A30 Chiverton to Carland Cross
TR010026

6.2 ENVIRONMENTAL STATEMENT CHAPTER 14 CLIMATE CHANGE

Planning Act 2008

APFP Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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Planning Act 2008

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

A30 Chiverton to Carland Cross
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6.2 ENVIRONMENTAL STATEMENT

CHAPTER 14 CLIMATE CHANGE

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Table of Contents

Table of Tables

Table of Appendices Volume 6 Document Ref 6.4

14 Climate Change

14.1 Introduction

14.1.1 This chapter of the ES presents the following assessments undertaken as part of the climate change topic:

- the carbon assessment; and
- the climate change resilience (CCR) assessment.

14.1.2 The carbon assessment quantifies and reports – in the form of a 'carbon footprint' – the reasonable worst case scenario carbon emissions associated with the construction and operation of the scheme. This chapter refers to 'carbon' as including all main greenhouse gases[1]. Greenhouse gas (GHG) emissions are converted into tonnes of carbon dioxide equivalent (tCO_2e), a calculation which normalizes the global warming potential of the main GHG into one measure, based on the global warming potential of CO_2.

14.1.3 The climate change resilience assessment considers potential climate change impacts on the design, construction and operation of the scheme over its lifetime.

14.1.4 These assessments are considered to be appropriate for the ES, in line with the latest legislation and regulatory requirements, as discussed in Section 14.3 of this chapter. Additionally, an in-combination climate change impacts (ICCI) assessment has been conducted, assessing the combined effect of the scheme and climate change in the receiving environment; the ICCI assessment is presented in **Consideration of Cumulative Effects** (Volume 6 Document Reference 6.2 ES Chapter 15).

14.1.5 As stated in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) Synthesis Report[2], mitigation (reducing carbon emissions), and adaptation (responding to climate change impacts), are complementary approaches to reducing risks of climate change impacts. Mitigation will in the middle/long term substantially reduce climate change impacts. Benefits from adaptation are realised now in addressing current events, and will further address emerging climate change risks in the future. Innovation and investments in environmentally sound infrastructure and their supporting technologies can both reduce carbon emissions and enhance resilience to climate change. These elements are set out within this Chapter in respect of the scheme assessment.

14.2 Competent Expert

14.2.1 The Climate Change lead is a Chartered Environmentalist (CEnv) with a Civil Engineering degree MEng (Hons) and a Doctorate in Environmental Technology (EngD). Full details are provided in Volume 6 Document Ref 6.4 Appendix 1.1.

[1] The seven main GHGs are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Source: National Atmospheric Emissions Inventory (2017), Overview of greenhouse gases. Available online at: http://naei.defra.gov.uk/overview/ghg-overview

[2] Intergovernmental Panel on Climate Change (IPCC), 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available online at: http://ar5-syr.ipcc.ch/topic_summary.php

14.3 Legislative and Policy Framework

National

14.3.1 At the European level, the EIA Directive 2011/92/EU[3] places a requirement upon projects which have the potential for significant effects on the surrounding environment and communities to make a formal assessment of these effects. The amended EIA Directive 2014 identifies the important role that the EIA process can play in assessing climate change impacts. It states that EIAs shall identify, describe and assess the direct and indirect significant effects of climate change relevant to the project (i.e. carbon, CCR and in-combination climate change impacts). The Directive 2014/52/EU entered into force on 15th May 2015 and contains the amendments to the 2011 Directive in full. The Regulations implementing this Directive were transposed into UK legislation in May 2017.

Carbon assessment

Climate Change Act 2008

14.3.2 The scheme is assessed within the context of the UK's evolving strategies to carbon emissions mitigation. The Climate Change Act 2008[4] committed the UK to its first statutory carbon-reduction target to reduce emissions by at least 80% from 1990 levels by 2050. To ensure that regular progress is made towards the target the Climate Change Act established a system of carbon budgets. The first five carbon budgets, leading to 2032, have been set in law. Meeting the fourth (2023-27) and fifth (2028-2032) carbon budgets will require that carbon emissions are reduced by 50% (by 2025) and 57% (by 2030) relative to 1990 levels. The Government published a plan for meeting the legislated carbon budgets in October 2017[5].

National Networks National Policy Statement 2014

14.3.3 The National Networks National Policy Statement (NN NPS)[6] emphasises the need to minimise carbon emissions within the transport sector, including road transport. Whilst the NN NPS points out that it is unlikely that the impact of any single road project, considered in isolation, would affect the Government's ability to meet the carbon targets (paragraph 3.8 of the NN NPS), applicants should provide evidence of the carbon impact of the project and an assessment against the Government's carbon budgets (paragraphs 5.16-5.19 of the NN NPS). The effectiveness of any proposed carbon reduction measures will be considered by the Secretary of State to ensure that the carbon footprint is not unnecessarily high; the Secretary of State's view of the adequacy of the proposed carbon reduction measures relating to design and construction will be a material factor in the decision-making process.

[3] Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment. Available online at: http://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=celex%3A32014L0052

[4] Department of Energy & Climate Change, *The Carbon Plan – reducing greenhouse gas emissions*, 2011; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47621/1358-the-carbon-plan.pdf; Accessed: 4 August 2016

[5] HM Government, The Clean Growth Strategy – Leading the way to a low carbon future, 2017. https://www.gov.uk/government/publications/clean-growth-strategy; accessed 14th November 2017

[6] Department for Transport, *National Policy Statement for National Networks*. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/387223/npsnn-web.pdf; Accessed 10 January 2018

Paris Agreement 2015

14.3.4 In December 2015, a global climate agreement – the Paris Agreement[7] – was adopted at the 21st Conference of the Parties (COP21). A central aim of the Paris Agreement is to strengthen the global response to climate change by limiting the global temperature increase this century to below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. To achieve this aim, the Paris Agreement additionally sets a target for net zero[8] global carbon emissions in the second half of this century. The Paris Agreement was ratified and entered into force in November 2016. In line with the Paris Agreement, the Government has indicated it intends to set a UK target for reducing domestic emissions to net zero[9].

CCR assessment

Climate Change Act 2008

14.3.5 At a national level, the Climate Change Act 2008 requires the UK Government to undertake a national Climate Change Risk Assessment (CCRA) every five years. The second CCRA was published in 2017[10] and provides assessments of climate change risks for different sectors of society, including infrastructure, people and the built environment, natural environment and natural assets, business and industry as well as international dimensions and cross-cutting issues. The assessment builds upon the CCRA 2012[11] and aims to assess the urgency of further action to tackle different climate change risks for the UK, as well as realise potential opportunities. The most urgent climate change risks for the UK include flooding and coastal change risks; risks to health, well-being and productivity from high temperatures, risks of shortages in the public water supply and for agriculture, energy generation and industry, risks to natural capital, including terrestrial, coastal marine and freshwater ecosystems, soils and biodiversity, risks to domestic and international food production and trade, and new and emerging pests and diseases and invasive non-native species, affecting people, plants and animals.

