured e.g., diesel, plastic products	300
European manufactured e.g., steel	1,500

15.3.57 Uncertainties in the quantities of construction phase activities, were addressed by Project-specific calculations of emissions per million pounds of spend and added as a 'risk' category on top of the calculated GHG emissions.

15.3.58 The activity data is based on preliminary design information and generally uses forecast data rather than actual data, which is not available at this stage (with the exception of actual data that has been used for PAS 2080 sub-stage A0 emissions, where available). The carbon model is therefore a best estimate, calculated using the most representative, accurate and plausible data available.

Operational phase

15.3.59 The operation or 'use' stage included emissions resulting from maintenance (including repair, replacement and refurbishment activities), mechanical and electrical energy use (for example tunnel lighting, tunnel services buildings and ventilation system), as well as the net variation in emissions from vehicle journeys (also referred to as 'road-user GHG emissions') in the Project's validated transport model.

15.3.60 The road-user GHG emissions were calculated using the outputs from the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021). This covers a 60-year appraisal period from the 2030 opening year of the Project.

15.3.61 In line with the method described to forecast the future GHG emissions baseline, a sensitivity test was applied to CO_2e emissions calculated for the Project's road-user GHG emissions to address the gap between the current assessment guidance (TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021)) and the effect of the Government's Transport Decarbonisation Plan (DfT, 2021a).

15.3.62 The Project GHG emissions have been presented as a worst-case impact derived from the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021) method. The outputs of the Transport Decarbonisation Plan sensitivity test have been included. Emissions from the sensitivity test are presented with a lower and upper bound and would provide a more realistic representation of likely GHG emissions from future road users of the Project.

15.3.63 As explained under the 'scope of the assessment' heading above, the end of life (decommissioning) stage was excluded from the GHG emissions impact assessment.

Determining significance of effects

15.3.64 The methodology to determine the significance of environmental effects on climate, is based on the specific criteria set out within the NPSNN (DfT, 2014) and DMRB LA 114 Climate (Highways England, 2021).

15.3.65 Paragraph 5.17 of the NPSNN (DfT, 2014) requires applicants to provide evidence of the carbon impact of their projects and assessment against the Government's carbon budgets. Paragraph 5.18 of the NPSNN states: '*Therefore, any increase in carbon emissions is not a reason to refuse development consent, unless the increase in carbon emissions resulting from the proposed scheme are so significant that it would have a material impact on the ability of Government to meet its carbon reduction targets*'.

15.3.66 DMRB LA 114, paragraph 3.20 (Highways England, 2021) has a similar requirement: '*The assessment on climate shall only report significant effects where increases in GHG emissions will have a material impact on the ability of the Government to meet its carbon reduction targets*'.

15.3.67 The budgets relevant to the GHG emissions impact assessment (for the construction and operational phases), expressed in the form of tCO_2e, are detailed in Table 15.5.

Table 15.5 UK carbon budgets applicable to the GHG emissions assessment

Budget	Carbon budget level (million tCO_2e)	Reduction below 1990 levels
Fourth carbon budget (2023 to 2027)	1,950	51% by 2025
Fifth carbon budget (2028 to 2032)	1,725	57% by 2030
Sixth carbon budget (2033 to 2037)	965	78% by 2035

15.3.68 A quantification of what is considered a material impact on the ability of the Government to meet its carbon reduction targets is lacking in the NPSNN (DfT, 2014) and DMRB LA 114 (Highways England, 2021). However, paragraph 5.17 of the NPSNN states in that regard: *'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'.*

15.3.69 Recent decision letters by the DfT, granting development consent for road schemes, confirmed that there is no set significance threshold for carbon. Recent decision letters also make reference to the approach of the recently published guidance by the Institute of Environmental Management & Assessment (IEMA); *IEMA Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance* (IEMA, 2022). Assessing the significance of carbon emissions, the IEMA guidance states: '*The crux of significance therefore is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050'.*

15.3.70 The IEMA guidance distinguishes the following three types of projects when determining the significance of emissions:

a. '*A project that follows a 'business-as-usual' or 'do minimum' approach and is not compatible with the UK's net zero trajectory or accepted aligned practice or area-based transition targets, results in significant adverse effect.*'

b. '*A project that is compatible with the budgeted science-based 1.5°C trajectory (in terms of rate of emissions reduction) and which complies with up-to-date policy and 'good practice' reduction measures to achieve that has a minor adverse effect that is not significant.* [Such a project] *may have residual emissions but it is doing enough to align with and contribute to the relevant transition scenario to keep the UK on track towards net zero by 2050 with at least a 78% reduction by 2035 and thereby potentially avoiding significant adverse effects.*'

c. '*A project that achieves emissions mitigation that goes substantially beyond the reduction trajectory, or substantially beyond existing and emerging policy compatible with that trajectory, and has minimal residual emissions, is considered to have negligible effect that is not significant.* [Such a] *project is playing a part in achieving the rate of transition required by nationally set policy commitments.*'

15.3.71 Therefore, the assessment of whether the GHG emissions have a material impact on the ability of the Government to meet the carbon reduction targets will include the following:

a. A comparison of the GHG emissions against the budgets.

b. An evaluation against the IEMA guidance.

Assumptions and limitations

15.3.72 The following assumptions and limitations are noted with respect to the GHG emissions assessment and have been used to establish the Do Something scenario GHG emissions (referred to as the Project's carbon model in the Carbon and Energy Management Plan (Application Document 7.19)).

15.3.73 Following grant of DCO there would be preparatory works, referred to in the draft DCO (Application Document 3.1) as preliminary works taking place in 2024. The main construction period for the Project would start in early 2025, with the road being open for traffic in late 2030.

15.3.74 While considered sufficient to inform the assessment of embodied carbon, quantifications of material assets and waste arisings forecast from the Project and reported in the Project's carbon model and Chapter 11: Material Assets and Waste, have been derived from Project cost estimates and professional judgement on the preliminary design. Therefore, the GHG assessment presented in Section 15.6, and the Project's carbon model presented within the Carbon and Energy Management Plan (Application Document 7.19), is a robust quantification of emissions arising from the material asset demand. This was calculated using the most representative, accurate and plausible data available to develop a credible carbon model and the data sources used are set out within the document.

15.3.75 Where possible, emission factors were researched for the exact material or product specified for the Project. Primary sources of emission factors are listed above. In some cases, an exact match could not be identified, and therefore assumptions were made to select a representative material or product from

these databases. Emission factor sources have been included within the Carbon and Energy Management Plan (Application Document 7.19).

15.3.76 Data collection for GHG calculations was based on the set of standard data quality principles detailed in the Guidance Document for PAS 2080 (British Standards Institution, 2016b) and summarised in Table 15.6. Applying these principles allowed the results from the GHG assessment to be robust.

Table 15.6 GHG Protocol principles

Data quality principle	Application to Project
Age	The GHG assessment is based on activity data and GHG emissions factors applicable to the study period. The construction year baseline (2024) for the GHG assessment incorporates GHG emissions from fuel use for construction activities along with embodied carbon within material assets used for the construction phase. The assessment has been based on an estimation of the types and quantities of key materials required for the construction and operation of the Project.
Geography	The activity data is specific to the Project, and emission factors used are representative of the UK construction industry and UK transport sector.
Technology	The activity data and emission factors used are representative of the UK construction and transport sectors.
Methodology	The activity data is specific to the Project and has been provided by the Project's engineering and design teams.
Competency	The activity data is specific to the Project and has been provided by the Project's engineering and design teams. The emission factors used are from published sources. A full list of emission factors used is presented in the Carbon and Energy Management Plan (Application Document 7.19). Data gaps have been filled using best available data, for example extrapolating existing data or using industry guidance documents.

15.3.77 Zero carbon maintenance from 2040 and zero carbon network operations (network lighting, National Highways' vehicles) throughout the operational phase of the Project were assumed, in line with the Net Zero Highways plan (National Highways, 2021a).

15.3.78 In the absence of a standard approach to quantifying the net GHG emissions resulting from land use change, emission factors were calculated using data from the Emissions and Removals Greenhouse Gases from Land Use, Land Use Change and Forestry for England, Scotland, Wales and Northern Ireland: 1990 – 2012 Report by the National Atmospheric Emissions Inventory (NAEI) (NAEI, 2014). This report presents a summary of the net emissions and removals of greenhouse gases for 1990 – 2012 by the Land Use, Land Use Change and Forestry sector of the UNFCCC National Inventory for each of the UK Administrations (England, Scotland, Wales and Northern Ireland). The NAEI report provided comprehensive data on the area of land use change categories (e.g., grassland converted to forest land) in kilo hectares (kha) and the associated emissions from the land use change category (in thousand tons (kTCO2e). Using the kha and the $kTCO_2e$ data for England, emission factors

were calculated by dividing the carbon emissions by the area for each land use change category. Emission factors were converted to give a unit of tCO_2e/m^2/year.

15.3.79 The type and area of land change has been determined in line with the assessment presented in ES Chapter 8: Terrestrial Biodiversity. Details of the ongoing land use requirements, including proposed environmental mitigation and their design and management regimes are set out and secured through their inclusion within the control plan documents, most notably the Outline Landscape and Ecology Management Plan (Application Document 6.7), Design Principles (Application Document 7.5) and the Environmental Masterplan (ES Figure 2.4, Application Document 6.2).

Nitrogen deposition compensation sites

15.3.80 The DCO application documents identify the locations of habitat creation sites proposed as compensation for the effects of nitrogen deposition.

15.3.81 The design and management regimes for these locations will be developed as part of the detailed design, in accordance with the control plan documents including the Outline Landscape and Ecology Management Plan (Application Document 6.7), Design Principles (Application Document 7.5) and the Environmental Masterplan (ES Figure 2.4, Application Document 6.2). For the purpose of the land use change assessment, it is assumed these sites would comprise 70% woodland and 30% grassland. This assumption aligns with the requirements set out within the control plan and is therefore robust.

Vulnerability of the Project to climate change

Study area

15.3.82 In line with DMRB LA 114 Climate (Highways England, 2021), the study area for assessing the potential effects resulting from the vulnerability of the Project to climate change during the construction and operational phases is the Order Limits, which captures all assets, environmental mitigation areas and physical infrastructure associated with the Project (e.g., earthworks, structures, pavement, temporary land take and compounds). It should be noted that the existing baseline and forecast future baseline reported for the assessment have been derived using regional climate and projection data. Further explanation on the establishment of the existing baseline and forecasting of the future baseline is provided below.

15.3.83 The study area has been redefined compared to that contained within the Scoping Report, to address the concerns of the Planning Inspectorate on the large extent of the study area (refer to Appendix 4.1: The Inspectorate's Scoping Opinion and National Highways Response (Application Document 6.3)). It is noted that DMRB LA 114 Climate (Highways England, 2021), which provides guidance on the matter, was published after the preparation of the Scoping Report.

Temporal scope

15.3.84 The environmental assessment uses defined temporal scales for the assessment period and to characterise the duration of potential effects.

15.3.85 The temporal scope of the assessment includes the following:

a. The complete construction phase (estimated at six years)

b. A sixty-year operational phase, In line with DMRB LA 114 Climate (Highways England, 2021)

15.3.86 The temporal scope of the assessment for the operational phase for roads (60 years) covers a longer period than presented in the Scoping Report (40 years), in response to DMRB LA 114 (Highways England, 2021), published after the Scoping Report had been issued.

15.3.87 In two cases the temporal scope for the operational phase is longer than 60 years:

a. Fluvial design flood events have been simulated for a range of flood events including the 2, 20, 100 and 1,000-year return period events for the years 2030 and 2130, as agreed with the Environment Agency.

b. The appraisal period for the tunnel infrastructure is set at 120 years as stipulated in the Scoping Report, except for the flood risk assessment which is set at 100 years as described above.

15.3.88 Effects associated with the construction phase are short term, as the assessment only covers a six-year period and the construction activities impacted often have short duration and are transient in nature.

15.3.89 Effects associated with the vulnerability of the Project during the operational phase are considered long term as the incremental and extreme effects of climate change will occur over the entire appraisal period of the Project.

Limits of deviation and Rochdale Envelope

15.3.90 The Project's application of the Rochdale Envelope and limits of deviation (LOD) are described in Chapter 2: Project Description. The LOD for the Project represent an 'envelope' within which the Project would be constructed. The LOD for the Project are described in Table 2.2 in Chapter 2: Project Description.

15.3.91 The assessment of vulnerability to climate change has a number of aspects that ensures a reasonable worst-case scenario is assessed:

a. The United Kingdom Climate Projections 2018 (UKCP18) (Met Office, 2018) Representative Concentration Pathway (RCP) 8.5 scenario for the 2080 projections at the 50% probability level was used to determine the future baseline for the climate variables. RCP8.5 is the closest scenario to the high emissions scenario presented in previous climate projections.

b. For the assessment of flood risk, a reasonable worst-case approach has also been adopted. The flood models have included several conservative assumptions, for example, representing the Bowaters Sluice (a key flood

defence asset) as fully blocked, and incorporating generous freeboard allowances to the soffits of watercourse crossing structures (over and above the modelled floodwater levels). Climate change over the appraisal period of the Project has been accounted for. The viaduct crossing of the Mardyke and its tributaries has a design height set to provide for clearance to allow machinery to work beneath the structure to undertake maintenance of the watercourses.

c. Climate change allowances for the assessment of flood risk, as agreed with the Environment Agency, have been incorporated into the Project design, which inherently covers for uncertainty in the future climate projections, and the adaptability of the design to a credible maximum climate change scenario has also been assessed and confirmed (refer to Appendix 14.6, Application Document 6.3).

Method of establishing existing baseline conditions

15.3.92 To establish the existing baseline for the assessment of the vulnerability of the Project to climate change, published current and historical regional weather data in the location of the Project was reviewed, including Local Climate Impacts Profiles (LCLIPs) (UKCIP, 2018) and historical flood data – see Appendix 15.2: Climate Resilience Baseline (Application Document 6.3).

15.3.93 In addition, a desk-based review of the following data sources was undertaken in preparing Chapter 14: Road Drainage and the Water Environment to determine baseline conditions across the Project study areas and to inform conceptual and numerical models of flooding:

a. Flood data, including hydraulic models, and flood defence asset data (Environment Agency, various dates 2018 and 2019)

b. Groundwater Flood Risk Maps GW5 (GeoSmart, 2020)

c. Groundwater level monitoring data records from observation boreholes (Environment Agency, December 2017, June 2018, March 2020)

d. Various local strategic flood risk assessments/strategies (refer to Part 2 of Appendix 14.6: FRsment, Application Document 6.3)

15.3.94 Met Office historic climate data, from the period 1981 – 2010, was obtained from the weather stations closest to the Project Order Limits and allowed the identification of current conditions within the study area:

a. Stanford-le-Hope – grid reference TQ 687822

b. Writtle – grid reference TL 680066

c. Gillingham No2 – grid reference TQ 784682

d. East Malling – grid reference TQ 709566

Forecasting the future baseline (Without Scheme scenario)

15.3.95 UKCP18 (Met Office, 2018), developed by the Met Office Hadley Centre Climate Programme, was used to provide projections for future climate scenarios and trends in the study area. The UKCP18 data is recognised as a robust source of information on the UK's future climate.

15.3.96 UKCP18 provides probabilistic projections of climatic variables (presented below). For the purposes of the assessment, and in line with requirements set out in DMRB LA 114 Climate (Highways England, 2021), the future baseline for the assessment of the vulnerability of the Project to climate change covers the timescales for the construction phase and the Project operational phase of 60 years from the opening year. Therefore, the UKCP18 projections for the climate variables listed below were analysed for the selected 20-year time periods of 2020 – 2039, 2040 – 2059, 2060 – 2079, and 2080 – 2099:

a. Mean annual temperature

b. Mean summer temperature

c. Mean winter temperature

d. Maximum summer temperature

e. Minimum winter temperature

f. Mean annual precipitation

g. Mean summer precipitation

h. Mean winter precipitation

15.3.97 The UKCP18 RCP8.5 scenario for the 2080-2099 projections at the 50% probability level was used to determine the future baseline for the above climate variables. RCP8.5 is the closest scenario to the high emissions scenario presented in UKCP09 (Met Office, 2009), which was the proposed approach presented in the Scoping Report.

15.3.98 UKCP18 (Met Office, 2018) probabilistic projections for RCP8.5 were analysed for the relevant two 25km by 25km grid squares in which the Project would be located. These figures were expressed as temperature and precipitation anomalies in relation to the 1981–2000 baseline. The 50% probability level has been presented for the assessment appraisal period which is 60 years (general), 100 years (flood risk) and 120 years (tunnel) for the operational life cycle stage plus the timescales for the construction stage.

15.3.99 In addition, climate change could increase peak rainfall intensity. This increased peak rainfall intensity would result in a corresponding increase in the rate and volume of runoff being discharged to local watercourses and subsequently creates an escalation in flood risk. Furthermore, sea levels are also projected to rise as a result of climate change.

15.3.100 The Environment Agency guidance on climate change allowances for FRAs was updated in May 2022 (Environment Agency, 2022a). The Environment Agency's guidance on climate change allowances for flood risk assessments

has undergone a number of iterations since publication of UKCP18 (Met Office, 2018). These iterations are detailed in Table 4.1 of Part 6 of Appendix 14.6: FRA (Application Document 6.3).

15.3.101 Fluvial and tidal flood risk zones and flood defence assets are illustrated in Appendix 14.6: FRA (Application Document 6.3).

Method of assessment – construction and operational phases

15.3.102 Assessment of the vulnerability of the Project to climate change was carried out in line with the assessment standard of DMRB LA 114 Climate (Highways England, 2021). The assessment considered the strategic aims and objectives encompassed within government, National Highways and local planning strategy and policy. These have the overarching aim of minimising the adverse impacts of climate change, while requiring new development to take climate change considerations into account within design.