The National Adaptation Programme

14.3.6 Following the CCRA 2012, the first National Adaptation Programme (NAP)[12] was published, detailing the Government's long-term strategy to address the main climate change risks and opportunities for the UK. The NAP is published every five years and was updated in 2018. The Committee on Climate Change (CCC) and its Adaptation Sub-Committee conduct an independent assessment of progress by the NAP every two years[13]. These progress reports contribute

[7] Paris Agreement. Available online at: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf; Accessed 3 April 2017

[8] Net-zero means "a balance between anthropogenic emissions by sources and removals by sinks of carbon emissions in the second half of this century". Article 4 Paragraph 1. Available online at: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

[9] Committee on Climate Change, *UK climate action following the Paris Agreement*, 2016

[10] Committee on Climate Change (2017),Progress in preparing for climate change. Available online at: https://www.theccc.org.uk/uk-climatechange-risk-assessment-2017/

[11] DEFRA (2012) CCRA - UK Climate Change Risk Assessment 2012 - GA0204. Available online at: http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=15747

[12] DEFRA (2013), The National Adaptation Programme: Making the country resilient to a changing climate. HM Government, London: The Stationery Office

[13] Committee on Climate Change (2015), Reducing emissions and preparing for climate change: 2015 Progress Report to Parliament. Available at https://www.theccc.org.uk/publication/reducing-emissions-and-preparing-for-climate-change-2015-progress-report-to-parliament/

towards the wider understanding of national climate change risks, including risks specific to the transport sector and rail infrastructure. Further understanding of UK climate change impacts can be obtained through the reports submitted under the UK Adaptation Reporting Power (ARP) in the first and second rounds of reporting. Reports are produced by organisations with functions of a public nature and statutory undertakers, including Highways England[14].

National Networks National Policy Statement 2014

14.3.7 The NN NPS[6] specifies the need for new developments to consider climate change impacts when planning location, design, build and operation. New national networks infrastructure typically is a long-term investment, which will need to remain operational over the course of decades in the face of a changing climate. All relevant impacts of climate change need to be considered and addressed within an environmental statement, alongside any relevant adaptation measures to ensure the long-term resilience of a scheme.

14.3.8 The Environment Agency has produced guidance[15] on climate change allowances to be used in flood risk assessments. This guidance supports the National Planning Policy Framework (NPPF)[16], which sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. The NPPF is further supported by Planning Practice Guidance (PPG)[17], which prioritises addressing climate change impacts in the planning and decision making process for major transport infrastructure projects.

Local

Cornwall Local Plan 2016

14.3.9 Cornwall Council has committed to assessing the risks associated with climate change and the implications for affected services and communities and adapting accordingly. Furthermore, Cornwall Council has committed to encouraging all sectors of the community to reduce their own greenhouse gas emissions and adapt to the impact of climate change[18]. Additionally, one of the objectives of the Cornwall Local Plan[19] is to make the best use of resources by increasing resilience to climate change (Objective 9). This is further highlighted in a number of policies within the Local Plan, including Policy 2 (Spatial strategy); Policy 12 (Design); Policy 13 (Development standards); Policy 16 (Health and wellbeing); Policy 23 (Natural environment); Policy 24 (Historic environment); and Policy 26 (Flood risk management and coastal change).

[14] Highways England (2016), Climate Adaptation Risk Assessment Progress Update – 2016. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/596812/climate-adrep-highways-england.pdf
15 Environment Agency (2016). *Guidance. Flood risk assessments: Climate change allowances*. Available online at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances; Accessed 7 August 2018.
16 Ministry of Housing, Communities and Local Government (2018). National Planning Policy Framework. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/728643/Revised_NPPF_2018.pdf ; Accessed 7 August 2018.
17 Ministry of Housing, Communities and Local Government (2014). *Guidance. Climate Change*. Available online at: https://www.gov.uk/guidance/climate-change#why-is-it-important-for-planning-to-consider-climate-change; Accessed 7 August 2018.
[18] https://www.cornwall.gov.uk/environment-and-planning/sustainable-development/climate-change-and-energy/
[19] Cornwall Council (2016). *Cornwall Local Plan.* Available online at: https://www.cornwall.gov.uk/media/22936789/adopted-local-plan-strategic-policies-2016.pdf; Accessed 7 August 2018.

Guidance

Carbon assessment

14.3.10 The Government's Construction Industry Strategy[20] presents the UK's low carbon construction aspirations. It includes the aspiration to decrease construction carbon emissions by 50% by 2025 based on 1990 levels, as reported in the Green Construction Board's Low Carbon Routemap for the Built Environment[21].

14.3.11 The boundaries and outline methodology for carbon assessments undertaken as part of the EIA have been agreed based on the latest approach by Highways England.

14.3.12 Although there is no specific standard for reporting infrastructure carbon emissions in EIA, a variety of existing guidance has been used to steer this assessment:

- The Publicly Available Specification (PAS) 2080[22] on carbon management in infrastructure;
- BS EN 15804[23] which outlines the requirement for quantifying and reporting emissions at a product level;
- IEMA's guide to assessing carbon emissions and evaluating their significance in EIA[24];
- DMRB HA 207/07, which provides a calculation method for regional emissions[25];
- Highways England Interim Advice Note 185/15[26], which advises on emissions factors to be used to model carbon emissions from traffic; and
- Highways England's Carbon emissions calculation tool, which provided emissions factors for the assessment[27].

14.3.13 The carbon assessment has used the principles and methods set out in existing standards and guides as illustrated. It was supported by a combination of carbon modelling tools (Highways England carbon calculator), publicly available information including the University of Bath's Inventory of Carbon and Energy[28] on construction materials, and specific data from environmental product declarations (EPDs).

CCR assessment

14.3.14 The outline methodology for CCR assessments undertaken as part of the EIA has been agreed based on the latest approach by Highways England.

[20] HM Government (2013). *Industrial Strategy: government and industry in partnership*. HM Government, London
[21] The Green Construction Board, *Low Carbon Routemap for the UK Built Environment*, (2013); http://www.greenconstructionboard.org/otherdocs/Routemap%20final%20report%2005032013.pdf; Accessed: 4 August 2016
[22] British Standard Institute, (2016), PAS 2080:2016, *Carbon management in infrastructure,* PAS 2080:2016.
[23] British Standard Institute, (2013), BS EN 15804+A1:2013. *Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products,* BS EN 15804+A1:2013.
[24] IEMA (2017), *Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance*.
[25] Highways England (2007) DMRB HA 207/07 Air Quality
[26] Highways England (2015), Interim Advice Note 185/15: Updated traffic, air quality and noise advice on the assessment of link speeds and generation of vehicle data into 'speed-bands' for users of DMRB Volume 11, Section 3, Part 1 'Air Quality and Volume 11, Section 3. Part 7 Noise
[27] Highways England, Carbon emission calculation tool, September 2016. https://www.gov.uk/government/publications/carbon-tool; Accessed 2 October 2017
[28] Hammond, G.P. and Jones, C.I, (2008,,), *Inventory of Carbon & Energy (ICE) Version 1.6a*, University of Bath, UK

14.3.15 The European Commission (EC) has released sector specific guidance[29] on the interface between climate change and infrastructure, including projected impacts and resilience levels. This document accompanies the Communication "*An EU strategy for adaptation to climate change*"[30] and provides further background material supportive of the narrative and arguments put forward in the Communication. This sector guidance also presents, for some areas, an outline of actions that the Commission will be undertaking, as announced in the Communication.

14.3.16 IEMA has published guidance[31] on climate change resilience and adaptation in response to the requirements specified in the amended EIA Directive 2014. This guidance provides an approach to undertaking assessments of in-combination climate change impacts and climate change resilience within the EIA process in the UK.

14.3.17 The Environment Agency[32] (EA) provides guidance on climate change allowances to be used in flood risk assessments as set out in the National Planning Policy Framework (NPPF). This advice includes climate change allowances for peak river flow and peak rainfall intensity for flood risk assessments for different UK river basin districts, flood zones and land use sensitivities. The assessments made of the implications of climate change for future flood risks associated with the scheme take account of the content of this guidance; the Road drainage and water environment assessment is described in Chapter 13 of this ES.

14.4 Study Area

Study Area and Assessment Scenarios

Carbon assessment

14.4.1 For the assessment of capital carbon (see Section 14.6), the study area is defined by the red line boundary and comprises the assets and infrastructure planned for the scheme. This consists of a large number of materials and construction works activities often in small amounts. To ensure that all substantial sources of carbon emissions to the scheme are included, the convention[33] of 99% by mass input to the scheme has been applied.

14.4.2 The assessment of the operational carbon has adopted the same convention with 99% energy inputs to the scheme across the same study area. This covers all operational activities associated with the day to day running of the scheme, such as lighting and powered signage that are required up to the study cut-off year 2050[34].

[29] European Commission (2013), Adapting Infrastructure to Climate Change- Communication from the commission to the European Parliament, the council, the European economic and social committee and the committee of the regions: An EU Strategy on Adaptation to Climate Change. Available online at: https://ec.europa.eu/clima/sites/clima/files/adaptation/what/docs/swd_2013_137_en.pdf
[30] European Commission (2013), An EU strategy for adaptation to climate change. Available online at: https://ec.europa.eu/clima/sites/clima/files/docs/eu_strategy_en.pdf
[31] Institute of Environmental Management and Assessment (IEMA) (2015), IEMA Environmental Impact Assessment Guide To Climate Change Resilience And Adaptation. Available at: http://www.iema.net/system/files/iema_guidance_documents_eia_climate_change_resilience_and_adaptation.pdf
[32] Environment Agency (2017), Flood risk assessments: climate change allowances. Available online at: https://www.gov.uk/guidance/flood-riskassessments-climate-change-allowances
[33] BS EN 15804: 2012 Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products
[34] Aligns with the Governments objective of reduce national carbon emissions by 80% by 2050.

14.4.3 For the assessment of user carbon (i.e. the tailpipe emissions from vehicles using the scheme) the study area covers the entire area modelled by the traffic model. This wider boundary captures the user emissions from the scheme, but also those arising from the outlying road network, and vehicle movements that have been indirectly influenced by the scheme (positively and negatively). Unlike the Air Quality study area, the assessment of user carbon includes the total emissions across the model, irrespective of presence and location of receptors. The assessment of user carbon covers the period from 2023 to 2050; this is consistent with the temporal boundary for the assessment of operational carbon.

14.4.4 The carbon emissions evaluation is based around a series of scenarios to 2050 taking the following structure:

- **'Do minimum' –** This can be described as the baseline scenario, where the assessment is based on an existing status scenario, in which the road remains unaltered. This scenario uses 2016 as the baseline year and is akin to the highway continuing as normal benefiting only from standard maintenance practice into the future and accounting for a projection of ongoing operational energy demand (e.g. for lighting and signalling). In this scenario, user carbon emissions from vehicle traffic are estimated over the time period 2016 to 2050, and presented on both a time series (i.e. annualised reporting) and cumulative basis.
- **'Do something' –** This is the assessment scenario, where the scheme is constructed as presented in the current application documents. Traffic is modelled as the 'Do minimum' scenario up until 2023 (scheme opening year), and then it is modelled based on Stage 3 design[35]. The design benefits from a degree of embedded carbon mitigation, as described in Section 14.10. In this scenario user carbon emissions from vehicle traffic are estimated over the time period 2023 (scheme opening) to 2050, and are presented on a cumulative basis.

14.4.5 In all scenarios, carbon emissions from highway users are based on those arising (directly and indirectly) from vehicles using the scheme. These are calculated based on traffic flow and average vehicle speeds from the traffic model developed for the scheme and wider study area. Carbon emission factors are taken from the Highways England interim advice note 185/15 (and associated updates provided by email from Highways England to Arup), which adjusts factors for different speed bands to assess the effects of congestion, and applied to the traffic model outputs. These are based on the Emissions Factor Toolkit v8.0, produced by DEFRA. As these only provide guidance to 2030, they are extrapolated for the purposes of modelling to 2050. Where relevant, sensitivity testing of different study scenario projections has been applied. This was undertaken by using the traffic model outputs and applying different vehicle emission factors from those in IAN185/15 and subsequent updates. The variation in emissions factors and how they were calculated is discussed in more detail in Section 14.7.

CCR assessment

14.4.6 The study area of the CCR assessment includes relevant potential climate hazards for the infrastructure and assets associated with the scheme to the end

[35] As per the Project Control Framework (PCF) major projects life cycle. The GHG emissions assessment is based on design details from Stage 3.

of their design life (60 years) and the identification of any significant climate change risks; a list of the climate hazards to be considered is summarised in Section 14.6.

14.4.7 Assessment scenarios are based on current and future climate baselines, as described in Section 14.7. In line with the approach presented in the Highways England Climate Adaptation Risk Assessment Progress Update – 2016[15], the CCR assessment is based on the 50th percentile of climate results associated with the high emissions scenario; this approach is also consistent with the requirements set out in the National Policy Statement for National Networks (NPS NN).