15.3.103 The following key terms and definitions relating to the vulnerability of the Project to climate change assessment were used:

a. Climate hazard – a weather or climate-related event which could do harm to environmental or community receptors or assets, for example increased winter precipitation

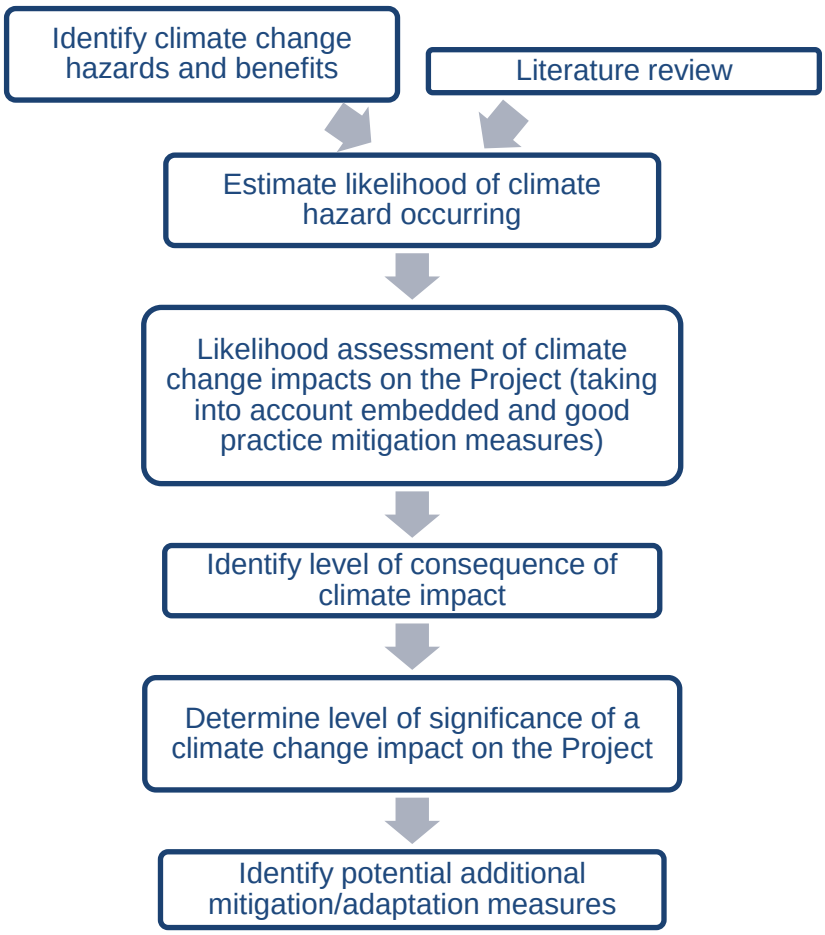
b. Likelihood – probability and frequency of occurrence of the climate hazard

c. Climate change impact – an impact from a climate hazard which affects the ability of the receptor or asset to maintain its function or purpose

d. Consequence of impact – any effect on the receptor or asset as a result of the climate hazard having an impact

15.3.104 Plate 15.3 summarises the methodology and stages for the assessment of vulnerability of the Project to climate change.

Plate 15.3 Vulnerability of the Project to climate change



15.3.105 The Independent Assessment of UK Climate Risk – Advice to Government for the UK's third Climate Change Risk Assessment (CCRA3) (CCC, 2021), adopted by the Government in the UK Climate Change Risk Assessment 2022 (HM Government, 2022), and UKCP18 data outputs (Met Office, 2018) for the two 25km by 25km grid squares in which the Project is situated were used to identify potential climate hazards that may affect the geographical location of the Project.

15.3.106 The assessment considered vulnerability against both the gradual increase of average temperature and rainfall and the risks associated with an increased frequency of severe weather events as per the UKCP18 climate change projections (Met Office, 2018).

15.3.107 A review of the potential climate change impacts was followed by an assessment of their potential consequence and likelihood of occurrence, taking into account the measures incorporated in the design of the Project the proposed standards of management and maintenance of the Project, and secured commitments that would increase the Project's resilience to climate change.

15.3.108 The assessment presented in Appendix 15.3: Climate Resilience Impacts and Effects (Application Document 6.3) includes all infrastructure and assets associated with the Project and identifies the Project's receptors within the study area that are vulnerable to the future climate change scenarios developed as follows:

a. Construction phase receptors (e.g., workforce, plant and equipment)

b. The Project assets and their operation, maintenance and refurbishment (e.g., pavements, structures, earthworks and drainage, technology assets)

c. End users (e.g., members of public, commercial operators that will use Project assets)

Determining significance of effects

15.3.109 To determine the significance of climate change on project receptors, the assessment uses the specific criteria set out within DMRB LA 114 Climate (Highways England, 2021).

15.3.110 The 60-year (general), 100-year (flood risk) and 120-year (tunnel) Project appraisal periods include the operational phase from the opening of the Project. The assessment has also accounted for the construction phase. As the construction phase would be much shorter in duration than the operational phase and is expected to be undertaken within the six years following the granting of a DCO, future climate change is less relevant to the assessment of construction impacts and effects. Accordingly, for the construction assessment, a qualitative description of the disruption risk was reported, in line with paragraph 3.40 of DMRB LA 114 Climate (Highways England, 2021).

15.3.111 For the operational phase of the Project, a risk assessment of the likelihood (probability and frequency of occurrence) and measure of consequence of a climate change impact occurring to a receptor (where relevant) was used to determine the significance over the selected future time frame for operation (60 years (general), 100 years (flood risk) and 120 years (tunnel) from the Project opening).

15.3.112 The assessment of likelihood and consequences of the potential climate impacts was undertaken using the framework provided in DMRB LA 114 Climate (Highways England, 2021) and is presented in Table 15.7 and Table 15.8.

Table 15.7 Likelihood categories

Likelihood category	Description (probability and frequency of occurrence)
Very high	The event (climate impact) occurs multiple times during the lifetime of the Project (60 years), e.g., approximately annually, typically 60 events.
High	The event (climate impact) occurs several times during the lifetime of the Project (60 years), e.g., approximately once every five years, typically 12 events.

Likelihood category	Description (probability and frequency of occurrence)
Medium	The event (climate impact) occurs limited times during the lifetime of the Project (60 years), e.g., approximately once every 15 years, typically four events.
Low	The event (climate impact) occurs during the lifetime of the Project (60 years), e.g., once in 60 years.
Very low	The event (climate impact) may occur once during the lifetime of the Project (60 years).

Table 15.8 Measure of consequence

Consequence of impact	Description
Very large adverse	Operation – national level (or greater) disruption to strategic routes lasting more than one week.
Large adverse	Operation – national level disruption to strategic routes lasting more than one day but less than one week, or regional level disruption to strategic routes lasting more than one week.
Moderate adverse	Operation – regional level disruption to strategic routes lasting more than one day but less than one week.
Minor adverse	Operation – regional level disruption to strategic routes lasting less than one day.
Negligible	Operation – disruption to an isolated section of a strategic route lasting less than one day.

15.3.113 Using Table 15.9, the likelihood and consequence were combined to determine the significance of each impact following the framework provided in DMRB LA 114 Climate (Highways England, 2021).

Table 15.9 Significance measure

Measure of consequence	Measure of likelihood				
	Very low	Low	Medium	High	Very high
Very large	Not significant	Significant	Significant	Significant	Significant
Large	Not significant	Not significant	Significant	Significant	Significant
Moderate	Not significant	Not significant	Significant	Significant	Significant
Minor	Not significant	Not significant	Not significant	Not significant	Not significant
Negligible	Not significant	Not significant	Not significant	Not significant	Not significant

Assumptions and limitations

15.3.114 The following assumptions and limitations are noted with respect to assessment of the vulnerability of the Project to climate change:

a. Climate change, by its very nature, is associated with a range of assumptions and limitations. To overcome these issues, current climate change data and science have been incorporated into the assessment, and proven, effective approaches undertaken for similar project types were replicated. The assessment has used the latest UKCP18 (Met Office, 2018) probabilistic projections which simulate a range of future scenarios based on model assumptions, for example future greenhouse gas emissions assumptions. Limitations to UKCP18 are detailed in the UKCP18 Guidance: Caveats and limitations (Met Office, 2018). UKCP18 currently provides the leading climate change projections for the UK.

b. In relation to the FRA, the Environment Agency (2022a, 2022b and 2022c) provides guidance on allowances for peak rainfall intensity, peak river flow and sea level rise (refer to Sections 4.2, 4.3, 4.4 and 4.5 of Part 6 of Appendix 14.6: FRA). Adopted allowances for the Project are described in detail in Section 4 of Part 6 of Appendix 14.6: FRA. The peak rainfall and river flow allowances in the Environment Agency's guidance on climate change allowances (2022a) only extend to 2125. In the absence of climate change allowances for rainfall and flows in 2130, the peak rainfall and river flow allowance for 2125 has been used for the assessment. Sea level rise beyond 2125 was extrapolated by assuming the same rate of rise (mm/year) specified for 2125 continues beyond 2125. A justification is provided in Section 4 of Part 6 of Appendix 14.6: FRA.

c. As the revised guidance on allowances for peak rainfall intensity was published after the drainage design was undertaken, the Environment Agency verbally agreed at a meeting held on 4 May 2022 that a 5% departure on peak rainfall intensities was acceptable. With this departure taken into account, the 20% and 40% uplift on peak rainfall intensity are deemed to be accepted for drainage design (excluding carriageway drainage). The departure on peak rainfall intensity is recorded in the Statement of Common Ground between National Highways and the Environment Agency (Application Document 5.4.1.1).

Nitrogen deposition compensation sites

15.3.115 The DCO application documents identify the locations of habitat creation sites proposed as compensation for the effects of nitrogen deposition. The design and management regimes for these locations, including resilience against climate change, will be developed as part of the detailed design, in accordance with the control plan documents including the outline Landscape and Ecology Management Plan (oLEMP) (Application Document 6.7), Design Principles (Application Document 7.5) and Figure 2.4: Environmental Masterplan (Application Document 6.2).

15.4 Baseline conditions

GHG emissions

Existing baseline

15.4.1 The existing baseline presents the GHG emissions estimated on the road network for the baseline year of 2016, which is the base year for the Project's validated transport model.

15.4.2 GHG emissions in the baseline year were calculated using outputs from the Project's transport model (ComMA (Application Document 7.7)) and amounted to approximately 8,869,800 tCO_2e. Table 15.10 presents GHG emissions for the baseline year. A sensitivity test was not completed on this scenario given it is a historic year.

Future baseline ('Without Scheme' scenario)

15.4.3 The future baseline identifies anticipated changes to the existing baseline over time in the absence of the Project and is used as a basis against which to predict the potential impacts of the Project. A description of how the future baseline has been considered within the assessment is provided in Chapter 4: EIA methodology.

15.4.4 The future baseline conditions for the 'Without Scheme' (Do Minimum) scenario were identified based on the modelled volumes of traffic, and its predicted use (accounting for forecast increases in traffic and associated congestion) for the years 2030 to 2045 as well as the total over the full 60-year appraisal period. This established the baseline against which the resultant Project emissions were subsequently compared, to identify any variation in GHG over time. The GHG emissions for the Do Minimum scenario were forecast using the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021). A sensitivity test to review the effect of the policy measures set out in the Transport Decarbonisation Plan (DfT, 2021a) was also carried out and is compared against the TAG outputs in Table 15.10 to show a more realistic estimate of emissions over the appraisal period.

Table 15.10 Future baseline end-user GHG emissions forecast with TAG GHG Workbook / EFT v11 and transport decarbonisation sensitivity test**

Without Scheme scenario				
Method of forecast	**2016 existing baseline**	**2030 opening year (tCO_2e)**	**2045 design year (tCO_2e) (% change from opening year)**	**60-year appraisal period***
TAG GHG Workbook / EFT v11***	8,869,800	8,900,890	6,891,450 (- 23%)	414,268,636
Transport Decarbonisation Plan upper bound	N/A	8,310,643	1,427,308 (- 83%)	99,083,293

Without Scheme scenario				
Method of forecast	**2016 existing baseline**	**2030 opening year (tCO_2e)**	**2045 design year (tCO_2e) (% change from opening year)**	**60-year appraisal period***
Transport Decarbonisation Plan lower bound	N/A	5,617,480	500,236 (-91%)	44,269,175
* It should be noted that the National End Trip Model (NTEM) Version 7.2 (DfT, 2017) was used. 2051 is the final year of the DfT traffic growth forecasts. Therefore, GHG emissions are at a level rate from 2051 to 2089 for the remainder of the 60-year operational assessment. ** The presented numbers are the result of model calculations. They should still be considered as estimates however. *** TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021)				

15.4.5 Table 15.10 presents estimates of how GHG emissions associated with the use of the existing road network would change between the baseline year and future baseline years without the Project. Under this scenario, GHG emissions associated with the use of the road network ('Do Minimum' scenario) in the opening year of 2030 were found to be similar when compared to the baseline year emissions, with a slight increase in 2030.

15.4.6 Under the Do Minimum scenario, the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021) showed that there is expected to be a net decrease of 23% in the GHG emissions when comparing the emissions for the 2030 opening year to the 2045 design year. This downward trend suggests that decarbonisation of the UK's fleet is overtaking the projected growth in traffic, therefore resulting in a net reduction of GHG emissions.

15.4.7 Within the Transport Decarbonisation Plan (DfT, 2021a), the sensitivity test carried out on the Do Minimum scenario demonstrates the projected effect of the net zero policies in the transport sector. GHG emissions show a greater drop off between 2030 and 2045 with a reduction of between 83% and 91% when comparing the future baseline years.

15.4.8 The total (cumulative) GHG emissions over the full 60-year appraisal period was also forecast for the Do Minimum scenario. This highlighted that the policies of the Transport Decarbonisation Plan would reduce road-user emissions between 76% and 89% when compared to the estimates using the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021). GHG emissions reduced from approximately 414.269 to 44.269 million tCO_2e following the implementation of the net zero policies of the Transport Decarbonisation Plan (DfT, 2021a).

Vulnerability of the Project to climate change

Existing baseline

15.4.9 Relevant information sources have been reviewed to establish existing and future baseline data and current understanding with regard to climate and

extreme weather impacts. A summary of these sources is provided below, with more detailed information in Appendix 15.2: Climate Resilience Baseline (Application Document 6.3).

15.4.10 The Project sits within the Met Office 'South East and Central Southern' and 'East Anglia' districts. Climate observations for this region, presented as 10-year averages between 1970 and 2019, identify a relatively rapid warming trend, with an increase of 1.17°C in mean maximum annual temperatures in the period 2010 – 2019 as compared to the period 1970 – 1979. Mean annual rainfall has decreased by 4.09% when comparing these two periods.

15.4.11 Local Climate Impact Profiles (LCLIP) have been developed to assess the vulnerability of local authorities' services to severe weather events for Kent County Council, Essex County Council, Thurrock Council and the London Borough of Havering. Medway, Gravesham and Brentwood local authorities have not produced separate LCLIPs but have contributed towards their respective county profiles. All four LCLIPs show a pattern with regard to the frequency and severity of extreme weather events and highlight the impacts these have on services, including spending pressures, across the counties. A summary of the key findings from the LCLIPs for Kent, Essex, Thurrock and Havering is provided in Table 1.2 of Appendix 15.2: Climate Resilience Baseline (Application Document 6.3).

15.4.12 The Project is primarily in Flood Zone 1 but includes three sections that would cross Flood Zones 2, 3a and 3b. The Highways Agency Drainage Data Management System (HADDMS) (Highways Agency, 2013) indicates that there have been the following historical flooding incidents:

a. Several surface water flooding incidents along the A2/M2 corridor, many of which have already been mitigated according to the HADDMS Hotspot Action Status record. The remainder fall in areas where new drainage provisions would be included as part of the Project and any legacy flooding issues at the incident locations would be resolved. However, this section of the Project would be located in a local depression so would always be susceptible to surface water flooding.

b. One surface water flooding incident occurred at the A13 / A1089 junction, which is recorded as having low impact. This junction would be remodelled to incorporate the Project road and new drainage provision would be included.

15.4.13 Fluvial and tidal flood risk zones and flood defence assets are illustrated in Appendix 14.6: FRA (Application Document 6.3).

Future baseline ('Without Scheme' scenario)

15.4.14 The future baseline identifies any anticipated changes to the existing baseline over time in the absence of the Project and is used as a basis against which to robustly predict the potential impacts of the Project.

15.4.15 Relevant information sources have been reviewed to establish existing and future baseline data and current understanding with regard to climate and extreme weather impacts. A summary is provided in the following paragraphs,

with more detailed information in Appendix 15.2: Climate Resilience Baseline (Application Document 6.3).

15.4.16 For the two 25km by 25km grid squares within which the Project would be located, UKCP18 (Met Office, 2018) projects an increase in mean summer and winter air temperatures, while precipitation rates are expected to become more seasonal, with more precipitation expected in winter and less precipitation in summer.

Construction year (2025)

15.4.17 Between 2020 and 2039, annual average daily temperatures are projected to be 1°C higher than the 1981–2000 baseline average. For the same future time period, annual mean daily precipitation levels are projected to be higher, with a 6.1% increase projected for winter, and a 10.1% decrease projected for summer (when compared to the 1981 – 2000 baseline average).

15.4.18 UKCP18 (Met Office, 2018) projections for changes to the frequency of severe weather events (under the high emissions scenario, 50% probability level), have been assessed for the Project's location. These projections indicate that there is likely to be an increase in the average annual frequency of heatwaves, days when the temperature exceeds 28°C, prolonged periods with no rainfall (10+ days) and days when precipitation is greater than 25mm per day. These projections are against a baseline average for 1981 – 2000.

15.4.19 In addition, climate change could increase peak rainfall intensity. This increased peak rainfall intensity would result in a corresponding increase in the rate and volume of runoff being discharged to local watercourses and subsequently create an escalation in flood risk. Furthermore, sea levels are also projected to rise as a result of climate change; the higher central allowance for the River Thames is 5.7mm per year (2000 to 2035) (refer to Section 4 of Part 6 of Appendix 14.6: FRA for further details).

Opening year (2030)

15.4.20 The opening year baseline would be much the same as the construction year, as 2030 still falls within the 2020 – 2039 climate projection period. It is, however, likely to be slightly warmer than in 2025 as the average temperature moves towards those projected within the 2040 – 2059 period.