14.5 Potential Impacts

Carbon assessment

14.5.1 The scheme will have an impact on climate change due to carbon emissions during construction as well as operation. User carbon emissions are likely to reduce as a result of the scheme due to the beneficial predicted relief in congestion outweighing the predicted increases in traffic volumes. Carbon emissions associated with construction are relatively small when compared with the total user carbon emissions over the study period. Carbon emissions associated with the operation of the asset are expected to be relatively small compared to user emissions.

14.5.2 This will lead to a net increase in carbon in the short term due to construction of the scheme. However, in the long term the scheme will result in a reduction in carbon.

CCR assessment

14.5.3 The A30 provides an important transport link for Cornwall and is a crucial part of the SRN in the region. The scheme is expected to increase the resilience of transport systems in Cornwall to a range of hazards, including those resulting from climate change, and hence provide benefit for the overall resilience of the region.

14.5.4 Assets and infrastructure designed and constructed as part of the scheme are likely to be impacted by climate change in a number of ways. The potential risks are expected to be mostly mitigated through the application of appropriate design standards as well as suitable asset management procedures during operation.

14.6 Assessment Methodology

Magnitude of Impacts

Carbon assessment

14.6.1 The assessment of the magnitude of carbon emissions is undertaken in accordance with the principal steps identified in PAS2080 and the IEMA carbon emissions guide. Consideration has also been given to TAG Unit A3 Environmental Impact Appraisal (DfT, 2015), Chapter 4 Greenhouse Gases.

14.6.2 A whole-life approach is adopted, capturing both direct and indirect carbon emissions as a result of the scheme, and from supply chain, construction,

operation and use. End of life is not considered due to the long design life of the asset (i.e. there is no date for de-commissioning), and given that emissions associated with end of life of this type of asset are relatively small.

14.6.3 The assessment estimates three types of carbon emission including:

- Works and supply chain (capital) carbon emissions for both initial construction and maintenance
- Operational carbon emissions during scheme service life; and
- Traffic carbon emissions (user carbon) from vehicle tailpipes.

14.6.4 Emissions from these sources are compared to a baseline scenario (Section 14.4) to quantify the impact of the scheme.

14.6.5 The scheme assessment is based on the following information sources:

- Capital carbon is assessed, based on information from the bill of quantities (from Design Fix 3) and relevant drawings. The Highways England carbon calculation tool is used along with its carbon factors for the calculation, supplemented with other factors where necessary as discussed in Section 14.3. An estimation of carbon associated with maintenance of the road is also included;
- Operational carbon is taken as the emissions associated with lighting and signage on the new road. Information for this is obtained from the design documentation; and
- User carbon is based on vehicle tailpipe emissions. These are calculated from the traffic model with the study area being the same as that of the traffic model.

14.6.6 The carbon footprint of the scheme is therefore assessed as the difference between the emissions associated with the baseline scenario and that associated with the scheme.

14.6.7 The assessment of user carbon follows the principles of the regional assessment of pollutants outlined in DMRB HA207/07. This includes all road links of the transport (SATURN) model network without any screening of the carbon emissions. The analysis incorporates the latest DMRB requirements in conjunction with applying emission rates for carbon to the outputs from the SATURN highway assignment component. By taking the average speed on a link-by-link basis along the route, the method makes allowance for the increase in emissions from acceleration/deceleration of vehicles due to congestion. The impact of junctions and gradient of road is also applied to the traffic model. As the model provides data for only three years (baseline year 2016, opening year 2023 and opening year +15 2038), traffic data between those years has been extrapolated linearly. Beyond 2038 traffic increases are extrapolated as described in 14.9.4.

CCR assessment

14.6.8 The resilience of the scheme to climate change impacts is qualitatively assessed, based on professional expertise and judgement.

14.6.9 In the case of flood risk, detailed planning requirements and design guidance relating to climate change exist. Therefore, an assessment of climate change impacts on flood risk is carried out within **Road drainage and the water** (Volume 6 Document Reference 6.2 ES Chapter 13), taking into account current EA

climate change allowances for increases in peak river flow and rainfall intensity, as described in Section 13.10.

14.6.10 The CCR assessment is composed of two parts: 1) the assessment of climate hazards; and 2) the risk and resilience assessment. As part of the assessment of climate hazards, the potential climate change impacts on all assets and infrastructure designed and constructed within the scheme are identified for the following climate hazards:

- high temperatures
- low temperature
- high precipitation
- low precipitation
- humidity
- insolation (solar irradiation)
- storms/lightning strikes; and
- wind

14.6.11 As part of the climate change resilience assessment, the potential likelihood and consequence of climate change risks during the operation of the infrastructure and assets associated with the scheme are scored using a qualitative five point scale, as agreed based on the latest approach by Highways England; these are set out in Table 14-1 and Table 14-2 respectively.

Table 14-1 Qualitative five-point scale of likelihood of climate change risks

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

Table 14-2 Qualitative five-point scale of consequences of climate change risks

Consequence of impact	Description
Very large adverse	• National level (or greater) disruption to strategic route(s) lasting more than 1 week.
Large adverse	• National level disruption to strategic route(s) lasting more than 1 day but less than 1 week OR • Regional level disruption to strategic route(s) lasting more than 1 week.

Moderate adverse	• Regional level disruption to strategic route(s) lasting more than 1 day but less than 1 week.
Minor adverse	• Regional level disruption to strategic route(s) lasting less than 1 day.
Negligible	• Disruption to an isolated section of a strategic route lasting less than 1 day.

14.6.12 The CCR assessment for risks for the construction phase focuses on weather resilience of the construction process. Risks are qualitatively assessed with respect to the potential disruption to the construction programme, whereby the potential disruption is classified as 'small, 'medium' or 'large'. These qualitative descriptions are assigned based on expert judgement.

14.6.13 A qualitative assessment of uncertainty is undertaken for each climate change risk, based on the uncertainty of the relevant climate change projections and the uncertainty in the respective effect on asset performance. This process has been adapted from the process for assessing uncertainty in climate change effects on road infrastructure presented in the Highways England Climate Adaptation Risk Assessment (2016)[15].

14.6.14 As part of the risk and resilience assessment, the need for any additional resilience measures to protect against the effects of climate change is identified. Where necessary, high level resilience measures are developed in collaboration with relevant engineering and design teams as part of the ES.

Assessment of Significance

Carbon assessment

14.6.15 In accordance with the National Policy Statement for National Networks (NPS NN), carbon emissions associated with the scheme are compared to the national UK carbon budgets. The fourth carbon budget (2023 to 2027) allows the UK to emit 1,950 MtCO2e during the 5-year period. A significant effect would occur where 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.

CCR assessment

14.6.16 The significance of the identified risks is assessed using the significance matrix shown in Table 14-3;

Table 14-3 Climate Change Risk matrix

		Measure of Likelihood				
		Very low	Low	Medium	High	Very High
Measure of consequence	Negligible	NS	NS	NS	NS	NS
	Minor	NS	NS	NS	**S**	**S**
	Moderate	NS	NS	**S**	**S**	**S**
	Large	NS	**S**	**S**	**S**	**S**
	Very Large	NS	**S**	**S**	**S**	**S**

Table notes
- NS = Not significant
- S = Significant

14.7 Baseline Conditions

Carbon assessment

14.7.1 As discussed in Section 14.4, the baseline for the project is assumed as the "Do-Minimum" scenario, in which no construction activity is undertaken on any of the roads in the area other than that required to maintain the existing road.

14.7.2 Traffic modelling has been undertaken for a baseline year of 2016 and calibrated against measured data. Future predictions of traffic in the study area have been made for opening year 2023 and 2038. Uncertainties or limitations related to transport data are discussed in the Transport Report (Volume 7 Document Ref 7.5). It outlines the forecasting assumptions and deals with uncertainty in forecasting by discussing low and high growth. The Transport Report also outlines modelling assumptions for the development of the base model and reports on the data collection for the traffic model. These limitations have been overcome as far as possible by verifying the modelled concentrations against monitoring results in appropriate locations. The traffic data used is appropriate for the purposes of this assessment.

14.7.3 A fixed yearly carbon emission associated with maintenance of the existing road has been included in the capital carbon, which has been assumed on the basis that 100% of the road surface will resurfacing every ten years and 100% of the full road depth will require rebuilding once within the study period. Over the study period, this equates to 10,180tCO_2e.

14.7.4 For operational carbon associated with the existing road lighting, reductions are seen over time as a result of an expected reduction of carbon intensity of the UK electricity grid using the IAG dataset predictions discussed in Section 14.9. Energy needed for operation is modelled as constant. Yearly operational carbon emissions reduce from 20tCO_2e in 2016 to 2tCO_2e in 2050. The value at opening in 2023 is 15tCO_2e. This presents a steady increase in cumulative operational carbon emissions over the study period, to a total of 306tCO_2e over the period.

14.7.5 As the vehicle emissions factors in IAN 185/15 and the subsequent update provided by Highways England do not give emissions factors beyond 2030, they

have been assumed as constant beyond 2030. This is assumed to provide an 'upper bound' estimate of user carbon as the vehicle fleet is expected to continue to reduce in carbon intensity beyond 2030 due to, for example, increase in uptake of electric vehicles. A qualitative assessment of the impact of emissions factors reducing beyond 2030 is discussed in 14.10.11.

14.7.6 User carbon for the baseline assessment is much higher than the capital and operational carbon by several orders of magnitude, as summarised in Table 14-4. The user component accounts for over 99% of the total carbon emissions associated with the scheme.

14.7.7 The baseline carbon over the study period 2016-2050 is summarised in Table 14-4 highlighting that the majority of carbon comes from the vehicles associated with road use.

Table 14-4 Summary of baseline carbon for study area

Carbon component	Estimated carbon over study period (t carbon)	Percentage (%)
Capital carbon	10,180	0.11
Operational carbon	310	0.00
User carbon	9,116,810	99.89
Total whole life carbon	**9,127,300**	**100.00**

Climate baselines – current climate

14.7.8 Table 14-5 presents historical climate data for the Chiverton and Carland Cross area, serving as the current climate baseline data for the scheme. The current baseline for average climate variables has been obtained from the MetOffice gridded observational data, made available as part of the United Kingdom Climate Projections 2009 (UKCP09) at a spatial resolution of 25km for the period 1961-1990[36].

14.7.9 Simulated baseline data for extreme weather events have been obtained from the UKCP09 Weather Generator (WG)[37]. The UKCP09 WG implements a statistical method based on simulated baseline data for creating synthetic time series of future daily climate that are consistent with climate change projections.

36 UKCP09 Gridded observation data sets. Available at: http://www.metoffice.gov.uk/climatechange/science/monitoring/ukcp09/. Accessed on 22 August 2017
37 UKCP09 Weather Generator. Available at: http://ukclimateprojections.metoffice.gov.uk/23261. Accessed on 22 August 2017

Table 14-5 Historical climate data for Chiverton and Carland Cross (1961-1990)

	Parameter	Long-term average (1961-1990)
Temperature	Mean winter daily temperature [°C]	6.3
	Mean summer daily temperature [°C]	15.3
	Mean daily summer maximum temperature [°C]	18.8
	Mean daily summer minimum temperature [°C]	11.7
	Mean daily winter maximum temperature [°C]	8.8
	Mean daily winter minimum temperature [°C]	3.7
Precipitation	Annual mean daily precipitation [mm/day]	3.0
	Winter mean daily precipitation [mm/day]	4.1
	Summer mean daily precipitation [mm/day]	2.0
Cloud	Annual cloud cover [%] (sunshine hours obtained from Newquay Cornwall Airport climate summary[38])	69% (1743 sunshine hours per year)
Extreme weather events (from UKCP09 WG)	Annual number of days when daily mean temperature is >25°C	0
	Annual number of days when daily mean temperature is 0°C or lower	2.3
	Annual number of day per year when precipitation is greater than 25mm per day (Met Office definition of 'heavy rain')	3.8
	Annual number of dry spells (10+ days with no precipitation)	2.8

14.7.10 A Local Climate Impacts Profile (LCLIP) for Cornwall Council was developed as part of a larger South West LCLIP (2010)[39]. The profile aims to provide an understanding of the nature of past extreme weather events and the impacts they have had on the community, environment and economy. The majority of weather impacts for Cornwall County are experienced in the transport and distribution networks. Floods and snow/ice events are most impactful to the region. However, impacts are exacerbated during high winds as these often coincide with high tides resulting in storm surges (although this has little impact on the project).

14.7.11 Table 14-6 summarises the primary weather events currently affecting the region and provides a high-level overview of the types of impacts experienced.

38 Met Office Newquay Cornwall Airport climate. Available at: http://www.metoffice.gov.uk/public/weather/climate/gbuqyjzyd Accessed on 22 August 2017

39https://www.researchgate.net/profile/Alisdair_Cunningham/publication/256494335_South_West_Local_Climate_Impacts_Profile_LCLIP_Final_Report/data/0046352319b1e59aaa000000/CSW-LCLIP-Report-v3.pdf

Table 14-6 Summary of weather events and associated impacts for Cornwall

Weather event	Impacts
Heavy rain/ flash floods[40]	• Damage to highway infrastructure- main A&B road network • Damage to railway branch lines (short period) • Damage to coastal defence and boats[41] • Travel disruption and delay • Landslides/ mudslides[42] • Closure of schools • Household evacuations • Damage to green space and South west coastal path (tourism affected) • Power cuts
High winds/tornado[43]	• Closure of the Tamar Bridge • Reduced transport routes • Blocked road • Fallen trees • Cancelled Ferries • Power cuts
Heat wave	• Health warnings • Melting roads, rails and tracks • Fire[44] • Closure of schools
Lightning[45]	• Increased Fire Department calls • Lightning strikes to buildings in north Cornwall • Small fires
Snow and Ice	• Fallen trees • Closure of schools

Climate baselines – future climate

14.7.12 This section presents projected climate conditions and extreme weather events for the area encompassing Chiverton and Carland Cross for the 2020s and 2080s.