Design year (2045)

15.4.21 Between 2040 and 2059, annual average daily temperatures are projected to be 1.7°C higher than the 1981 – 2000 baseline average. For the same future period, annual mean daily precipitation levels are projected to be 0.6% lower, with a 9.5% increase projected for winter, and a 20.2% decrease projected for summer (when compared to the 1981 – 2000 baseline average).

End of appraisal period year (2089)

15.4.22 Between 2080 and 2099, annual average daily temperatures are projected to be 3.7°C higher than the 1981–2000 baseline average. For the same future period, annual mean daily precipitation levels are projected to be 3.7% lower, with a 20.8% increase projected for winter, and a 35.9% decrease projected for summer (when compared to the 1981 – 2000 baseline average).

15.4.23 For both the design year and the end of the appraisal period year, the projections for changes to the frequency of severe weather events indicate that there is likely to be an increase in the average annual frequency of heatwaves, prolonged periods with no rainfall and days when precipitation is greater than 25mm per day. These projections are against a baseline average for 1981 – 2000.

15.4.24 Severe storms or other extreme weather conditions combined with high tides can cause sea levels to rise above normal levels and will become more likely during this period. This can cause flooding along undefended tidal rivers.

15.4.25 As the Project is considered to be essential infrastructure (as defined in Ministry of Housing, Communities and Local Government, 2021a) and has a long operational life, the upper end and central rainfall intensity allowances have been used as detailed in Part 6 of Appendix 14.6: FRA (Application Document 6.3).

15.4.26 Outputs of the current UK climate projections (UKCP18) (Met Office, 2018) were published in November 2018 through a web-based user interface, providing climate projections for user-selected locations. The Environment Agency guidance on climate change allowances for FRAs was updated in December 2019 to apply UKCP18 sea level rise allowances, further amended in July 2021, applying revisions to guidelines for river flow allowances, and amended twice in May 2022 to update the peak rainfall allowances using UKCP local 2.2km projections, and provide clarifications (Environment Agency, 2022b).

15.4.27 In line with the required temporal scope, fluvial design flood events have been simulated for the years 2030 and 2130. The Environment Agency's guidance on climate change allowances provides uplifts for rainfall for the period covering 2015 to 2115, and river flow sea level rise for the period covering 2000 to 2125.

15.4.28 In the absence of climate change allowances for 2130, the Environment Agency's climate change uplifts to rainfall for 2061-2125 and for river flow to 2070-2125 have been adopted for the purposes of this assessment. This approach is consistent with 'Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities' (Environment Agency, 2016). Sea level rise beyond 2125 has been extrapolated by assuming the same rate of rise (mm/year) as specified for 2125, continues beyond 2125.

15.4.29 The Project design and assessment has applied the climate change allowances as detailed in Appendix 14.6: FRA (Application Document 6.3). In addition, sensitivity testing was undertaken to consider the potential impacts on the Project of the credible maximum climate change scenario, for which, Environment Agency's guidance on climate change allowances (2022a) recommends the following:

a. The H++ climate change allowances for sea level rise

b. The upper end allowance for peak river flow

c. The sensitivity test allowances for offshore wind speed and extreme wave height

d. An additional 2mm for each year on top of sea level rise allowances from 2017 for storm surge

15.4.30 The credible maximum climate change scenario flow uplift for the South Essex Management Catchment (Environment Agency, 2022d) is +48%. This catchment encompasses the part of the Project that lies to the north of the River Thames. The part of the Project that lies to the south of the River Thames falls within the Medway Management Catchment. As there are no watercourses in this part of the Project, peak river flow allowances are inconsequential in the context of this assessment and are not considered further.

15.4.31 H++ sea level rise allowances are specified in the current guidance as +1.9m in 2100, with no specified value beyond 2100. H++ storm surge allowances are specified as annual rates of rise of 2mm/year from 2017 onwards. Applying +1.9m sea level rise and 2mm/year storm surge from 2017 to 2130 gives a H++ sea level rise and storm surge allowance of +2.13m at Southend, relative to 2017.

15.5 Project design and mitigation

15.5.1 Environmental considerations have influenced the Project throughout the design development process, from early route options assessment through to refinement of the Project's design. An iterative process has facilitated design updates and improvements, informed by environmental assessment and input from the Project engineering teams, stakeholders and public consultation.

15.5.2 As applied for, the Project includes a range of environmental commitments. Commitments of relevance to climate are set out in this section under the following categories:

a. Embedded mitigation: measures that form part of the engineering design, developed through the iterative design process summarised above.

b. Good practice: standard approaches and actions commonly used on infrastructure development projects to avoid or reduce environmental impacts, typically applicable across the whole Project.

c. Essential mitigation: any additional Project-specific measures needed to avoid, reduce or offset potential impacts that could otherwise result in effects considered to be significant in the context of The Town and Country Planning (Environmental Impact Assessment) Regulations 2017. Essential mitigation has been identified by environmental topic specialists, taking into account the embedded and good practice mitigation.

15.5.3 Embedded mitigation is included within the Design Principles (Application Document 7.5) or as features presented on Figure 2.4: Environmental Masterplan (Application Document 6.2). Good practice and essential mitigation are included in the Register of Environmental Actions and Commitments (REAC). The REAC forms part of Appendix 2.2: Code of Construction Practice (CoCP) (Application Document 6.3). Each entry in the REAC has an alpha-numerical reference code (REAC Ref. CC0XX) to provide cross reference to the secured commitment.

15.5.4 The Design Principles, Environmental Masterplan, CoCP and REAC, all form part of the Project control plan. The control plan is the framework for mitigating, monitoring and controlling the effects of the Project. It is made up of a series of 'control documents' which present the mitigation measures identified in the application that must be implemented during design, construction and operation to reduce the adverse effects of the Project. Further explanation of the control plan and the documents which it comprises is provided in the Introduction to the Application (Application Document 1.3).

GHG emissions

15.5.5 The Applicant can influence but not control the emissions from user carbon (i.e., user traffic). These emissions are covered by wider Government policy, principally the Transport Decarbonisation Plan (DfT, 2021a). The Net zero highways plan (National Highways, 2021a) provides details of how National Highways plans to contribute to reducing user emissions. For example, National Highways has committed to publishing a blueprint for EV charging services on the strategic road network by 2023 and delivering £950 million of charging infrastructure by 2023, aiming at providing at least six 150-350kW charge points at each motorway service area. The availability of sufficient, reliable, and convenient EV charging stations will promote the uptake of electric vehicles and facilitate the reduction of carbon emissions by end users.

15.5.6 In line with DMRB GG 103 (Highways England, 2019a), Section 11 of the Sustainability Statement (Application Document 7.11) presents how the Project design delivers sustainable development goal number 8: 'be resource efficient and reflect a circular approach to the use of materials'. The Sustainability Statement describes the design approaches to address, as far as reasonably possible, the following three DMRB GC 103 requirements:

a. DMRB GG 103 Requirement: E/1.20 Design solutions shall seek to minimise the consumption of materials and the generation of waste.

b. DMRB GG 103 Requirement: E/1.20.1 Opportunities to reuse site-won materials or arisings from on-site demolition, where available, should be identified, assessed and incorporated into design.

c. DMRB GG 103 Requirement: E/1.21 Safe design solutions that enable deconstruction, demounting and decommissioning to facilitate future high value recycling, re-manufacture, or re-use at end of first life, shall be identified and where feasible incorporated into design.

15.5.7 Applying resource efficiency and circular economy principles will reduce the material demand for the Project and consequently save GHG emissions by reducing:

a. The need to import material (embodied carbon in the material)

b. The need to transport new material to the Order Limits

c. The need to transport (waste) materials offsite (in case of on-site reuse / recycling of excavated soil and demolition materials)

15.5.8 DMRB LA 114 Climate (Highways England, 2021) states that: '*Projects shall seek to minimise GHG emissions in all cases to contribute to the UK's target for net reduction in carbon emissions*'. This requirement applies whether or not the project is anticipated to generate a significant effect on climate.

15.5.9 In line with DMRB LA 114 Climate (Highways England, 2021), the Applicant is committed to reducing GHG emissions from the activities by implementing the following hierarchy for GHG emissions:

a. Avoid and/or prevent – measures that maximise potential for reusing and/or refurbishing existing assets

b. Reduce:

   i. Apply low carbon solutions

   ii. Procure materials locally as far as possible to minimise transport emissions

   iii. Construct efficiently using techniques (during construction and operation) that reduce resource consumption over the life cycle of the Project

c. Remediate – after addressing a) and b), measures to further reduce carbon through onsite or offsite offsetting or sequestration

15.5.10 The requirements of DMRB GG 103 and DMRB LA 114 were applied throughout the preliminary design process and in the development of Project commitments secured through their inclusion within the REAC, oMHP (Annex B of the CoCP) and Carbon and Energy Management Plan.

15.5.11 The carbon model described in the Carbon and Energy Management Plan (Application Document 7.19) takes these REAC and oMHP commitments into account. Further opportunities for GHG emission reduction and the mechanism to achieve this are also described in the Carbon and Energy Management Plan, which is a secured document, and summarised under the header ('Carbon and Energy Management Plan' in this section.

Preliminary design and REAC / oMHP commitments

15.5.12 Embedded mitigation / avoid or prevent – The Applicant has reduced the size of, or removed some Project assets, which has reduced the amount of material required, and therefore the embodied emissions associated with those assets. Examples include:

a. Removing the bridge at Hornsby Lane

b. Reducing the number of lanes on the Project road south of the M25

c. Widening the existing Rectory Road rather than constructing a new highway

d. Reducing the span of the Tilbury Viaduct from 1.2km to 600m

e. Removing the formerly proposed A226 junction

f. Removing the formerly proposed A128 junctions with the Project and A13

15.5.13 These changes have not impacted the integrity of the design but have reduced the volumes of aggregate, asphalt, concrete and steel and therefore, reduced the carbon emissions associated with construction.

15.5.14 Embedded mitigation and enhancement / reduce – The Project design includes plans to maintain and enhance connectivity for walkers, cyclists and horse riders (WCH), to allow for a better and more pleasant environment for those living near the Project. This facilitates active travel, in line with the strategic priorities of the Transport Decarbonisation Plan (DfT, 2021a) to reduce GHG emissions, and gives local road users alternatives to using vehicles for local trips.

15.5.15 The Project design incorporates provision of new routes for WCH, designed to improve access to the existing network, to increase access for users (including those with limited mobility) while considering and mitigating potential impacts from misuse and anti-social behaviour through good design. The total additional and improved provision equates to approximately 64km of routes, as summarised in Chapter 13: Population and Human Health, together with the Design Principles to which they relate.

15.5.16 Good practice / reduce - During detailed design, materials that are renewable, reclaimed or have a recycled content would be specified (REAC Ref. MW001):

a. Where design specification permits, key construction materials used would include a measurable recycled or secondary content.

b. In line with the target set out in DMRB LA 110 Material assets and waste (Highways England, 2019b), 31% of aggregates used in construction would be recycled or secondary, for those applications where it is technically and economically feasible to substitute these alternative materials for primary aggregates. To facilitate compliance with this target, the Contractors would calculate the total aggregate required to achieve the detailed design, and the total where design specification dictates only primary aggregate is used. During construction, the Contractors would record the amount of primary and secondary/recycled aggregate by weight and calculate compliance with the target (offsetting the amount excluded by design specification).

c. Also, in line with the target set out in DMRB LA 110, 70% of suitable, uncontaminated concrete from demolition activities would be recycled and reused within the Order Limits to substitute for primary material

d. Suitable uncontaminated concrete from demolition and construction activities would be processed to achieve non-waste status e.g., in accordance with the Aggregates from Inert Waste Quality Protocol (WRAP, 2013).

15.5.17 Good practice / reduce - The Project would require onsite reuse of approximately 11,176,500m3 of excavated materials, as per paragraph 7.2 of the oMHP (Annex B of the CoCP, Application Document 6.3).

15.5.18 Good practice / reduce – The Contractors would be required to review the design and investigate opportunities to standardise (where reasonably practicable) construction aspects, for example, beam depths, abutment sizes and piers to increase efficiency of materials use in production and reduce waste production. This initiative would be progressed through detailed design and documented in a material efficiency design report submitted to National Highways prior to construction (REAC Ref. MW003).

15.5.19 Good practice / reduce – The Contractors would be required to review the design to investigate the use of prefabricated structures and components; and encourage a process of assembly rather than no construction onsite where economically and technically feasible (REAC Ref. MW004).

Carbon and Energy Management Plan

15.5.20 The Project has been designated a pathfinder project to explore carbon-neutral construction and to support the Applicant's broader plan to become a net zero business, described in the Net zero highways plan (National Highways, 2021a). To deliver on this, the Applicant has set carbon aims for the Project:

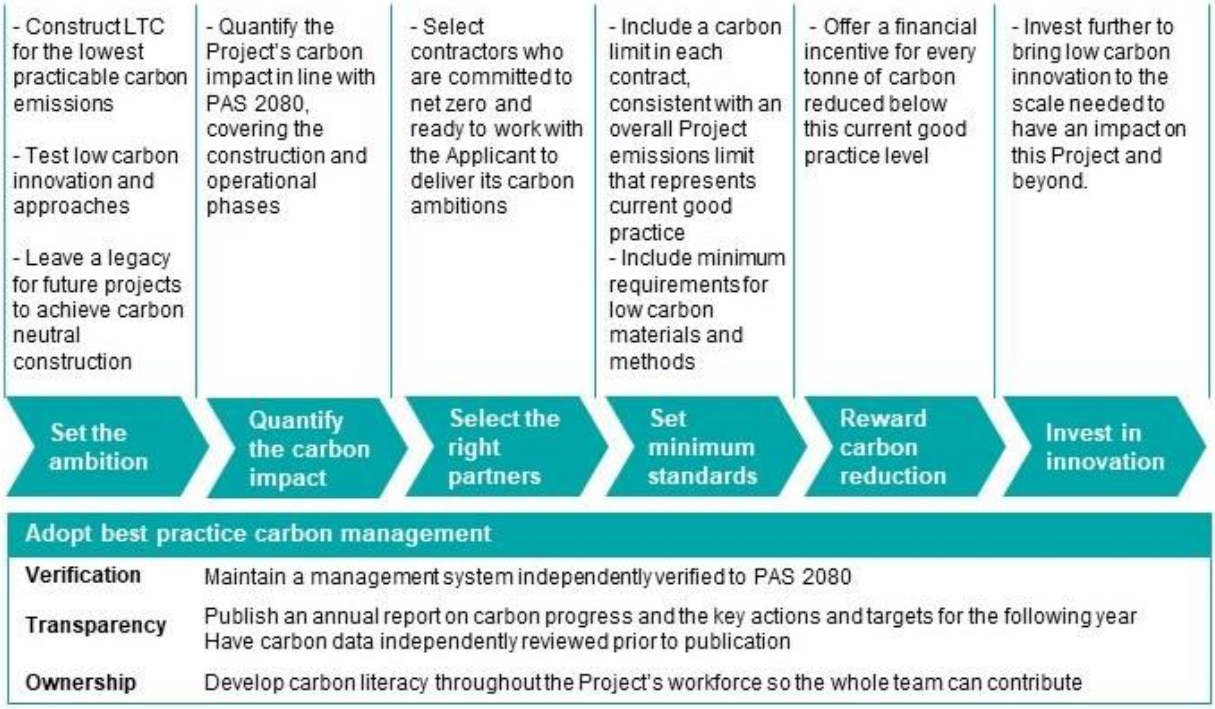
a. To construct it for the lowest practicable carbon emissions

b. To test low carbon innovation and approaches

c. to leave a legacy that enables future projects to decarbonise, in line with National Highways' ambition for net zero construction emissions by 2040

15.5.21 The Carbon and Energy Management Plan (Application Document 7.19) sets out the mechanisms and management arrangements the Applicant would use to deliver on this. A summary of the plan is provided in Plate 15.4.

Plate 15.4 The Project's carbon plan



15.5.22 The procurement process has been designed to set a carbon limit, for each of the three design and build contracts, consistent with an overall level of emissions for the construction phase of the Project of 1.763 million tCO2e. The Applicant considers that level to represent current best practice for low carbon construction because it can only be delivered by incorporating an extensive range of commercially available, low carbon technologies and approaches.

15.5.23 Appendix D of the Carbon and Energy Management Plan (Application Document 7.19) illustrates and Table 15.11 summarises these technologies and approaches, representing one of numerous possible pathways to achieve this level of emissions. The actual route will be determined by the Contractors and their designers but whichever pathway they select, Contractors must, as a minimum, not exceed this level of emissions.

Table 15.11 Carbon reduction measures included in the construction emissions calculation

Carbon reduction measure	Detail	Carbon impact (tCO2e)
65% ground granulated blast-furnace slag (GGBS) replacement for ordinary Portland cement (OPC) in concrete2	The Applicant has assumed 65% GGBS replacement for OPC in all main concrete grades used on the Project (accounting for 97% of total quantity of concrete used).	-275,000
Reuse of excavated material, topsoil and vegetation	The Project is reusing over 20 million tonnes of material excavated from the construction of the roads and tunnels. This saves carbon by reducing a) the need to transport material offsite b) the need to import material for landscaping (embodied carbon in the material) c) the need to transport new material onsite for landscaping	-227,000
50% GGBS replacement for OPC in cement	The Project has two main uses for cement: in concrete and in ground improvement. For cement in concrete, it has assumed 65% GGBS replacement of OPC (see row 1 of this table). For cement in ground improvement, it has assumed 50% GGBS replacement of OPC.	-127,000
Renewable electricity for construction	The Project will use renewable electricity for construction which results in lower carbon emissions than if the Project used grid-average electricity.	-67,000
Concrete grade optimisation	The Project has reviewed the assumed strength grade of the key concretes used during construction and has reduced the grade where possible.	-53,000

[2] Concrete has a wide variation of cement contents for the same strength class of concrete so this carbon impact is an estimate modelled using the ICE Cement, Concrete & Mortar mode (Circular Ecology, 2019).