14.7.13 Using the historical baseline data, two methods are implemented to establish the future climate baseline. The changes in average climate conditions are obtained from the UKCP09 probabilistic projections of climate change[46]. The changes in extreme weather events are obtained using the UKCP09 WG[47].

14.7.14 Climate change projections for a range of meteorological parameters are presented for different probability levels and emission scenarios for the 2020s and 2080s.

14.7.15 Table 14-7 presents expected changes in climate conditions, such as mean temperature and precipitation, and Table 14-8 presents changes in extreme weather events, such as number of heavy rain days. The UKCP09 models future climate for three scenarios[48] for global greenhouse gas emissions. As discussed

[40] https://www.cornwall.gov.uk/media/10579670/Cornwall-Storm-Impacts-update-19-Nov-2014-V1-3.pdf
[41] http://www.bbc.co.uk/news/uk-england-26044323
[42] https://www.theguardian.com/news/blog/2010/nov/17/cornwall-floods-live-updates
[43] http://www.bbc.co.uk/programmes/b01pmb5h
[44] http://www.express.co.uk/news/uk/819757/heatwave-fire-cornwall-firefighters-battle-gorse-blaze
[45] https://www.piratefm.co.uk/news/latest-news/2297720/watch-lightning-and-floods-strike-cornwall/
[46] UKCP09 climate change projections. Available at: http://ukclimateprojections.metoffice.gov.uk/21684 ; Accessed on 22 August 2017
[47] UKCP09 Weather Generator. Available at: http://ukclimateprojections.metoffice.gov.uk/22540 ; Accessed 22 August 2017
[48] http://ukclimateprojections.metoffice.gov.uk/23198

in Section 14.4, this assessment is based on the high emissions scenario; results for the medium emissions are also presented, demonstrating the uncertainty associated with the choice of emissions scenario.

14.7.16 Temperatures in the area of Chiverton and Carland Cross are projected to increase in both winter and summer. The largest increase in temperature is projected to be in the mean daily maximum temperature in summer, which is expected to increase from 18.8°C to 24.6°C in the 2080s, in the high emissions scenario.

14.7.17 Annual average precipitation in the region is anticipated to remain largely unchanged throughout the century. However, the projected changes in mean precipitation vary more substantially for winter and summer. Mean winter precipitation is expected to increase from 4.1mm/day for the baseline period to 4.3 mm/day for the 2020s and 4.9 mm/day for the 2080s, high emissions. The mean summer precipitation is expected to decrease from 2.04 mm/day for the baseline period to 1.9 mm/day for the 2020s and 1.4 mm/day for the 2080s.

14.7.18 The number of hot days, when the mean temperature is above 25°C, is anticipated to increase from 0 to 6.0 days per year in the 2080's for the high emission scenario. The average number of days in a given year, when the mean daily temperature is below 0°C, is anticipated to decrease from 2.3 to 0.2 until the end of the century under the high emissions scenario.

14.7.19 In the case of extreme precipitation, the number of days with heavy rain (precipitation greater than 25mm/day) in a given year is expected to increase from 3.81 in the baseline period to 6.16 by the 2080s. Similarly, the average annual number of dry spells (periods of at least 10 consecutive days with no precipitation) is projected to increase from 2.80 for the baseline period to 4.68 for the 2080s under the high emissions scenario.

Table 14-7 UKCP09 climate change projection for the area of Chiverton and Carland Cross for the 2020s and 2080s

Parameter and baseline (in brackets, 1961-1990)		2020s (2010-2039)			2080s (2070-2099)		
		Medium emissions scenario	High emissions scenario	Range	Medium emissions scenario	High emissions scenario	Range
Temperature	Mean winter daily temperature [°C] (6.3°C)	7.5	7.4	6.8-8.2	9.0	9.5	7.8-11.2
	Mean summer daily temperature [°C] (15.3°C)	16.7	16.6	15.7-17.6	18.9	19.8	17.2-22.5
	Mean daily summer maximum temperature [°C] (18.8°C)	20.6	20.5	19.3-22.0	23.4	24.6	20.7-28.8
	Mean daily summer minimum temperature [°C] (11.7°C)	13.1	13.1	12.2-14.1	15.3	16.4	13.4-19.4
	Mean daily winter maximum temperature [°C] (8.8°C)	10.0	10.0	9.3-10.8	11.3	11.8	9.7-14.0
	Mean daily winter minimum temperature [°C] (3.7°C)	5.2	5.1	4.3-6.1	7.0	7.7	5.1-10.3
Precipitation	Annual mean daily precipitation (3.0 mm/day)	3.0	3.0	2.8-3.1	3.0	3.0	2.8-3.2
	Winter mean daily precipitation (4.1 mm/ day)	4.3	4.3	3.9-4.9	4.8	4.9	4.0-6.5
	Summer mean daily precipitation (2.0 mm/day)	1.9	1.9	1.5-2.4	1.5	1.4	1.0-2.1
Wind	Change in winter mean daily wind speed	-	-	-	-	-	-
	Change in summer mean daily wind speed	-	-	-	-	-	-
Relative humidity	Annual relative humidity	84.2	84.3	83.2-85.2	83.2	82.7	81.1-84.9
Cloud cover	Annual cloud cover [%] (69%)	69	69	67-71	67	67	64-70

Table 14-8 Projected changes in extreme weather events

Parameter and baseline (in brackets, 1961-1990)		2020s (2010-2039)			2080s (2070-2099)		
		Medium emissions scenario	High emissions scenario	Range[49]	Medium emissions scenario	High emissions scenario	Range
Temperature	Annual number of days when daily mean temperature is >25°C (0)	0.02	0.02	0-0.08	2.2	6.0	0-18.80
	Annual number days, when daily mean temperature is 0°C or lower) (2.3)	0.8	1.0	0.20-1.68	0.3	0.2	0-0.74
Precipitation	Annual number of days per year when precipitation is greater than 25mm per day (Met Office definition of 'heavy rain') (3.8)	4.5	4.5	3.47-5.54	5.9	6.2	4.23-8.06
	Annual number of dry spells (10+ day with no precipitation) (2.8)	3.4	3.4	2.35-4.47	4.4	4.7	2.83-6.25

Value of Receptor

Carbon assessment

14.7.20 Monetary valuation of changes in the carbon emissions is not undertaken as part of this ES. Carbon emissions are responsible for global climate change, which is estimated to have potential negative cost impacts. These will be burdened by society at large, and in some instances, they could impact the scheme directly[50]. Therefore, the receptor is considered to be of high value.

CCR assessment

14.7.21 The scheme is of strategic importance to the region; this makes it a high value receptor in the context of the CCR assessment.

14.8 Consultation

14.8.1 Cornwall Council has been consulted on the assessment methodology and approach. The Planning Inspectorate were consulted during the scoping stage and provided an opinion[51]. This provided key statutory and non-statutory bodies an opportunity to comment on the proposed approach, methodology, baseline conditions and anticipated potential effects associated with the scheme which were known at that time. No changes to the scope or approach of addressing the

49 The range is obtained by comparing the 10% and 90% level for medium and high emissions and selecting the widest range of these values.
50 IPCC 2014, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Available at http://www.ipcc.ch/report/ar5/wg2/
51 The Planning Inspectorate, 2017. Scoping Opinion: Proposed A30 Chiverton to Carland Cross. Available online at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010026/TR010026-000033-Scoping%20Opinion.pdf

climate change assessments set out in this chapter were made as a result of the Scoping Opinion issued by the Planning Inspectorate.

14.9 Assessment Assumptions and Limitations

Carbon assessment

14.9.1 It has been assumed that the existing A30 road continues to be operational right up until opening year 2023, i.e. no allowance for disruption to the study area due to construction has been allowed for. This effect will be small and is not expected to significantly impact the accuracy of the model.

14.9.2 For capital carbon calculation, the bill of quantities (BoQ) provided by Highways England at Design Fix 3 (July 2018) has been used. The following assumptions have been made during the assessment:

- Earthworks and landscaping
  - Assumed that all topsoil material can be site-won and any surplus material can be reused in landscaping on site
  - 5% bulking factor for site-won fill
  - 5% excavated material will be contaminated and unsuitable for use as fill and will need to be processed or disposed of off-site.
  - Contaminated fill will potentially be disposed of at Biffa Waste Services, Swindon (315km from site). This is the nearest facility identified in Section 10.10. As stated in Section 14.10 this is a significant opportunity for carbon reduction.
  - Imported fill will be sourced from local china clay quarries (25km from site)
  - No allowance for the benefit to carbon emissions from the planting of new plants/trees has been made as the extent of this is not complete at the time of writing. It is anticipated, however, that the area of trees planted as part of the scheme will exceed that removed by a significant margin.
- Lighting
  - Lighting on the scheme is summarised in Section 2.1.
- Pavement
  - Allowance has been made to import material to create an unbound sub base.
- Civil structures
  - Where detailed quantities are unavailable for an underpass or overpass, the quantities of a similar structure on the scheme have been used as basis for proxy estimation, scaling for size.
- Construction plant
  - An allowance has been made based upon professional experience and benchmarking against previous projects.
- Waste – a 5% uplift in material carbon emissions has been taken to account for waste on site.
- Employee travel

  - Total staff of 500 people for the peak 22 months of the project, with 20-30 staff for the first six months and the last three months (see Section 12.12 for a more detailed breakdown)
  - Approximately 70% of staff will be non-local, travelling from 400km away on Monday and Friday and staying locally during the week
  - Assumed local staff will travel an average of 40km to get to work
  - Assumed all travel is by car (1 staff member per car)
- Transport of materials to site, excluding earthworks (see chapter 10 for potential material source locations)
  - Assumed HGVs will be used to transport all materials to site
  - Steel will be sourced from South Wales
  - Precast concrete will be sourced from the Midlands
  - Asphalt will be transported 40km to site
  - Sub-base material will be transported 40km to site
  - All other materials will travel an average of 40km to site based on experience from other projects
- Carbon factors
  - Carbon factors for material carbon have been taken in the first instance from the Highways England Carbon Calculation Tool. Where factors are not provided, typically the Bath Inventory of Carbon and Energy (ICE) database has been used. As this database is the source of many of the factors in the Highways England tool, this is deemed to be reasonable.
  - 'Typical' industry-wide carbon factors have been used for the assessment. Opportunities for carbon reduction through, for example, specifying lower carbon materials or more sustainable sourcing of materials have not been accounted for in this calculation.
- Maintenance
  - A fixed yearly carbon emission associated with maintenance of the road has been included in the capital carbon, which has been assumed on the basis that 100% of the road surface will resurfacing every ten years and 100% of the full road depth will require rebuilding once within the study period.

14.9.3 A list of all assumptions made for the quantification of capital carbon are presented in **Carbon Assessment assumptions** (Volume 6 Document Reference 6.4 ES Appendix 14.1).

14.9.4 For user carbon, the following assumptions have been made:

- There is no impact on the road network from the scheme outside of the traffic model study boundary areas.
- Uncertainties or limitations related to transport data are discussed within the Traffic Report (Volume 7 Document Ref 7.5), it outlines the forecasting assumptions and deals with uncertainty in forecasting by discussing low and high growth. The Traffic Report also outlines modelling assumptions for the development of the base model. The Traffic Report details the data collection for the traffic model. These limitations have been overcome as far as possible by verifying the modelled concentrations against monitoring results in appropriate locations.

- There is uncertainty regarding predictions of future emission factors used within the carbon assessment for vehicle tailpipe emissions. Beyond the factors available up to 2030 from IAN 185/15 and subsequent Highways England revisions, emissions factors have been kept constant.
- Vehicle numbers change linearly between the modelled years of 2016, 2023 and 2038, and continue to change linearly on the same trajectory after 2038 as between 2023 and 2038. This is expected to be conservative as in reality the additional congestion from increasing traffic volumes over time would likely reduce growth.
- As the user carbon predictions are highly dependent on the emissions factor predictions in IAN 185/15, any future changes in emissions factors could affect the results.

14.9.5 For operational carbon, the following assumptions have been made:

- Carbon intensity of the UK electricity grid reduces in line with Interdepartmental Analysts Group (IAG) dataset predictions.
- Do-Minimum operational carbon – the existing street lights run between sunset and sunrise (an average of 12.3 hours/day) but are turned off between midnight and 5am. Each light consumes 400W. No other significant uses of power have been considered.
- Do-Something operational carbon – as discussed in Section 2.1, the scheme lighting is minimal and power consumption has been assumed as negligible in the context of the scheme.

CCR assessment

14.9.6 The CCR assessment has been informed by the following assumptions:

- the assessment assumes that all relevant design standards are suitable for current weather conditions;
- the assessment has assumed that mitigation measures relevant to different assets will be implemented effectively; and
- implicit in the assessment are the assumptions associated with climate modelling and climate change projections, incorporated in UKCP09.