Carbon reduction measure	Detail	Carbon impact (tCO2e)
Use of steel fibre reinforced concrete	The Project has assumed the use of SFRC for most of the concrete segments in the bored tunnels which has a lower emission factor than steel bar reinforced concrete.	-31,000
Reduced disposal of other material offsite	The Project has identified measures to reduce the amount of material being disposed of offsite including less offsite disposal of the following: • Clean surplus material • Contaminated Materials (Class U1B – non-hazardous) • Contaminated Materials (Class U2 – hazardous) • Topsoil surplus Reducing the amount of offsite disposal saves carbon by reducing the following: • The need to transport material offsite • The need to process materials offsite	-28,000
Design efficiency	The Project has proposed a more carbon-efficient design for the tunnel portal, changing from a large rectangular box to a caterpillar design.	-27,000
Other	The Project has: • identified measures to reduce the amount of aggregate that needs to be imported • assumed that zero tailpipe emission generators will be used rather than diesel generators • reviewed planned utility diversions and removed the need for some of these • assumed that the current best practice level of hybrid and electric plant will be used • assumed the use of warm mix asphalt on the base and binder courses • reduced the average onsite haul distance and the amount of double handling and stockpiling of materials • recycled a proportion of its hazardous waste rather than sending it to landfill.	-63,000
Total carbon impact		**-898,000**

15.5.24 Three iterations of the Carbon and Energy Management Plan will be produced as detailed in The Carbon and Energy Management Plan and Table 15.12.

Table 15.12 Iterations of the Carbon and Energy Management Plan

Iteration	Status	Contents	Approval process
First	• Secured document pursuant to Requirement 16 of Schedule 2 (Requirements) of the draft Development Consent Order (DCO) (Application Document 3.1)	• Relates to the construction and operational phases and provides the overarching approach to reducing emissions • Sets out a process for reducing construction emissions below the maximum level described above, so that the Project is constructed for the lowest practicable carbon emissions • Identifies commitments covering both the construction and operational phases, listed in this plan with the prefix CBN	• Secured control plan under Requirement 16 of the draft Development Consent Order and would therefore form part of any decision to approve the DCO by the Secretary of State
Second	• Would follow the grant of the DCO and must be approved by the Secretary of State before the relevant part of the authorised development commences (Requirement 16). • Must be substantially in accordance with the first iteration of the plan, under Requirement 16	• Relates to the construction phase and provides the detailed approach to reducing emissions including (a) how the Contractors will comply with the maximum level of emissions secured as part of the first iteration and (b) the further measures and proposals Contractors will deploy during the construction phase to reduce emissions below this maximum level • Commitments in the first iteration which relate to the construction of the authorised development will need to be reflected in the second iteration	• Submitted to the Secretary of State for approval prior to commencement of the relevant part of the authorised development • The authorised development must then be carried out in accordance with the approved Carbon and Energy Management Plan (Second Iteration)

Iteration	Status	Contents	Approval process
Third	• Must be submitted for the approval of the Secretary of State by the end of the construction, commissioning and handover stage of any part of the authorised development	• Must address the matters set out in the Carbon and Energy Management Plan (First Iteration) which are relevant to the operation and maintenance of the authorised development • Must explain how carbon emissions will be managed and minimised during the operation and maintenance of the authorised development, with an emphasis on continuous improvement and compliance with evolving best practice • Must support the Applicant's carbon policies, plans and strategies	• Submitted to the Secretary of State for approval by the end of the construction, commissioning and handover stage of any part of the authorised development. • The authorised development must then be operated and maintained in accordance with approved Carbon and Energy Management Plan (Third Iteration)

15.5.25 The Applicant's carbon commitments are listed in Appendix E of the Carbon and Energy Management Plan (Application Document 7.19) and set out in Table 15.13. These are all considered good practice measures.

Table 15.13 Register of carbon commitments included in the C&EMP

ID	Commitment	Iteration of C&EMP
CBN01	The Applicant will include carbon as a key criterion in the evaluation of tenders for the three design and build contracts.	First
CBN02	The Applicant will require Contractors to have corporate net zero plans setting out how they will reach a net zero position that aligns with the 1.5°C reduction of the Paris Agreement (United Nations, 2015) and the UK's commitment to be net zero by 2050. The plans must include science-based targets for emissions reduction.	First
CBN03	The Applicant will ensure that formal regular collaborative carbon reduction workshops are held with representatives of all Contractors present.	First & second
CBN04	The Applicant will develop and, where appropriate, implement measures to avoid / prevent, reduce and remediate emissions arising from the construction of the Project to ensure that net construction emissions do not exceed 1.763 million tCO_2e.	First & second
CBN05	Contractors will be required not to exceed a carbon limit which is aligned to the level set out in CBN04	First

ID	Commitment	Iteration of C&EMP
CBN06	The Applicant will require Contractors to provide Environmental Product Declarations for the ten construction products contributing the most to carbon emissions in their contract. The Environmental Product Declarations must show that the emission factor for the product being used is better than European average.	First & second
CBN07	The Applicant will require Contractors to procure renewable electricity throughout construction, to meet any demand that is not met through onsite renewables and will provide Renewable Energy Guarantee of Origin (REGO) certificates covering the total amount of electricity consumed.	First & second
CBN08	The Applicant will require Contractors to provide and maintain electric vehicle charging facilities, using zero carbon electricity, for 30% of parking capacity in each compound, increasing this as necessary to satisfy demand.	First & second
CBN09	The Applicant will require Contractors to use zero tailpipe emission vehicles for all staff movements within the working areas of compounds and to and from public transport hubs.	First & second
CBN10	The Applicant will require Contractors to promote the use of active transport for personnel to and from the compounds and to provide managed electric charging facilities for e-bikes at each compound, in covered cycle parking areas, to satisfy demand.	First & second
CBN11	The Applicant will provide commercial incentives for Contractors to reduce emissions below their carbon limit.	First
CBN12	The Applicant will include a contractual mechanism that allows Contractors to be paid the additional costs of implementing agreed carbon reduction technologies, together with an incentive payment to further encourage their identification and adoption.	First
CBN13	The Applicant will obtain PAS 2080 certification for the Project from an independent, UKAS accredited third-party certification body by the end of 2023 and will maintain the certification annually.	First
CBN14	The Applicant will require Contractors to obtain PAS 2080 certification from an independent, UKAS accredited third-party certification body within 52 weeks of the contract starting date and will maintain the certification annually[1].	First & second
CBN15	The Applicant will require Subcontractors to obtain PAS 2080 certification within 52 weeks of appointment, unless otherwise agreed by the Applicant[2].	First & second
CBN16	The Applicant will publish an annual carbon report that will include information on forecast life cycle carbon emissions, carbon reductions and progress against carbon commitments as well as key actions and targets for the following year.	First & second

[1] Starting date is the Contract Date which is defined in the NEC4 Engineering and Construction Contract as the date when the contract came into existence
[2] Appointment is the earlier of the date when the relevant sub-contractor commenced providing its works and the date it entered into a subcontract with the Contractor

ID	Commitment	Iteration of C&EMP
CBN17	Carbon data published by the Applicant in the annual carbon performance report will be independently reviewed prior to publication.	First & second
CBN18	The Applicant will deliver carbon literacy training and achieve silver certification from the Carbon Literacy Project by the end of 2023.	First
CBN19	The Applicant will require Contractors to develop the carbon literacy of their workforce working on the Project to Carbon Literacy Project level silver within 52 weeks of the contract starting date[3].	First & second
CBN20	The Applicant will require Subcontractors to develop the carbon literacy of their workforce working on the Project to Carbon Literacy Project level silver within 52 weeks of their engagement[4].	First & second
CBN21	The Applicant will require Contractors to appoint a director responsible for carbon.	First & second
CBN22	The Applicant will publish a third iteration of this Carbon and Energy Management Plan explaining how carbon emissions will be managed and minimised during the operation and maintenance of the Project, to support the Applicant's carbon policies, plans and strategies. This would include measures such as the use of low energy lights.	First & third

15.5.26 The Carbon and Energy Management Plan (Application Document 7.19) is a secured document. The carbon commitments in Table 15.13 are therefore not repeated in the Design Principles (Application Document 7.5) or Register of Environmental Actions and Commitments (REAC), part of Appendix 2.2: Code of Construction Practice (CoCP) (Application Document 6.3).

Vulnerability of the Project to climate change

15.5.27 A number of measures to increase the Project's capacity to be resilient to the effects of climate change are described below. The assessment of the Project's critical features (such as earthworks, the tunnel and structures) with an appraisal period of 60 years or more has been carried out in line with the UKCP18 RCP8.5 (Met Office, 2018) scenario for the 2080 projections at the 50% probability level (as a minimum) to provide sufficient resilience against a reasonable worst case in terms of climate change (in line with paragraph 4.41 of the NPSNN (DfT, 2014), but applying the equivalent UKCP18 projected climate change scenario instead of the superseded UKCP09 high emissions scenario referred to in NPSNN).

15.5.28 Appendix 15.3 to this chapter includes all identified mitigation measures related to the vulnerability of the Project to climate change, covering climate event categories in line with table 3.35N of DMRB LA 114 (Highways England, 2021). Hereunder, some examples of the mitigation measures from Appendix 15.3 are presented.

[3] Starting date is the Contract Date which is defined in the NEC4 ECC as the date when the contract came into existence
[4] Engagement is the earlier of the date when the relevant sub-contractor commenced providing its works and the date it entered into a subcontract with the Contractor

Embedded mitigation

Construction phase

15.5.29 No construction phase embedded mitigation is presented for vulnerability of the Project to climate change as the measures which relate to the construction phase reflect good practice rather than measures which are embedded in the design of the Project.

Operational phase

15.5.30 The Project design and assessment have applied the climate change allowances specified in the Environment Agency's guidance (Environment Agency, 2022a), and in consultation with the Environment Agency, as detailed in Appendix 14.6: FRA (Application Document 6.3). In addition, sensitivity testing has been undertaken to consider the potential impacts on the Project of the credible maximum climate change scenario. Credible maximum climate change scenario allowances are provided in the Environment Agency's (2022a) climate change guidance.

15.5.31 Operational phase embedded mitigation of relevance to the vulnerability of the Project to climate change is as follows:

a. Through undertaking the FRA (Appendix 14.6: FRA, Application Document 6.3), the vertical alignment of the carriageway, the design of watercourse crossings and protection measures for the tunnel portals all include appropriate allowance for climate change effects on river flows and water levels in the Thames Estuary. Climate change effects on groundwater resources have also been considered in the design of the Project. These measures to increase the Project's capacity to cope with future flood risk, are embedded within the design.

b. Flood mitigation measures can have a beneficial effect on biodiversity as well. At the area at Orsett Fen, new freshwater habitats would be created (ditches and open waterbodies), which would provide for aquatic and riparian habitats, and improve flood resilience by storing water in the upper catchment of the Mardyke.

c. The design of all the elements of the Project has built-in climate change resilience for the flood risk appraisal period of the Project (2030 – 2130). For example, the operational drainage design has included an allowance for the predicted changes to rainfall intensity and the implications for operational road drainage volumes and rates. The Project's drainage would be designed in accordance with CG 501 Design of Highway Drainage Systems (Highways England, 2020e). Further details are provided in Appendix 15.3; the future baseline subsection of Section 14.4 of Chapter 14: Road Drainage and the Water Environment; Appendix 14.5: Hydrogeological Risk Assessment; and Appendix 14.6: FRA (Application Document 6.3).

d. The drainage design would reduce the risk of causing flooding elsewhere by using attenuation features as presented on Figure 2.4: Environmental Masterplan (Application Document 6.2). Drainage of operational areas on greenfield sites would be designed to ensure that post-development surface water runoff rates do not exceed existing rates (LSP.16). Where this attenuation is provided via ponds, the ponds would be designed to appear as naturalistic elements within the wider setting, with planting provided to soften edges where this is appropriate (LSP.17). This strategy would protect receiving watercourse flow regimes as well as preventing increased scour near drainage outfalls and changes to sediment deposition/accretion in downstream reaches.

e. Signs and signals will be designed in accordance with DMRB CD 354 Design of Minor Structures (Highways England, 2020d). In addition, they will be inspected periodically in accordance with DMRB CS 125 Inspection of Traffic Signs (Highways England, 2020j) to maximise the design life of the assets and to ensure assets stability. In addition, signs and signals will be positioned in accordance with DRMB CD 146 Positioning of Signalling and Advance Direction Signs (Highways England, 2020a).

f. Climate change requirements in DMRB CD 352 Design of road tunnels (Highways England, 2020g) would be taken into account in the detailed design of tunnel ventilation and drainage (REAC Ref. CC001).

Good practice

Construction phase

15.5.32 Good practice construction measures of relevance to climate change vulnerability are as follows:

a. The Contractors would design the permanent works in accordance with the design standards identified in Table 2.1 and Table 2.2 in Appendix 15.3 (Application Document 6.3) and use construction materials that would be resilient to the effects of projected future climate change in line with UKCP18 (Met Office, 2018) (REAC Ref. CC001). This commitment includes:

   i. the use of short to mid-term weather forecasting to plan key construction activities

   ii. the design of worksite drainage to include allowances for a 20% increase in peak rainfall intensities

   iii. the management of material stockpiles and the management of geotechnical risks in light of projected climate changes

   iv. the selection of water and temperature-sensitive construction materials in line with projected climate change set out in UKCP18 (Met Office, 2018), or as updated.

b. Worksite drainage systems would be inspected and maintained to ensure they continue to operate to their design standard, safeguarding surface and groundwater quality (REAC Ref. RDWE002).

c. The Contractors shall develop a construction phase drainage plan. The plan shall demonstrate how the Contractor would manage surface water runoff across the worksite, including details of how offsite impacts would be prevented. The surface water drainage design for temporary works shall include climate change allowances up to 2030 in accordance with Flood risk assessments: climate change allowances (Environment Agency, 2022). Work site drainage systems would incorporate pollution control systems designed in line with Control of Water Pollution from Construction Sites C532 (CIRIA, 2001) or as agreed with the Secretary of State. Surface watercourses and waterbodies (as identified in Table 14.9 of Chapter 14) near work sites would be regularly inspected for signs of siltation or other forms of pollution in line with CIRIA C741 guidance (CIRIA, 2015) and pumped groundwater, process effluents and construction site runoff would be tested to ensure compliance with discharge consent requirements. Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and would be subject to treatment prior to discharge. Rainfall runoff from areas of low contamination risk would be captured and reused where reasonably practicable to reduce consumptive water use (e.g., to supply wheel wash facilities or for dust suppression). (REAC Ref. RDWE006).

d. Implementation of effective standard operating procedures and severe weather emergency planning in the event of necessary road closure or traffic diversions. The Contractors would give due consideration to the impacts of potential extreme weather events and related conditions during construction. The Contractors would use a short to medium-range weather forecasting service from the Met Office or other approved meteorological data and weather forecast provider, and Environment Agency flood forecasts where relevant, as well as tidal information from the Port of London Authority to inform short to medium-term programme management, environmental controls and impact mitigation measures. In addition, the Contractors would ensure that the relevant measures within the CoCP (Application Document 6.3, Appendix 2.2) are implemented and, as appropriate, consider additional measures to ensure the resilience of the proposed mitigation of impacts during extreme weather events. As appropriate, method statements would also consider extreme weather events where risks have been identified.

Operational phase

15.5.33 Operational phase good practice mitigation of relevance to the vulnerability of the Project to climate change, is as follows:

a. The Contractors would design the permanent works in accordance with the DMRB standards identified in Table 2.1 and Table 2.2 in Appendix 15.3 (Application Document 6.3) and use construction materials and products that would be resilient to the effects of projected future climate change in line with UKCP18 (Met Office, 2018) (REAC Ref. CC001). This commitment includes the following:

   i. The design criteria for all drainage pipe networks ensure that there should be no surcharge for the 1 in 1-year storm and no flooding for the 1 in 5-year storm, including an uplift of 20% in the peak rainfall intensity as an allowance for climate change. A test based on a 40% uplift in peak rainfall intensity would also be undertaken to assess the sensitivity of the design.

   ii. Storage volumes for balancing ponds and infiltration basins have been based on the worst 1 in 100-year storm event. To account for the effects of climate change, pond sizes and basins have been determined on the basis that there is a 20% increase in peak rainfall intensity with a further check to ensure no flooding occurs for a 40% increase in peak rainfall intensity. Full details of the surface water drainage proposals for the Project are set out in Part 7 of Appendix 14.6 (Application Document 6.3).

   iii. Implementation of current standards for maintenance of critical Project assets such as pavements, bridge structures and the tunnels to ensure deterioration and/or defects are identified and managed.

Essential mitigation

Potentially significant effects

15.5.34 A review of the Project design taking into account the embedded mitigation and good practice, was undertaken to identify any potentially significant effects that would require essential mitigation. Climate change effects that could be significant and therefore required further consideration for essential mitigation were identified for the construction and operational phases.

Construction phase

15.5.35 Construction phase essential mitigation of relevance to the vulnerability of the Project to climate change is as follows:

b. While the Project has been delivered in accordance with the NNNPS, the FRA should also meet the requirement set out within NPPF as article 1.18 of the NPS states that the NPPF is also likely to be an important and relevant consideration in decisions on Nationally Significant Infrastructure Projects. Article 1.17 of the NPSNN states that the NPSNN and NPPF have equally important roles.

c. In accordance with the requirements of the NPPF regarding development and flood risk (Ministry of Housing, Communities and Local Government, 2021a), the northern tunnel entrance compound and Station Road compound to the north of the River Thames, and the southern tunnel entrance compound and Milton compound to the south of the River Thames, which are partially sited within Flood Zones 2 and 3, would be laid out in accordance with a site-specific FRA, where facilities at highest vulnerability to flooding, e.g. sleeping accommodation, medical, welfare and principal office facilities, are located in the lowest flood risk zone (Zone 1). Only low vulnerability and water-compatible uses should be situated in the high-risk Flood Zone 3 (REAC Ref. RDWE022). Construction compounds are presented in Figure 2.5 (Application Document 6.2).

d. REAC commitments RDWE037, RDWE022 and RDWE001 cover management of flood risk during construction, including provision of compensation to offset temporary floodplain storage losses, managing work site runoff, establishment and layout of construction compounds, etc.

Operational phase

15.5.36 Operational phase essential mitigation of relevance to the vulnerability of the Project to climate change is as follows:

a. New retention ponds shall be designed as vegetated drainage systems in accordance with the relevant provisions of DMRB CD 532 and will be sized to ensure no increase in flood risk outside the highway boundary by providing for discharge that is attenuated to the 1 in 1-year greenfield runoff rate (or 1 litre per second, whichever is higher) for all events up to and including the 1 in 100-year rainfall event with climate change. Attenuation would be by means of vortex controls, orifice plates or a combination thereof. Notwithstanding the above, the minimum discharge rate from new retention ponds shall be 1l/s. Discharge rates from existing retention ponds shall be reduced by at least 50% on current discharge rates (REAC Ref. RDWE035).

b. Flood protection would be provided around the North Portal to reduce the risk of inundation of the tunnel. The flood protection will comprise flood walls, bunds and targeted earthworks. The portal protection would be designed to accommodate a 1 in 1,000-year River Thames extreme tide level event with climate change allowances up to 2130 and a freeboard (residual uncertainties) allowance of 1,000mm. The portal protection would be as shown on Drawing No. 010180 and described in Part 6 of Appendix 14.6: FRA (Application Document 6.3) (REAC Ref. RDWE029).

c. A drainage channel, illustrated in Drawing No. 00181 of Appendix 14.6 (Application Document 6.3), would be provided between the Mardyke and the viaduct abutment immediately to the west of the river. The channel would be designed to manage the intercepted floodplain flows for a 1 in 100-year storm event with climate change allowances up to 2130 (REAC Ref. RDWE040).

d. A raised bund would be constructed to prevent the formation of a new flow path from Golden Bridge Sewer to the Mardyke in Orsett Fen. The bund would be designed to prevent the formation of a new flow path for a 1 in 100-year storm event with climate change allowances up to 2130 and a freeboard (factor of safety) allowance of 600mm. The bund would be as described in Part 6 of Appendix 14.6: FRA, and as shown in Drawing No. 00181 of the FRA (REAC Ref. RDWE039).

e. The Project road would intercept an overland flow path running east to west across East Tilbury Marshes. To offset the loss of the flood flow path, three existing culverts would be removed and one enlarged replacement culvert would be added (ref X-EFR-2-02). A flow control structure (ref S-EFR-2-01) would be constructed in West Tilbury Main. This structure would manage flooding levels in East Tilbury Marshes. Watercourse structures would be altered as described in Part 10 of Appendix 14.6: FRA, and as illustrated on Drawing Nos. 10180-100182 of the FRA (REAC Ref. RDWE046).

f. To ensure continued functionality of the West Tilbury Main, an existing blockage of the culvert where Station Road crosses the West Tilbury Main (as presented on Drawing No. 10180 of Appendix 14.6: FRA (Application Document 6.3)) would be cleared and the section of West Tilbury Main running northward from Station Road would be re-established as a flowing watercourse (REAC Ref. RDWE047).

15.6 Assessment of likely significant effects

15.6.1 This section presents the assessment of likely significant effects on climate resulting from GHG emissions arising from the construction and operational phases of the Project. It also presents the assessment of the Project's vulnerability to climate change. These are based on the preliminary design of the Project and take into account the mitigation as presented in Section 15.5.

GHG emissions

Construction phase emissions

15.6.2 In the worst-case scenario, construction phase emissions are calculated to be approximately 1.763 $MtCO_2e$. Table 15.10 of this chapter summarises, and Table 3 in Appendix D of the Carbon and Energy Management Plan (Application Document 7.19) presents in more detail, possible GHG emission reduction measures, representing one of numerous possible pathways to achieve this level of emissions. This scenario represents current best-practice because it can only be delivered by incorporating an extensive range of commercially available, low carbon technologies and approaches. The Applicant is therefore legally committing to a process which would ensure that the Project's construction emissions would not exceed 1.763 $MtCO_2e$.

15.6.3 However, the Applicant is committed to going further and to using the time available before construction of the Project begins to explore ways of achieving greater reductions in emissions, reflecting the Project's 'pathfinder' status.

15.6.4 To deliver this, the Applicant has set the following carbon aims for the Project:

a. To construct it for the lowest practicable carbon emissions

b. To test low-carbon innovation and approaches

c. To leave a legacy that enables future projects to achieve carbon-neutral construction

15.6.5 The first iteration of the Carbon and Energy Management Plan (Application Document 7.19) therefore provides a framework within which the Applicant and Contractors would, working closely with industry partners, seek to identify and develop innovative ways of reducing the Project's construction emissions below today's industry-leading position.

15.6.6 Table 15.14 presents a breakdown of the worst-case construction phase emissions by the PAS 2080 modules identified in Table 15.2. The quantification provides the Do Something scenario for the construction phase and these emissions are considered net GHG emissions.

15.6.7 Embodied carbon accounted for the largest proportion of the construction phase emissions, contributing over 50% of the total construction phase emissions whilst 16% of the overall emissions were from risk items allocated a carbon impact.

15.6.8 Appendix D of the Carbon and Energy Management Plan (Application Document 7.19) has broken down the construction phase GHG emissions in a number of ways including by emission source, material type and contract.

Table 15.14 Construction phase Do Something scenario by PAS 2080 module***

PAS 2080 Module		Carbon emissions (tCO_2e)	Activity data
Product stage	A-0 Pre-construction	5,311	Survey activity data Staff travel
	A-1 Raw material supply A-2 Transport A-3 Manufacture	1,114,670	Embodied carbon in raw materials for temporary and permanent works for tunnels, highways and utility works
Construction process stage	A-4 Transport of materials to and from works site	231,448	Construction phase traffic (including transport of material assets, waste and workers)
	A-5 Construction / Installation processes	411,537	Plant and equipment, fuel and energy used on site Disposal of wastes Net emissions resulting from land use change* Risk**
Construction stage total emissions		1,762,967	

PAS 2080 Module	Carbon emissions (tCO_2e)	Activity data
*Land use change – an assessment of the GHG emissions mobilised from vegetation or soil loss during the construction stage in addition to GHG emissions associated with land use change through the Project's planting proposals and ongoing sequestration of carbon each year during the operational phase (60 years from the Project opening year). The type and area of land subject to change has been assessed in line with the proposals presented on the Environmental Masterplan (ES Figure 2.4, Application Document 6.2) and resulted in a net sequestration of carbon of -133,955 tCO_2e over the 60-year appraisal period. The control plan, including the Environmental Masterplan, Outline Landscape and Ecology Management Plan (Application Document 6.7) and Design Principles (Application Document 7.5) sets out and legally secures the ongoing design and management regimes of the proposed landscaping and environmental mitigation, giving high confidence in their successful delivery in perpetuity. In this assessment, tree planting and habitat creation is identified as part of the strategy to mitigate part of the construction phase GHG emissions. The net emissions from land use change have been included in the construction stage as all the works to create the landscaping occur during this phase. Allocating the sequestration benefit to the operational phase would not materially change the conclusions of the assessment of significance. **Risk covers the emissions from scenarios that are uncertain, e.g., the degree of ground improvement that is required for the highways. More ground improvement will result in higher carbon emissions due to the embodied carbon in the material used (e.g., cement) and due to the diesel consumed by plant undertaking the ground improvement. Although these scenarios may not arise, an allowance of potential carbon emissions has been apportioned to them to provide a reasonable worst-case estimate of the overall emissions. *** The presented numbers are the result of model calculations. They should still be considered as estimates however.		

15.6.9 In line with DMRB LA 114 (Highways England, 2021), the construction GHG emissions of the Project have been benchmarked against other recent nationally significant highways projects.

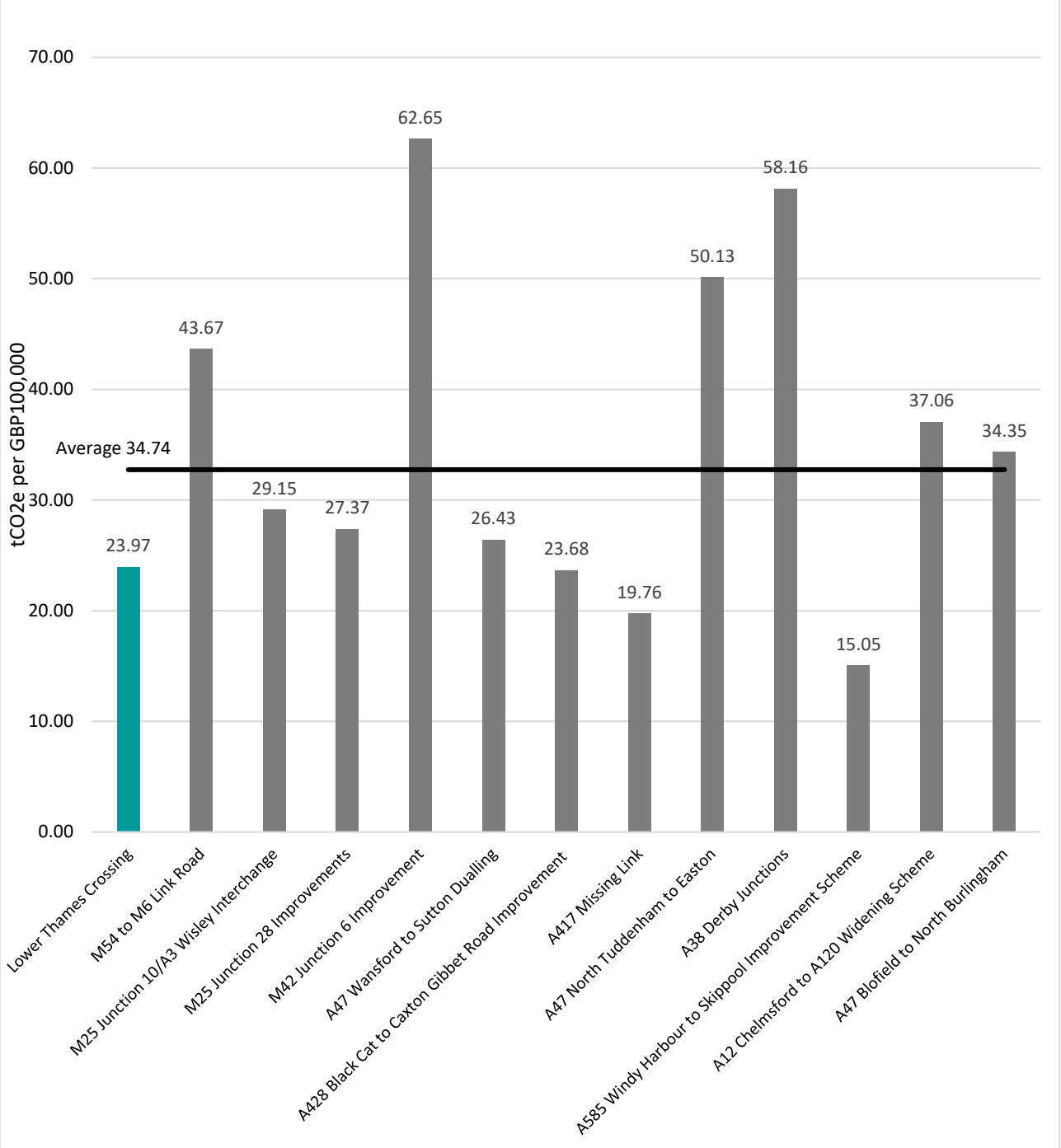
15.6.10 The benchmarking was carried out by dividing the forecast construction emissions for each project with the respective capital costs of construction giving a tCO_2e/£100,000 benchmarking parameter.

15.6.11 For consistency reasons, the benchmarking was limited to recent projects whose environmental statements were issued after publication of DMRB LA 114 (Highways England, 2021) and with project costs reported on the relevant National Highways project websites[3] (accessed September 2022). Where a cost range was reported, the average was calculated. Construction emissions for each project were taken from the respective environmental statements published on the Planning Inspectorate's website[4] (accessed September 2022).

15.6.12 The benchmarking comparison is given in Plate 15.5 and shows that the Project's emissions of 23.97 tCO_2e/£100,000 are about 26.8% lower than the average of 32.74 tCO_2e/£100,000 of the reported projects. It is noted that the projects included in the benchmarking show a great variety in size and complexity, which may impact the carbon intensity, and therefore the benchmarking is used as an indicative comparison only.

[3] [redacted]
[4] https://infrastructure.planninginspectorate.gov.uk/projects/register-of-applications/

Plate 15.5 Benchmarking carbon intensity (tCO_2e/£100,000) of highway schemes



Operational phase emissions

15.6.13 Table 15.15 presents a breakdown of the Do Something scenario for the operational phase. This includes GHG emissions associated with the ongoing maintenance and repair of the Project as well as emissions from road users for the 2030 opening year, the 2045 design year and the cumulative total over the 60-year appraisal period. For the road-user emissions, the output using the TAG GHG workbook (DfT, 2022a), EFT v11 (Defra, 2021) and the Transport Decarbonisation Plan sensitivity test (upper and lower bound) (DfT, 2021a) are presented in Table 15.15 for comparison.

Table 15.15 Operational phase GHG emissions (Do Something scenario)***

Emission source		2016 Existing baseline (tCO_2e)	2030 Opening year (tCO_2e)	2045 design year (tCO_2e) (% change from opening year)	60-year appraisal period** (tCO_2e)
Operation and maintenance, including repair, replacement and refurbishment		N/A	3,036	0	30,613*
Road-user emissions	TAG GHG Workbook / EFT v11****	8,869,800	8,993,269	6,974,840 (- 22%)	419,071,785
	Transport Decarbonisation Plan upper bound	N/A	8,396,935	1,445,287 (- 83%)	100,227,686
	Transport Decarbonisation Plan lower bound	N/A	5,675,995	507,118 (-91%)	44,799,689

* Zero carbon maintenance (maintenance, repair and replacement) from 2040 and zero carbon operations throughout the operational phase of the Project were assumed, in line with the Net zero highways plan (National Highways, 2021a)

** It should be noted that the National End Trip Model (NTEM) Version 7.2 (DfT, 2017) was used. 2051 is the final year of the DfT traffic growth forecasts. Therefore, GHG emissions are at a level rate from 2051 to 2089 for the remainder of the 60-year operational assessment.

*** The presented numbers are the result of model calculations. They should still be considered as estimates however.

**** TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021)

15.6.14 Similarly, to the Do Minimum scenario presented in Table 15.10, the data shows a trend of reduced emissions between the 2030 opening year and the 2045 design year, demonstrating the effect that the increased uptake of electric vehicles will have on road-user GHG emissions. These reductions are greater when taking into consideration the net zero policy of the Transport Decarbonisation Plan (DfT, 2021a), showing a reduction of up to 91% at the lower bound estimate.

15.6.15 Over the 60-year appraisal period, the net zero policies of the Transport Decarbonisation Plan (DfT, 2021a) would reduce road-user emissions by up to 89% when compared to the estimate from TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021).

15.6.16 To determine the net change in GHG emissions during the operational phase, the Do Something scenario was compared to the Do Minimum scenario. This is presented in Table 15.16 for the outputs of the TAG analysis and the Transport Decarbonisation Plan (DfT, 2021a) sensitivity test.

15.6.17 The total net GHG emissions estimated over the 60-year appraisal period and forecast with the TAG GHG Workbook (DfT, 2022a) / EFT v11 (Defra, 2021) was approximately 4.833 million tCO_2e. Of this net increase in emissions, 99% were from road-user emissions (approximately 4.803 million tCO_2e), with the remaining 1% (approximately 0.030 million tCO_2e) from the maintenance, repair, and replacement activities of the Project.

Table 15.16 The net change in the GHG emissions from the operational phase of the Project

Reporting category	Year of project opening (tCO_2e) (2030)	Design year (tCO_2e) (2045)	60-year appraisal (tCO_2e)
TAG GHG Workbook / EFT v11 with operation and maintenance			
Do Minimum	8,900,890	6,891,450	414,268,636
Do Something	8,996,305	6,974,840	419,102,398
Net change	**95,415**	**83,391**	**4,833,762**
Transport Decarbonisation Plan upper bound estimate with operation and maintenance			
Do Minimum	8,310,643	1,427,308	**99,083,29**3
Do Something	8,399,971	1,445,287	100,258,299
Net change	**89,328**	**17,979**	**1,175,005 (-76%)**
Transport Decarbonisation Plan lower bound estimate with operation and maintenance			
Do Minimum	5,617,480	500,236	44,269,175
Do Something	5,679,031	507,118	44,830,302
Net change	**61,551**	**6,881**	**561,127 (-88%)**
* The presented numbers are the result of model calculations. They should still be considered as estimates, however. ** TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021)			

15.6.18 The application of the Transport Decarbonisation Plan sensitivity test (DfT, 2021a) greatly reduces the net change in GHG emissions over the 60-year appraisal period, decreasing emissions by 76 - 88% (upper and lower bound respectively) to between approximately 0.561 and approximately 1.175 million tCO_2e over the 60-year period from opening. This is considered to provide a more realistic estimate for the net GHG emissions for the operational phase.

Appraisal period emissions

15.6.19 The total net GHG emissions over the appraisal period of the Project (construction stage plus 60-year operational phase from opening) are calculated to be approximately 6.596 million tCO_2e with TAG GHG Workbook (DfT, 2022a) / EFT v11 (Defra, 2021). The net zero policy of the Transport Decarbonisation Plan (DfT, 2021a) would reduce this total to between approximately 2.324 million and 2.938 tCO_2e with the lower estimate representing the lower bound estimate and reflecting a high level of policy success and implementation.

15.6.20 These calculations include the worst-case construction emissions scenario (approximately 1.763 million tCO_2e) and do not consider the Project's aim to reduce these emissions further and construct it for the lowest practicable carbon emissions.

Determining significance of effects

15.6.21 In line with DMRB LA 114 Climate (Highways England, 2021) and the requirement of the NPSNN (DfT, 2014), Table 15.17 provides an assessment of the Project's GHG emissions impact against the UK Government's five-year carbon budgets.

15.6.22 The GHG emissions assessment has considered emissions from the Project in two separate phases: emissions during construction and emissions during operation. The construction of the Project would be a short-term activity that runs from 2025 to 2030. Emissions from construction would therefore fall within the fourth and fifth carbon budgets. To determine the yearly contribution of construction emissions and therefore the split over the fourth and fifth carbon budgets, the construction phase GHG emissions were profiled in line with estimated spend profile for the Project. This provided an approximate proportion of the total emissions per year of construction, indicating a peak construction year of 2027.

15.6.23 Emissions from the operation of the Project would fall into the fifth, sixth and subsequent future budgets once set, through to 2050. The operational phase emissions calculated for the five-year carbon budget period include the modelled yearly road-user emissions, plus the average annual GHG emissions associated with maintenance, repair, and replacement.

Table 15.17 Modelled construction and operational phase emissions compared to relevant carbon budgets

Project phase	Modelled total GHG emissions over relevant carbon budgets (tCO_2e) (DS* scenario)	Net Project GHG emissions over relevant carbon budgets (tCO_2e) (DS*- DM*)	Net Project GHG emissions per relevant carbon budget (tCO_2e)**		
			Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth (2033 to 2037)
Construction	1,762,967	1,762,967	1,148,319	614,648	N/A
TAG GHG workbook / EFT v11* with operation and maintenance**					
Operation	76,122,688	746,624	N/A	284,451	462,173
Total	77,885,655	2,509,726	1,148,319	899,099	462,173
Percentage contribution to carbon budget			**0.058%**	**0.053%**	**0.048%**
Transport Decarbonisation Plan upper bound estimate with operation and maintenance					
Operation	52,512,613	579,934	N/A	254,700	325,234
Total	54,275,580	2,342,902	1,148,319	869,348	325,234
Percentage contribution to carbon budget			**0.058%**	**0.051%**	**0.034%**
Transport Decarbonisation Plan lower bound estimate with operation and maintenance					

Project phase	Modelled total GHG emissions over relevant carbon budgets (tCO_2e) (DS* scenario)	Net Project GHG emissions over relevant carbon budgets (tCO_2e) (DS*- DM*)	Net Project GHG emissions per relevant carbon budget (tCO_2e)**		
			Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth (2033 to 2037)
Operation	30,281,202	346,082	N/A	167,476	178,607
Total	32,044,169	2,109,049	1,148,319	782,123	178,607
Percentage contribution to carbon budget			**0.058%**	**0.046%**	**0.019%**

* DM = Do Minimum scenario; DS = Do Something scenario

** The presented numbers are the result of model calculations. They should still be considered as estimates, however.

*** TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021)

15.6.24 The assessment has established that during the period when GHG emissions from the Project would be at their highest, most intense level (short-term construction activity in the 3-year period 2025-2027), the Project construction emissions would represent 0.058% of the fourth carbon budget of 1,950 million tCO_2e. The Project's impact reduces to 0.053% and 0.048% for the fifth and sixth carbon budgets respectively. These contributions represent a maximum level of impact on carbon budgets for the construction and operation phase.

15.6.25 The contributions do not take account of the further reductions that would be delivered through innovation and good practice carbon management throughout the detailed design and construction phase. In addition, the use of the TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021) to model road user contributions do not reflect current net zero policy set out in the Transport Decarbonisation Plan (DfT, 2021a) and are therefore likely an overestimate.

15.6.26 Table 15.16 provides an assessment of the effect that the policies of the Transport Decarbonisation Plan (DfT, 2021a) would have on the Project's net GHG emissions during the operational phase. The sensitivity test has indicated a 3 – 13% (lower – upper bound respectively) reduction in net emissions contributing to the 5th carbon budget (2028-2032), and a 30 – 61% reduction in net GHG emissions contributing to the 6th carbon budget (2033 – 2037), which represents a more realistic effect on the UK carbon budgets over this period.

15.6.27 As shown in Table 15.17, the contribution of the Project's carbon emissions to the UK carbon budgets is small, in particular when the Government's carbon reduction policies to achieve the legally binding carbon budgets are taken into account. The carbon emissions presented in Table 15.17 would reduce further by National Highways pursuing the Project's carbon aims.

15.6.28 It is further noted that the Government's net zero policies to achieve the carbon budgets are adaptable to implement new developments and priorities, or to address (annual) advice of the CCC, an independent statutory body established under the CCA that reports periodically to Parliament on government's progress to meeting net zero. This constitutes a robust 'plan-do-check-act' mechanism for the UK to keep on track for net zero.

15.6.1 The worst-case construction emissions scenario (approximately 1.763 million tCO_2e) represents current best-practice because it can only be delivered by incorporating an extensive range of commercially available, low carbon technologies and approaches (refer to Table 15.11). The Applicant is committed to reducing emissions further to be delivered through innovation and best practice carbon management throughout the construction phase, as set out through the mechanisms presented in the Carbon and Energy Management Plan (Application Document 7.19) and summarised in this chapter (refer to Table 15.13).

15.6.2 These mechanisms would facilitate the Project's ambitions to deliver an industry leading carbon position to go substantially beyond the requirements of today's policy and would implement and promote new best practice for large-scale civil engineering projects to achieve carbon neutral construction. This approach would have a long-term positive effect in the construction industry's alignment with a budgeted science based 1.5°C trajectory set out through the UK carbon budgets.

15.6.3 Carbon emissions related to corporate level operations related to the Project (such as network lighting and use of traffic officer vehicles) would be net zero throughout the appraisal period and emissions related to maintenance, repair and replacement would be net zero by 2040, in line with the Net Zero Highways plan (National Highways, 2021a).

15.6.4 The Project cannot control the implementation of the policies related to reducing road-user emissions, as the levers to support the net zero trajectory in transport emissions are delivered by the Government. As shown in Plate 15.1, Table 15.15 and Table 15.16, implementation of the policies of the Transport Decarbonisation Plan (DfT, 2021a) will have a large effect in reducing road-user emissions associated with the Project and reflects a net zero trajectory consistent with the UK carbon budgets. The Project does not impede the Government from meeting its net zero carbon targets in relation to road-user emissions.

15.6.5 In line with the IEMA guidance: '*Assessing Greenhouse Gas Emissions and Evaluating their Significance'* (IEMA, 2022) the Project is compatible with the budgeted science-based 1.5°C trajectory (in terms of rate of emissions reduction) and both complies with and exceeds up-to-date policy and 'good practice' reduction measures. The Project emissions would not therefore have a significant impact within the meaning of the IEMA guidance. This is on the basis that:

a. The IEMA guidance assesses significance in terms of consistency with the required budgeted science-based 1.5°C trajectory to achieve net zero, rather than in terms of the scale of emissions

b. The Project goes beyond the significance criteria set out in the IEMA guidance because the approach to procurement, commercial incentives and management arrangements would drive further reductions from a starting point that already represents best practice in the construction industry today

c. Implementation of the policies of the Transport Decarbonisation Plan (DfT, 2021a) would reduce road-user emissions in line with the budgeted science-based 1.5°C trajectory set out through the UK carbon budgets. The Project does not impede the Government from meeting its net zero carbon targets in relation to road-user emissions.

15.6.6 In the context of the above, GHG emissions from the Project would not have a material impact on the ability of the Government to meet its carbon reduction targets, and it is concluded that the GHG emissions from the Project would be **not significant**.

Vulnerability of the Project to climate change

15.6.7 A summary of the forecasted future baseline for climate is provided in Section 15.4, with further detail provided in Appendix 15.2: Climate Resilience Baseline (Application Document 6.3). An assessment of the climate resilience impacts and effects, using the criteria set out in Section 15.3, is presented in Appendix 15.3: Climate Resilience Impacts and Effects (Application Document 6.3). A summary of the climate resilience impacts considered, is provided in the following paragraphs.

15.6.8 The assessment considers a variety of receptors, climate events and potential effects on the Project. Mitigation measures have been identified and the resulting (post mitigation) likelihood of impact and consequence of impact determined, based on which the significance was assessed. This is in accordance with DMRB LA 114 (Highways England, 2021) and described in Section 15.3.

Construction phase

15.6.9 A cross-section of examples of climate change events and impacts identified and assessed for the construction phase within Appendix 15.3: Climate Resilience Impacts and Effects (Application Document 6.3) are described below. Further details are provided in Appendix 15.3.

Increased average summer temperatures and increased frequency of extreme temperatures

15.6.10 An increase in average summer temperatures and increased frequency of extreme temperatures may lead to the following effects to the Project:

a. More rapid degradation of materials on existing surfaces and structures

b. Materials may become difficult to work with (for example asphalt) and increase the requirement for stronger fill materials. This in turn could lead to construction programme delays and additional quantities of excavated materials becoming waste

c. Increased risk of heat stress and exhaustion for construction site workers, leading to delays in the construction programme

15.6.11 A number of measures would be in place to minimise these effects (REAC Ref. CC001), including the use of short to medium-term weather forecasting in planning construction activities, environmental controls and impact mitigation

measures, and the selection of materials appropriate for the projected climate scenarios detailed within UKCP18 (Met Office, 2018). Following an assessment of the likelihood (the majority being low or very low) and consequence (the majority minor adverse or negligible) of these events occurring (Application Document 6.3, Appendix 15.3), it is concluded that all effects relating to increased temperatures would be **not significant**.

Decreased annual mean daily precipitation levels and increased frequency of extreme precipitation events

15.6.12 Increases in the frequency of extreme rainfall events could change the surface and groundwater regime. This could lead to potential adverse effects on the design and settlement of foundations, the overwhelming of site drainage as well as adverse effects to earthwork and stockpile activities related to increased sediment transport and erosion. Worksite drainage would be implemented for impermeable hard surfaces to manage surface water runoff, where necessary, to protect watercourses, prevent ponding and to keep general runoff separate from contaminated runoff (REAC Ref. RDWE006). Worksite drainage would be inspected and maintained to ensure it continues to operate to its design standard (REAC Ref. RDWE002).

15.6.13 In addition, the Project has been designed to DMRB CD 622 Managing geotechnical risk (Highways England, 2020f), which requires earthworks, slopes and foundations to be subject to short, medium and long-term engineering risk assessment considering groundwater conditions. Measures have also been included in the REAC (within the CoCP, Application Document 6.3, Appendix 2.2) and secured through the draft DCO (Application Document 3.1) to ensure the safe management of material stockpiles and handling during the construction phase to reduce the risk of ground movements.

15.6.14 Following an assessment of the likelihood and consequence of these events occurring (Appendix 15.3, Application Document 6.3), it is demonstrated that all effects relating to increased intensities of rainfall would be **not significant**.

Operational phase

15.6.15 A cross-section of examples of climate change events and impacts identified and assessed for the operational phase within Appendix 15.3: Climate Resilience Impacts and Effects (Application Document 6.3) are described below.

Increased average summer temperatures and increased frequency of extreme temperatures

15.6.16 An increase in mean summer temperatures and frequency of extreme temperatures could lead to the effects summarised below. A number of the effects identified within the risk assessment would be managed through the application of the current design standards identified in Tables 2.1 and 2.2 of Appendix 15.3 Climate Resilience Impacts and Effects (Application Document 6.3), which include allowances for future climate change (REAC Ref. CC001).

a. Thermal contraction and expansion of pavement and structure surfaces, as well as joints and bearings, leading to an increased rate of deterioration of materials and assets. The likelihood of effects related to the deterioration of materials and Project assets would be reduced through the application of

the latest DMRB standards (refer to Appendix 15.3 (Application Document 6.3)) within the design of structures, pavements and other critical features. Additionally, regularly inspecting and maintaining assets in line with the Routine and Winter Service Code (Highways Agency, 2009a) and the Network Management Manual (Highways Agency, 2009b) would eliminate the risk of adverse effects by identifying deteriorating material assets. Therefore, the assessment presented in Appendix 15.3 (Application Document 6.3) determines the effects to be **not significant**.

b. Alteration of growing characteristics, such as longer vegetation growing seasons and changing soil properties affecting the landscape planting strategy, increasing risks of tree falls and maintenance/management requirements. During detailed design, further detail would be developed through the Landscape and Ecology Management Plan (LEMP), which must be substantially in accordance with the outline LEMP (Application Document 6.7). The purpose of the LEMP would be to document the landscape and environmental commitments that would need to be delivered to achieve the intended environmental function and objective. This would include detailed requirements concerning the medium to long-term maintenance and management of all soft landscaping incorporated into the Project and the responsibility of National Highways in accordance with the DMRB GM 701 Asset Delivery Asset Maintenance Requirements (Highways England, 2020b) and DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020c). Additionally, measures related to the handling and reinstatement of soils within the Order Limits would be set out in the second iteration of the Environmental Management Plan, which is secured through Requirement 4 of the draft DCO (Application Document 3.1). These measures would aim to avoid a reduction in soil function. The assessment presented in Appendix 15.3 (Application Document 6.3) determined the effects to be **not significant**.

c. Overheating of tunnel portal areas and electrical equipment located within the tunnel , such as information and communication systems, leading to a potential fire risk. This risk is limited to areas closer to the tunnel portals due to the ground cover acting as insulation. Alongside the fire detection systems implemented within the tunnel design, the tunnel would be operated in accordance with the Routine and Winter Service Code (Highways Agency, 2009a) and the Network Management Manual (Highways Agency, 2009b). In addition, adequate space would be provided within the tunnels to account for anticipated cooling and ventilation requirements. REAC Ref. CC001 requires the Contractors to design the permanent works in accordance with the design standards identified in Tables 2.1 and 2.2 of Appendix 15.3 Climate Resilience Impacts and Effects (Application Document 6.3) and use construction materials and products that would be resilient to the effects of projected future climate change in line with UKCP18 (Met Office, 2018) projections. The assessment presented in Appendix 15.3 (Application Document 6.3) determined the effects to be **not significant**.

d. Increased risk of road-user accidents resulting from road-user vehicle overheating/fires and smoke drift from wildfires. The likelihood and consequence of this effect would be reduced through the implementation of emergency response and contingency plans and establishing standard operating procedures for use in the event of necessary road closure and/or traffic diversion. In addition, incidents will be managed in accordance with DMRB GM 703 Operational Requirements for Incident Management (Highways England, 2020d). The assessment presented in Appendix 15.3 (Application Document 6.3) determined the effects to be **not significant**.

Decreased mean daily precipitation levels and increased frequency of extreme precipitation events

15.6.17 A decrease in mean daily precipitation levels and increased frequency of extreme precipitation could lead to the effects summarised below. Effects identified within the risk assessment and related to decreased mean daily precipitation levels and increased frequency of extreme precipitation, would be managed through the application of the current design standards identified in Tables 2.1 and 2.2 of Appendix 15.3 Climate Resilience Impacts and Effects (Application Document 6.3), which include allowances for future climate (REAC Ref. CC001).

a. An increased frequency of intense rainfall could increase the flood risk in the Project area, leading to a reduction in safety, more road closures and disruption to the local area. A number of measures have been identified to reduce the consequence of this climate event to an acceptable level, including the setting of the vertical alignment of the road to above the design flood level with inclusions for freeboard and climate change allowances, increasing the Project resilience to flooding. Additionally, flood alleviation measures have been designed to include allowances for climate change for the agreed 100-year appraisal period from the opening year. These include providing compensation flood storage for any permanent losses of floodplain storage volume associated with the West Tilbury Main, Mardyke and Mardyke West tributary, while measures have been provided to maintain floodplain connectivity and prevent embankments forming continuous barriers to floodplain flow conveyance at the West Tilbury Main and the proposed viaduct spanning the Mardyke and Golden Bridge Sewer (REAC Refs. RDWE039, RDWE040, RDWE046 and RDWE047). The assessment presented in Appendix 15.3 (Application Document 6.3) has concluded that, following the implementation of the measures to increase the resilience of the Project to future flood risk, the effects are **not significant**.

b. Changes in rainfall patterns could alter the moisture content of soils and the overall hydrology of the study area. Consequently, this may lead to increased risk of ground movements affecting the foundations and substructures of Project structures, pavement and earthworks, and potentially lead to collapse or failure. As demonstrated by REAC commitment CC001, the engineering design and maintenance regime would accord with the current design standards set out within DMRB taking into account the projected future climate and potential for geo-technical risks. In accordance with DMRB CG 501 (Highways England, 2020e),

storage volumes for balancing ponds and infiltration will be based on the 1 in 100-year storm event. To account for the effects of climate change, pond sizes and basins have been determined as detailed in Appendix 14.6: FRA (Application Document 6.3). Given the measures described to reduce the likelihood and consequence of intense rainfall events, the effect was assessed as **not significant**.

c. 'Summer ice' can occur after a prolonged period of no rain when dirt and oil residue build up on the road. When the first rain event occurs, this material becomes very slippery and dangerous (similar to ice on the road). The risk of 'summer ice' occurring may increase due to the increased frequency of intense rainfall events. The Project's drainage will be designed in accordance with DMRB CG 501 (Highways England, 2020e) and would include provision for pollution treatment systems. The drainage would be inspected and maintained regularly in accordance with DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020c) and GM 701 Asset Delivery Asset Maintenance Requirements (Highways England, 2020b), as applicable, to ensure they continue to operate to their design standard and to ensure dirt and oil continues to be removed from the road surface. Following the assessment included within Appendix 15.3 (Application Document 6.3), the effect was identified as **not significant**.

d. Higher frequencies of intense rainfall events may lead to an increase in sediment transport entering the drainage system. Sediment overloading and failure of drainage systems could potentially lead to localised flooding. Drainage infrastructure and treatment systems would be inspected and maintained regularly in accordance with DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020c) and GM 701 Asset Delivery Asset Maintenance Requirements (Highways England, 2020b), as applicable, to ensure they continue to operate to their design standard. On the basis that the described measures can be assumed to reduce the likelihood and consequence of the impacts, the effect is assessed as **not significant**.

Sea level rise (tidal flooding)

15.6.18 A detailed FRA has been prepared, presented in Appendix 14.6 (Application Document 6.3), which includes sea level rise (tidal flooding). The FRA concluded that two sections of the Project road between the North Portal and the Tilbury Viaduct would be vulnerable to overtopping during a tidal flood event and would need to be protected. Protection measures are secured through REAC Ref. RDWE029. The post-mitigation effect was determined as **not significant**.

15.6.19 The overall conclusion is that post-mitigation, all effects related to climate change would be not significant. Generally, the likelihood of these events occurring is low or very low and the consequence minor adverse or negligible. Full details for each event are presented in Appendix 15.3 (Application Document 6.3).

15.7 Cumulative effects

GHG emissions

Intra-project effects

15.7.1 Cumulative effects of the Project can occur as a result of interrelationships between different environmental topics, which are referred to as 'intra-project effects'. For climate, interrelationships are identified with Chapter 7: Landscape and Visual; and Chapter 11: Material Assets and Waste. However, these interrelationships have already been taken into account in the GHG emission quantifications in this chapter (prescribed by PAS 2080 (BSI, 2016a) and DMRB LA 114 (Highways England, 2021) as outlined in Section 15.3. No further assessment of cumulative intra-project effects is therefore required.

Inter-project effects

15.7.2 In addition to intra-project effects, cumulative impacts can also occur due to the Project in combination with other existing and/or approved developments.

15.7.3 The Project's transport model as detailed within the ComMA (Application Document 7.7) is inherently cumulative with regard to operational carbon emissions. This is because it takes into account the assessment of the proposed scheme and other developments likely to have an influence on the proposed road scheme and on the area the proposed road scheme is likely to influence.

15.7.4 However, unlike other EIA topics like air quality and noise, the effect of carbon emissions on climate change is not limited to a specific geographical boundary but has a cumulative global impact, causing global warming.

15.7.5 To address global warming, the United Nations Framework Convention on Climate Change (UNFCCC) (United Nations, 1992) was adopted on 9 May 1992 and the Paris Agreement (United Nations, 2015) in December 2015. Both were ratified by the UK (refer to Appendix 15.1 for further details).

15.7.6 In line with the UNFCCC and Paris Agreement, the UK has set a legal target for achieving net zero carbon emissions by 2050 and carbon budgets for five-year periods in the trajectory to 2050, pursuant to the requirements of the CCA.

15.7.7 The carbon budgets are considered a proxy for the global climate. Consequently, the Project's GHG emissions have an inherently cumulative impact on the carbon budgets together with the sum of carbon emissions over a range of sectors at the national level.

15.7.8 There is no legal requirement for a breakdown of carbon emission targets per sector or for a smaller geographical scale. Hence, assessing the cumulative effects in combination with other local developments at anything other than a national level is not required under the NPSNN.

15.7.9 The cumulative effect of the Project's GHG emissions has therefore been assessed at a national level, against the UK carbon budgets. The methodology and outcome of this assessment are identical to that described in Section 15.6, where it is concluded that the GHG emissions of the Project would not have a material impact on the ability of the Government to meet the UK carbon budgets and, therefore, the effects were determined as **not significant**.

Vulnerability of the Project to climate change

Intra-project effects

15.7.10 For vulnerability of the Project to climate change, interrelationships are identified within Chapter 7: Landscape and Visual; Chapter 10: Geology and Soils; and Chapter 14: Road Drainage and the Water Environment, and include combined effects from climate change projections of:

a. increased frequency of intense rainfall events although drier winters

b. drier summers and hotter summers

c. warmer winters and less snow

15.7.11 Climate change intra-project effects are inherent to the DMRB LA 114 (National Highways, 2021) climate assessment method as it considers the combined impact of climate variables on the Project within the defined study area. and presented in more detail within Appendix 15.3: Climate Resilience Impacts and Effects (Application Document 6.3). A summary is provided below:

a. Chapter 7: Landscape and Visual – more-frequent heatwaves and droughts may adversely affect the growth rates of landscape planting and/or increase the likelihood of plant failure.

b. Chapter 10: Geology and Soils – greater frequency and severity of drought and high temperatures may adversely affect reinstated (after excavation) soil quality for agricultural use.

c. Chapter 14: Road Drainage and the Water Environment – greater frequency and severity of short periods of high rainfall may adversely affect drainage control measures embedded within the Project design. In addition, a larger number of heavier precipitation events may lead to risk of flooding and potential for impacts to surface water and groundwater quality.

15.7.12 The mitigation measures described in Appendix 15.3 and the referenced chapters ensure that these intra-project effects would be **not significant**.

Inter-project effects

15.7.13 The Project is designed to the most recent standards for climate resilience and there are no significant effects arising from the Project (refer to Section 15.5) on any receptors. The only identified potential inter-project cumulative effect arising from the Project in combination with other developments during the construction and operational phases would be traffic congestion as a result of flooding or failing infrastructure on the strategic road network within the validated Project transport model.

15.7.14 Cumulative vulnerability effects are determined with regard to their significance without the Project (do minimum scenario) compared to their significance if the Project and its climate vulnerability mitigation were to be in operation (do something scenario). If there is no change in significance a cumulative effect is deemed to be not significant.

15.7.15 The Need for the Project (Application Document 7.1) sets out the Project objectives, which include traffic, community and environment and economic aspects.

15.7.16 Under the transport objectives, the Project would deliver

a. Relief the congested Dartford Crossing and approach roads and improve their performance by providing free-flowing north-south capacity

b. Improvement to the resilience of the Thames crossings and the major road network

c. Improvements to safety on the strategic road network

15.7.17 Without the Project (the do minimum scenario), traffic flows at the existing Dartford Crossing, which forms the only existing road crossing of the River Thames to the east of London, are consistently in excess of its design capacity, therefore, a climate change event under this scenario would result in additional congestion and increased poor journey time reliability on the strategic road network.

15.7.18 Under the do something scenario, the Project would provide additional road traffic resilience by increasing the crossing capacity of the River Thames to the east of London. Being designed for climate resilience to the latest standards, the Project would also provide an alternative to parts of the existing strategic road network, notably the Dartford crossing, should those become affected by a climate change event. This alternative would not exist without the Project and therefore would constitute a positive effect from the Project on possible traffic congestion on the strategic road network during adverse weather conditions.

15.7.19 Therefore, the Project will improve the resilience of the strategic road network to the effects of climate change. It will do this by providing additional road capacity and improving accessibility within the study area; thereby improving the flow of traffic. In operation, the Project will enhance the resilience of the regional transport network to respond to cumulative climate vulnerability effects, i.e., failures of surrounding local and regional transport networks.

15.7.20 Potential inter-project cumulative effects arising from the Project in combination with other development schemes during the construction and operational phases (traffic congestion on the strategic road network) would therefore be **not significant**.

15.8 Monitoring

15.8.1 No likely significant adverse residual effects have been identified, and therefore no specific monitoring is required for climate receptors.

GHG emissions

15.8.2 The Carbon and Energy Management Plan (Application Document 7.19) sets out monitoring and reporting commitments as follows:

a. The Applicant will publish an annual carbon report that will include information on forecast life cycle carbon emissions, carbon reductions and progress against carbon commitments as well as key actions and targets for the following year (CBN16).

b. Carbon data published by the Applicant in the annual carbon performance report will be independently reviewed prior to publication (CBN17).

Vulnerability of the Project to climate change

15.8.3 The CoCP (Application Document 6.3, Appendix 2.2) sets out details of the monitoring to be undertaken during the Project's construction and operational phases to determine whether the mitigation measures embedded in the Project design are being appropriately implemented.

15.8.4 Inspection of assets during the construction and operation phase will be carried out regularly in accordance with requirements set out in Appendix 15.3 Climate Resilience Impacts and Effects (Application Document 6.3).

15.9 Summary

15.9.1 The assessment considered effects on climate from GHG emissions and the vulnerability of the Project to climate change during the construction and operational phases. Assessments were undertaken in accordance with DMRB LA 114 Climate (Highways England, 2021).

GHG emissions

15.9.2 The GHG emissions impact assessment considered the potential for effects of the Project on climate by quantifying likely emissions of GHG to the Earth's atmosphere, during both the construction and operational phases of the Project.

15.9.3 Through the application of DMRB LA 114 Climate (Highways England, 2021) the Applicant is committed to reducing GHG emissions from Project activities by implementing the hierarchy for GHG emissions (avoid and/or prevent, reduce remediate).

15.9.4 For the construction phase, the Project has established a worst-case scenario, with emissions of 1.763 $MtCO_2e$, which would constitute a contractual obligation (maximum carbon emission level) for the Contractors. This scenario represents current best-practice because it can only be delivered by incorporating an extensive range of commercially available, low carbon technologies and approaches.

15.9.5 However, the Applicant is committed to going further and to using the time available before construction of the Project begins, to explore ways of achieving greater reductions in emissions, reflecting the Project's 'pathfinder' status.

15.9.6 To deliver on this, the Applicant has set carbon aims for the Project:

a. To construct it for the lowest practicable carbon emissions

b. To test low-carbon innovation and approaches

c. To leave a legacy that enables future projects to achieve carbon-neutral construction

15.9.7 Carbon emissions related to corporate level operations related to the Project (such as network lighting and use of traffic officer vehicles) would be net zero throughout the appraisal period and emissions related to maintenance, repair and replacement would be net zero by 2040, in line with the Net zero highways plan (National Highways, 2021a).

15.9.8 The Project cannot control the implementation of the policies related to reducing road-user emissions, as the levers to support the net zero trajectory in transport emissions are delivered by the Government. However, emission projections within the Transport Decarbonisation Plan (DfT, 2021a) sensitivity test show that implementation of the policies will gradually reduce road-user emissions in line with the net zero trajectory. GHG emission projections within the TAG GHG Workbook (DfT, 2022a)/EFT v11 tool (Defra, 2021), not currently being in full alignment with the Transport Decarbonisation Plan policies, show higher values.

15.9.9 The total net GHG emissions over the appraisal period of the Project (construction stage plus 60-year operational phase from opening) are calculated to be approximately 6.596 million tCO_2e with TAG GHG Workbook (DfT, 2022a) / EFT v11 (Defra, 2021). The net zero policy of the Transport Decarbonisation Plan (DfT, 2021a) would reduce this total to between approximately 2.324 million and 2.938 tCO_2e with the lower estimate representing the lower bound estimate and reflecting a high level of policy success and implementation.

15.9.10 The modelled construction and operational phase emissions are compared to the relevant carbon budgets in Table 15.18. The assessment has established that during the period when GHG emissions from the Project would be at their highest, most intense level (short-term construction activity), the Project would contribute 0.058% of the fourth carbon budget of 1,950 million tCO_2e between 2025 to 2027. The contributions do not take account of the Project's ambitions (set out as carbon aims) for further reductions that would be delivered through innovation and best practice carbon management throughout the construction phase.

Table 15.18 Modelled construction and operational phase emissions compared to relevant carbon budgets

Project phase	Modelled total GHG emissions over relevant carbon budgets (tCO_2e) (DS* scenario)	Net Project GHG emissions over relevant carbon budgets (tCO_2e) (DS*- DM*)	Net Project GHG emissions per relevant carbon budget (tCO_2e)**		
			Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth (2033 to 2037)
Construction	1,762,967	1,762,967	1,148,319	614,648	N/A

Project phase	Modelled total GHG emissions over relevant carbon budgets (tCO_2e) (DS* scenario)	Net Project GHG emissions over relevant carbon budgets (tCO_2e) (DS*- DM*)	Net Project GHG emissions per relevant carbon budget (tCO_2e)**		
			Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth (2033 to 2037)
TAG GHG Workbook / EFT v11* with operation and maintenance**					
Operation	76,122,688	746,624	N/A	284,451	462,173
Total	77,885,655	2,509,726	1,148,319	899,099	462,173
Percentage contribution to carbon budget			**0.058%**	**0.053%**	**0.048%**
Transport Decarbonisation Plan upper bound estimate with operation and maintenance					
Operation	52,512,613	579,934	N/A	254,700	325,234
Total	54,275,580	2,342,902	1,148,319	869,348	325,234
Percentage contribution to carbon budget			**0.058%**	**0.051%**	**0.034%**
Transport Decarbonisation Plan lower bound estimate with operation and maintenance					
Operation	30,281,202	346,082	N/A	167,476	178,607
Total	32,044,169	2,109,049	1,148,319	782,123	178,607
Percentage contribution to carbon budget			**0.058%**	**0.046%**	**0.019%**

* DM = Do Minimum scenario; DS = Do Something scenario

** The presented numbers are the result of model calculations. They should still be considered as estimates, however.

*** TAG GHG Workbook (DfT, 2022a) and EFT v11 (Defra, 2021)

15.9.11 It is further noted that the Government's net zero policies to achieve the carbon budgets are adaptable to implement new developments and priorities, or to address possible (annual) advice of the CCC, an independent statutory body established under the CCA that reports to Parliament. This constitutes a robust 'plan-do-check-act' mechanism for the UK to keep on track for net zero.

15.9.12 The Project would fulfil both criteria used to determine that GHG emissions from the Project are considered **not significant**:

a. The GHG emissions from the Project do not have a material impact on the ability of the Government to meet the carbon reduction targets.

b. The Project is compatible with (or goes beyond) the budgeted, science-based 1.5°C trajectory of the Paris Agreement (in terms of rate of emissions reduction) and complies with up-to-date policy and 'good practice' reduction measures to achieve that.

Vulnerability of the Project to climate change

15.9.13 The study area is projected to be subject to climate change in the future. The assessment has also considered the vulnerability of the Project to this climate change.

15.9.14 The assessment of the vulnerability of the Project to climate change began with a review of the potential impacts and was followed by an assessment of their potential consequence and likelihood of occurrence, taking into account the measures incorporated into the design of the Project.

15.9.15 The assessment included all infrastructure and assets associated with the Project and identified the Project's receptors within the study area which are vulnerable to the future climate change scenarios developed.

15.9.16 Appendix 15.3: Climate Resilience Impacts and Effects (Application Document 6.3) sets out the vulnerability of the Project to climate change assessment and details the sources of impacts, pathways to effects and the approach for identifying receptors. Table 15.19 presents a summary of the assessment and shows that there would be no likely significant effects from climate change on the Project's receptors.

15.9.17 Likelihood categories and consequences of impact have been defined in accordance with the definitions provided in Table 15.7 and Table 15.8 respectively. A number of mitigation and adaptation measures to address the potential impacts associated with climate change events have been considered in Appendix 15.3: Climate Resilience Impacts and Effects (Application Document 6.3), many of which have been identified within other ES topic chapters, and through the development of the Project's design.

15.9.18 The REAC included within the CoCP (Application Document 6.3, Appendix 2.2) secures these mitigation and adaptation measures, which have been taken into consideration in this table. Consequences of impacts have been measured following the implementation of mitigation measures. No likely significant effects were identified following the assessment.

Table 15.19 Vulnerability of the Project to climate change impacts (summary)

Potential effect to Project (impact)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Construction phase (UKCP18 (Met Office, 2018) time period of 2020s)			
Pavement – Increased winter precipitation and decreased summer precipitation leading to changes in groundwater level and soil moisture. This could affect the foundation settlement, generate larger ground movement and heave.	Very low	Moderate adverse	Not significant
Pavement – Increased extreme temperatures leading to a risk of surface failure or deterioration. For example, curling or warping, sometimes called hogging of concrete pavements and slabs. These can be compounded by loading from passing traffic. Thermal contraction and expansion of the slabs can generate unacceptably large longitudinal internal stresses and excessive movements at joints.	Medium	Minor adverse	Not significant

Potential effect to Project (impact)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Pavement – Extended periods of hot and sunny conditions which could result in asphalt remaining workable for a considerable time, making it difficult to maintain profile during compaction.	Medium	Minor adverse	Not significant
Structures – Increased wind speed resulting in minor temporary structures potentially having to withstand larger wind loads. There is an increased risk of disruption to construction work (unable to operate in high winds).	Very low	Moderate adverse	Not significant
Structures – Increased mean temperatures and extreme temperatures may lead to the requirement for stronger fill material, therefore increasing the quantities of excavated material becoming waste.	Very low	Minor adverse	Not significant
Structures – Increased winter precipitation and decreased summer precipitation causing a change in the groundwater level. This could lead to ground movement and heave, requiring more robust foundations.	Very low	Minor adverse	Not significant
Structures – Increased extreme precipitation leading to increased scour risk for foundations.	Very low	Minor adverse	Not significant
Drainage – Increased risk of extreme precipitation leading to the overwhelming of the construction site drainage. This may lead to reduced safety.	Very low	Minor adverse	Not significant
Geotechnics – Increased precipitation leading to an increase in erosion of stockpiled site-won materials and cut earthworks.	Very low	Moderate adverse	Not significant
Geotechnics – Increased precipitation reducing earthwork stability and leading to the requirement for new/acceptable fill to be imported.	Very low	Moderate adverse	Not significant
Geotechnics – Increased extreme temperature and decreased summer precipitation reducing soil moisture and leading to the need for greater compactive effort. This may require increased costs and construction delays.	Very low	Moderate adverse	Not significant
Geotechnics – Increased winter precipitation and extreme precipitation leading to a change in the groundwater level. This could result in ground movement in areas of historic landfill and around the A2.	Very low	Minor adverse	Not significant
Workforce – Increased projected mean daily rainfall, especially in winter months, could lead to safety risks of slips, trips and falls to construction workers.	Very low	Minor adverse	Not significant

Potential effect to Project (impact)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Workforce – Increased summer temperatures, and frequency of hot days and heatwaves leading to stress/heat exhaustion for workers.	Very low	Minor adverse	Not significant
Construction site – Increased projected mean daily rainfall, especially in winter months, could cause excavations to flood. Site roads may also become impassable through flooding.	Very low	Minor adverse	Not significant
Construction site – Increased projected mean daily rainfall, especially in winter months, could lead to water ingress to critical equipment, including traction power distribution sites, leading to signalling or other electronic equipment failures, requiring switch-off or possibly causing damage.	Very low	Minor adverse	Not significant
Operational phase (UKCP18 time period of 2080s)			
Pavement – Increased mean daily rainfall leading to the moisture content of soils being altered. This could cause ground movements, soil settlement as well as expansion and contraction. This could also cause the Project pavements and foundations to heave.	Very low	Moderate adverse	Not significant
Pavement – Large changes in temperature causing thermal contraction and expansion of the slabs. This could generate unacceptably large longitudinal internal stresses and excessive movements at joints.	Very low	Minor adverse	Not significant
Pavement – Maintained high temperatures leading to excessive rutting of newly laid surfacing layers and the rapid embedment of any chippings, with the latter again causing a reduction of texture depth.	Very low	Minor adverse	Not significant
Pavement – An increase in frequency of heavy rainfall, an increase of average temperatures and an increase in frequency of hot days and heatwaves leading to a reduced pavement friction coefficient.	Low	Minor adverse	Not significant
Pavement – Changes in mean temperatures and daily rainfall leading to the reduced need for snow clearing.	Low	Negligible	Not significant
Structures – Increased heavy rainfall causing flooding and deterring users from their journeys.	Low	Moderate adverse	Not significant

Potential effect to Project (impact)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Tunnels – Increased mean temperature and increased frequency of hot days and heatwaves resulting in the overheating of the tunnel portal areas and a potential fire risk.	Low	Minor adverse	Not significant
Tunnels – Increased heavy rainfall resulting in tunnel flooding, deterring users from their journeys.	Low	Moderate adverse	Not significant
Structures – Increased mean daily rainfall causing changes in groundwater levels. This could lead to ground movements and soil settlement causing damage to foundations and substructure.	Low	Moderate adverse	Not significant
Drainage – Increased frequency and intensity of heavy rainfall, flooding and storm events could lead to an overwhelming of the drainage system and inundation of the road.	Low	Minor adverse	Not significant
Drainage – Increased mean daily rainfall could lead to increased risk of pollution mobilisation from accidental spillages with contaminants entering the water environment.	Low	Minor adverse	Not significant
Earthworks – Increased winter precipitation and extreme precipitation causing instability of embankments and cuttings.	Very low	Large adverse	Not significant
Earthworks – Increased frequency and intensity of heavy rainfall, flooding and storm events resulting in road network becoming inaccessible due to submergence in flood water.	Very low	Large adverse	Not significant
Soils – Changes in mean temperatures and daily rainfall impacting the soils reinstated by the Project for agricultural use. This may alter the productivity of the land.	Low	Negligible	Not significant
Signs, signals, lighting and fencing – Increased frequency and intensity of storms could reduce the design life of a number of key assets such as signage, lighting, road surface and road markings. This would lead to an increase in maintenance costs over the lifespan of the road.	Low	Minor adverse	Not significant
Signs and signals – Increased mean temperature and daily rainfall could increase the deterioration rate of road markings, reducing road user safety.	Low	Minor adverse	Not significant
Signs, signals, lighting and fencing – Increased wind speed and frequency of extreme wind events impacting the design life.	Low	Minor adverse	Not significant

Potential effect to Project (impact)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Signs, signals, lighting and fencing – Increased wind speed and frequency of extreme wind events impacting the stability of signals, signs and lighting columns due to increased wind loads.	Low	Minor adverse	Not significant
Signs and signals – Increased extreme weather events may damage and disrupt the power supply and other linked infrastructure.	Low	Moderate adverse	Not significant
Signs and signals – Increased mean temperature and frequency of hot days and heatwaves could cause the overheating of electrical equipment leading to failure and/or fire.	Medium	Minor adverse	Not significant
Soft estate – Decreased mean rainfall may lead to drought-tolerant trees becoming more prevalent. This may cause a change in the landscape character of the area and would likely affect biodiversity.	Medium	Negligible	Not significant
Soft estate – Increased mean temperature and daily rainfall may alter the growing characteristics such as soil properties and length of growing season and increase fire risk. This may impact the species used as part of the landscape planting and change the character of the landscape. This could also lead to tree fall and increased maintenance and management requirements.	Medium	Negligible	Not significant
Soft estate – Increased wind speed and frequency of extreme wind events leading to increased tree/habitat loss, habitat fragmentation and reduction in woodland blocks.	Medium	Negligible	Not significant
Soft estate – Increased wind speed and frequency of extreme wind events, dry spells and heavy rain potentially resulting in a loss of valued landscape features, opening up new views of the Project that were previously shielded.	Medium	Negligible	Not significant
Soft estate – Increased mean daily rainfall changing the hydrology which could lead to the landscape planting failing.	Low	Negligible	Not significant
Vehicle restraint systems – More-frequent extreme weather, changes in temperature and rainfall could increase the rate of deterioration of vehicle restraint systems.	Low	Minor adverse	Not significant

Potential effect to Project (impact)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
End-users (members of public, commercial operators, etc.) – Increased extreme weather events could lead to an increase in the rate of deterioration of assets. This could increase the frequency of maintenance workers and traffic officers working within the carriageway.	Medium	Minor adverse	Not significant
End-users – Increased frequency and intensity of storms may discourage the use of WCH facilities to complete journeys. This may lead to more users of the road.	Medium	Negligible	Not significant
End-users – Increased heavy rainfall and flooding causing closures and diversions of WCH facilities.	Medium	Negligible	Not significant
End-users – Increased frequency and intensity of heavy rainfall, flooding and storm events resulting in the potential for higher rates of vehicle collisions, severe disruption to the highway, harm to road users and adjacent receptors.	Medium	Minor adverse	Not significant
End-users – Increased mean temperature and frequency of hot days and heatwaves could increase the risk of incidents due to vehicle breakdowns, a higher frequency of vehicle fires, and smoke drifting across carriageways from wildfires.	Medium	Minor adverse	Not significant
End-users – Increased frequency of dry spells and heavy rainfall causing 'summer ice' leading to an increased risk of road collisions.	Medium	Minor adverse	Not significant
End-users – Increased frequency and intensity of heavy rainfall, flooding and storm events leading to reduced safety and visibility as a result of standing water.	Medium	Minor adverse	Not significant
End-users – Increased mean temperature and frequency of hot days and heatwaves may lead to an increase in stress for road users and maintenance workers.	Medium	Minor adverse	Not significant

References

British Standards Institution (2016a). PAS 2080:2016: Carbon Management in Infrastructure. London: British Standards Institution.

British Standards Institution (2016b) Guidance Document for PAS 2080.

Circular Ecology (2019). Inventory of Carbon and Energy (ICE Database) V3.0 – 10 Nov 2019. Accessed March 2020.

Climate Change Act 2008; Climate Change Act (2050 Target Amendment) Order 2019 (legislation.gov.uk)

Climate Change Committee (CCC) (2021) Independent Assessment of UK Climate Risk – Advice to Government for the UK's third Climate Change Risk Assessment (CCRA3). Accessed April 2022. Independent-Assessment-of-UK-Climate-Risk-Advice-to-Govt-for-CCRA3-CCC.pdf

Committee on Climate Change (CCC) (2020). Reducing UK emissions: 2020 Progress Report to Parliament. Accessed September 2020.

Department for Business, Energy and Industrial Strategy (2016). The Carbon Budget Order 2016. https://www.legislation.gov.uk/uksi/2016/785/contents/made

Department for Business, Energy and Industrial Strategy (BEIS) (2020). The Energy White Paper – Powering our Net Zero Future. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf

Department for Business, Energy and Industrial Strategy (BEIS) (2021). 2021 Government Greenhouse Gas Conversion Factors for Company Reporting. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1049346/2021-ghg-conversion-factors-methodology.pdf

Department for Business, Energy and Industrial Strategy (BEIS) (2022). Energy and Emission Projections: Net Zero Strategy Baseline (partial interim update December 2021). Accessed March 2022. https://www.gov.uk/government/publications/energy-and-emissions-projections-net-zero-strategy-baseline-partial-interim-update-december-2021.

Department for Energy and Climate Change (2011a). Overarching National Policy Statement for Energy (EN-1). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf

Department for Energy and Climate Change (2011b). National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37049/1941-nps-gas-supply-oil-en4.pdf

Department for Energy and Climate Change (2011c). National Policy Statement for Electricity Networks (EN-5). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37050/1942-national-policy-statement-electricity-networks.pdf

Department of Energy and Climate Change (2011d). The Carbon Budget Order 2011. https://www.legislation.gov.uk/uksi/2011/1603/made#:~:text=This%20Order%20sets%20the%20carbon,the%20Climate%20Change%20Act%202008.

Department for Environment, Food & Rural Affairs (Defra) (2018). The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727252/national-adaptation-programme-2018.pdf

Department for Environment, Food and Rural Affairs (Defra) (2021). Emissions Factors Toolkit version 11. Accessed December 2021. https://laqm.defra.gov.uk/air-quality/air-quality-assessment/emissions-factors-toolkit/

Department for Transport (2014). National Policy Statement for National Networks. Accessed June 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387223/npsnn-web.pdf

Department for Transport (2015). Highways England: Licence. Accessed June 2022. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/431389/strategic-highways-licence.pdf

Department for Transport (2017). National Trip End Model (NTEM). Accessed September 2020. https://www.data.gov.uk/dataset/11bc7aaf-ddf6-4133-a91d-84e6f20a663e/national-trip-end-model-ntem

Department for Transport (2019). TAG Unit M4. Accessed June 2021. https://www.data.gov.uk/dataset/11bc7aaf-ddf6-4133-a91d-84e6f20a663e/national-trip-end-model-ntem

Department for Transport (2020a). Decarbonising Transport: Setting the Challenge. Accessed September 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/878642/decarbonising-transport-setting-the-challenge.pdf

Department for Transport (2020b). Appraisal and Modelling Strategy: A route map for updating TAG during uncertain times. Accessed September 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987764/tag-route-map-2020.pdf

Department for Transport (2021a). Decarbonising Transport: A Better, Greener Britain. Accessed September 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf

Department for Transport (2021b) TAG Unit A.1.1 Cost-Benefit Analysis. Accessed August 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1007440/tag-unit-A1.1.pdf

Department for Transport (2022a). TAG Greenhouse Gases Workbook. Accessed June 2022. https://www.gov.uk/government/publications/tag-environmental-impacts-worksheets

Department for Transport (2022b) TAG Databook. Accessed June 2022. https://www.gov.uk/government/publications/tag-data-book

Environment Agency (2016). Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities[5]. https://www.gov.uk/government/publications/adapting-to-climate-change-for-risk-management-authorities

Environment Agency (2022a). Guidance - Flood risk assessments: climate change allowances. Accessed August 2022 https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Environment Agency (2022b). Guidance - Peak rainfall climate change allowances by management catchment. Accessed August 2022. https://www.gov.uk/government/publications/peak-rainfall-climate-change-allowances-by-management-catchment

Environment Agency (2022c). Flood and coastal risk projects, schemes and strategies: climate change allowance. Accessed July 2022. https://www.gov.uk/guidance/flood-and-coastal-risk-projects-schemes-and-strategies-climate-change-allowances

Environment Agency (2022d). Guidance - Peak river flow climate change allowances by management catchment. Accessed August 2022. https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow

European Parliament and European Council, Directive 2011/92/EU as amended by 2014/52/EU. [redacted] [and] https://www.legislation.gov.uk/eudr/2014/52/article/1

GeoSmart (2020). GeoSmart Groundwater Flood Risk Map, GW5

Highways Agency (2009a). Routine and Winter Service Code. [redacted]

Highways Agency (2009b). Network Management Manual. [redacted]

Highways Agency (2013). Highways Agency Drainage Data Management System (HADDMS).

Highways England (2017). Lower Thames Crossing, Environmental Impact Assessment – Scoping Report.

Highways England (2018). Preliminary Environmental Information Report – Statutory Consultation.

Highways England (2019a). Design Manual for Roads and Bridges (DMRB), GG 103 Introduction and general requirements for sustainable development and design. Accessed June 2020. [redacted]

Highways England (2019b). Design Manual for Roads and Bridges (DMRB) LA 110 Material assets and waste. Accessed January 2021. [redacted]

[5] This publication was withdrawn on 22 July 2020. This document has been replaced by a newer version. It is included here as this document was used to inform the hydraulic models. The replacement document is Flood and coastal risk projects, schemes and strategies: climate change allowance.

Highways England (2020a). DMRB LA 104 Environmental Assessment and Monitoring. Accessed November 2021.

Highways England (2020b). Design Manual for Roads and Bridges (DMRB), GM 701 Asset Delivery Asset Maintenance Requirements. Revision 1. Accessed June 2020.

Highways England (2020c). Design Manual for Roads and Bridges (DMRB), GS 801 Asset Delivery Asset Inspection Requirements. Revision 1. Accessed June 2020.

Highways England (2020d). Design Manual for Roads and Bridges (DMRB), GM 703 Operational Requirements for Incident Management. Accessed June 2020.

Highways England (2020e). Design Manual for Roads and Bridges (DMRB), CG 501 Design of Highway Drainage Systems. Revision 2. Accessed June 2020.

Highways England (2020f). Design Manual for Roads and Bridges (DMRB), CD 622 Managing Geotechnical Risk. Revision 1. Accessed June 2020.

Highways England (2020g). Design Manual for Roads and Bridges CD 352 Design of road tunnels.

Highways England (2021). Design Manual for Roads and Bridges (DMRB), LA 114 Climate. Version 0.01. Accessed September 2021.

HM Government (2020). Ten Point Plan for a Green Industrial Revolution. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

HM Government (2021a). Industrial Decarbonisation Strategy. Accessed March 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/975953/6.7348_BEIS_Industrial_Decarbonisation_Strategy_Large_Print_PRINT.pdf

HM Government (2021b). UK Hydrogen Strategy. Accessed August 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011658/6-7515_BEIS_UK-Hydrogen-Strategy_017-Print-content.pdf

HM Government (2021c). Transitioning to zero emission cars and vans: 2035 delivery plan. Accessed September 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005301/transitioning-to-zero-emission-cars-vans-2035-delivery-plan.pdf

HM Government (2021d). Net Zero Strategy: Build Back Greener. Accessed October 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf

HM Government (2022). UK Climate Change Risk Assessment 2022 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1047003/climate-change-risk-assessment-2022.pdf

Institute of Environmental Management & Assessment (IEMA) (2022). IEMA Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance. 2nd edition. Accessed May 2022. IEMA - Launch of the Updated EIA Guidance on Assessing GHG Emissions.

Kent County Council (2011). Preliminary Flood Risk Assessment. Accessed October 2019. https://www.kent.gov.uk/about-the-council/strategies-and-policies/environment-waste-and-planning-policies/flooding-and-drainage-policies/preliminary-flood-risk-assesment

Kent Thameside Delivery Board (2009). Strategic Flood Risk Assessment. [redacted]

London Borough of Havering (2017). Strategic Flood Risk Assessment. Accessed November 2019. https://www.havering.gov.uk/downloads/download/153/strategic_flood_risk_assessment_2017

Met Office (2009). UK Climate Projections 2009 (UKCP09). Accessed June 2020. https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/ukcp09-users

Met Office (2018). UK Climate Projections 2018 (UKCP18). Accessed June 2020. https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

Met Office, University of Reading and Centre for Ecology and Hydrology (2015). Developing H++ climate change scenarios for heat waves, droughts, floods, windstorms and cold snaps. Accessed June 2020.

https://d423d1558e1d71897434.b-cdn.net/wp-content/uploads/2015/10/Met-Office-for-the-ASC-Developing-H-climate-change-scenarios-for-heatwaves-droughts-floods-windstorms-and-cold-snaps3.pdf.

Ministry of Housing, Communities and Local Government (2021a). National Planning Policy Framework. Accessed November 2021. https://www.gov.uk/government/publications/national-planning-policy-framework--2

Ministry of Housing, Communities and Local Government (2021b). Flood risk and coastal change. https://www.gov.uk/guidance/flood-risk-and-coastal-change

National Atmospheric Emissions Inventory, 2014. Emissions and Removals of Greenhouse Gases from Land Use, Land Use Change and Forestry (LULUCF) for England, Scotland, Wales and Northern Ireland: 1990-2012.

Report: Emissions and Removals of Greenhouse Gases from Land Use, Land Use Change and Forestry (LULUCF) for England, Scotland, Wales and Northern Ireland: 1990-2012 - NAEI, UK (beis.gov.uk)

National Highways (2021a). Net zero highways: our 2030/2040/2050 plan. Accessed September 2021. [redacted]

National Highways (2021b). Digital Roads. Accessed August 2021. [redacted]

National Highways (2022). Preparing for Climate Change on the Strategic Road Network – Third Adaptation Report under the Climate Change Act. Accessed April 2022.

Planning Act 2008. Planning Act 2008 (legislation.gov.uk)

Planning Inspectorate (2017). Scoping Opinion: Proposed Lower Thames Crossing (Case Reference TR010032). Accessed June 2020. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010032/TR010032-000033-LTC%20-%20Scoping%20Opinion.pdf

Planning Inspectorate (2019). Advice Note Seventeen: Cumulative Effects Assessment. Version 2. Accessed June 2020. https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/12/Advice-note-17V4.pdf.

Royal Institute of Chartered Surveyors (RICS) (2017). Whole Life Carbon Assessment for the Built Environment.

Thurrock Council (2018). Level 1 Strategic Flood Risk Assessment. Accessed October 2019.

UKCIP (2018). LCLIP: Local Climate Impacts Profile

UNFCCC (2008). Kyoto Protocol Reference Manual.

UNFCCC (2015). The Paris Agreement. Accessed 2020.

World Resources Institute and World Business Council for Sustainable Development (2015). Accessed June 2022. GHG Protocol.

If you need help accessing this or any other National Highways information, please call **0300 123 5000** and we will help you.

If you have any enquiries about this publication email **info@nationalhighways.co.uk**
or call **0300 123 5000***.

*Calls to 03 numbers cost no more than a national rate call to an 01 or 02 number and must count towards any inclusive minutes in the same way as 01 and 02 calls.

These rules apply to calls from any type of line including mobile, BT, other fixed line or payphone. Calls may be recorded or monitored.

Printed on paper from well-managed forests and other controlled sources when issued directly by National Highways.

Registered office Bridge House, 1 Walnut Tree Close, Guildford GU1 4LZ

National Highways Company Limited registered in England and Wales number 09346363