14.9.7 The CCR assessment has the following limitations:

- The assessment is largely qualitative, with the exception of assessment relevant to drainage assets and flood risk, which have been informed by the Environment Agency climate change allowances for increases in peak river flow and rainfall intensity.
- There is inherent uncertainty in climate change projections. This study has been quantified using UKCP09, the latest set of probabilistic climate projections for the UK (but these are now ten years old).
- There is often uncertainty in the relationship between changes in climate hazards and the respective response in terms of asset performance. This uncertainty has been assessed qualitatively.
- The evidence relating to climate change impacts for some categories of assets and infrastructure is limited, e.g. the exact relationship between climate change and groundwater levels and the potential effects on the scheme. In these cases, the assessment has been informed by professional judgement.

Limits of deviation

14.9.8 An assessment has been conducted within the limits of deviation outlined in Limits of Deviation within **Approach to EIA** (Volume 6 Document Ref 6.2 ES Chapter 4).

14.9.9 The limits of deviation contained in Section 4.3 of Volume 6 Document Reference 6.2 Chapter 4 have been considered having regard to the scope for change under the draft DCO. The worst case has been taken into account and it considered that carbon will not change unless the scheme or the assumptions change significantly. The proposed limits of deviation will therefore not give rise to any materially new or materially worse adverse environmental effects from those already reported in the ES.

14.10 Design Mitigation and Enhancement Measures

Engineering Design

Carbon assessment

14.10.1 Since the preferred route announcement, the following design measures have been undertaken to aid in the reduction of carbon:

- Ensuring an approximate earthworks balance on the scheme with minimal import only at the Chiverton junction to assist the programme and accommodate an early side road diversion. The excess of topsoil on scheme will be retained on site within essential mitigation areas.
- The vertical alignment has been lowered between Ch6+300 - 7+300 and Ch10+000 – 11+400 to seek to win more site won material closer to where it needs to be deposited to reduce haulage distances (as well as lower the route for local landowners to reduce landscaping effects). The main cut on scheme is within the middle of the scheme between Ch7+500 and 9+500 and main deposit points are at each end at Chiverton and Carland Cross.
- Slip roads have been pushed out from the mainline at the grade separated junctions to remove the need for four retaining walls between the mainline and slip roads.
- An on demand lighting system within the three Walking, Cycling and Horse Riding underpasses has been developed.
- Developed a green bridge cross-section such that within the same width there is accommodation for a track for use by Walkers and Cyclists as well as the adjacent farm business agricultural vehicles (reducing the diesel needed to make the round trip for the farm to severed land).
- At Trevalso Farm, a new underpass structure that also serves as an ecology crossing point and significantly reduces the diesel needed to make the round trip to severed land.

14.10.2 In future design changes, a number of opportunities have been identified to further lower carbon:

- Materials
  - Reduction of material (structures and earthworks) generally through further design efficiencies, for example reducing the size of structural elements.
  - Cement replacement in concrete (for example with PFA or GGBS)

- Replacement of typical materials in the pavement with lower carbon alternatives, for example recycled plastic, concrete or glass, or the use of cold-rolled products where suitable.

CCR assessment

14.10.3 During the preliminary CCR assessment undertaken for the PEIR[52], three potential opportunities were identified, where additional mitigation may be considered:

- the need to review design temperature ranges for structure expansion joints, in line with projected increases in summer temperatures;
- the potential to use a different road surface material in order to increase performance in hotter weather conditions; and
- the potential to add surge protection to main electrical installations in order to increase resilience associated with lightning strikes, accounting for a projected increase in frequency and severity of storms.

14.10.4 Following further consideration of the potential effects of climate change on bridge expansion, it was concluded that insufficient information is available to prompt a departure from current design standards with respect to design temperatures for thermal loading. Current design standards are conservative and provide a level of resilience to projected increases in temperature. Thus, current design standards have been used for the preliminary design of bridges for thermal loading.

14.10.5 The potential to add surge protection to lighting and other roadside electrical equipment will be considered in later design stages.

14.10.6 The opportunity to use a different road surface material to account for future increases in summer temperatures was considered and is addressed in paragraph 14.10.9.

Operation Mitigation

Carbon assessment

14.10.7 Lighting across the scheme has been reduced since Design Fix 2, which will reduce the carbon associated with their operation.

14.10.8 As the design is developed further, consideration should be given to design for efficient maintenance, taking care that this does not increase capital carbon disproportionately.

CCR assessment

14.10.9 The opportunity to use a different road surface material to account for future increases in summer temperatures was considered. However, due to the short design life of road surface (resurfacing is expected every 10 years), this opportunity can be realised as part of the normal maintenance and renewal cycle for the asset. The range of road surface material recommended by current design

[52] A30 Chiverton to Carland Cross Improvement Scheme Preliminary Environmental Information Report. Available online at: https://highwaysengland.citizenspace.com/he/a30-chiverton-cross-to-carland-cross-statutory-con/supporting_documents/Preliminary%20Environmental%20Information%20Report.pdf

standards are deemed appropriate for current conditions and for ten years after construction.

Construction Mitigation

Carbon assessment

14.10.10 A number of opportunities to reduce carbon during construction are detailed below:

- Transport
  - As detailed in Section 14.9, a 40km transport distance has been assumed for materials making up the road pavement and concrete. Sources for these materials are available closer to the site and could be used, reducing carbon. For example, a 10km reduction in transport for the road pavement would reduce carbon by 1,200tCO_2e.
  - As detailed in Section 14.9, a 315km transport distance has been assumed for contaminated earthworks surplus. Reducing this transport distance to, for example, 100km would reduce the overall earthworks carbon by 25% (2,000tCO_2e); this could be achieved, for example, by selecting a more local hazardous waste management facility, if any are available.
- Employee travel
  - Maximising the amount of local labour would reduce carbon. Employee travel associated with local labour is approximately 40% of that from non-local labour.
  - Enacting measures to reduce use of cars to get to site (e.g. public transport, car sharing)
- Optimising compound locations and phasing construction

CCR assessment

14.10.11 The contractor should consider the potential impacts of extreme weather events on construction. The contractor should use a short to medium-range weather forecasting service from the Met Office or other approved weather forecast provider to manage climate-related risks and inform programme management and impact mitigation measures. The contractor should register with the Environment Agency's Floodline Warnings Direct service.

14.10.12 The contractor should ensure the measures detailed within the CEMP are implemented, alongside any additional measures to ensure the resilience of the scheme to extreme weather events during construction.

14.10.13 The contractor's EMS should consider all measures deemed necessary and appropriate to manage extreme weather events and should specifically cover training of personnel and prevention and monitoring arrangements.

14.11 Assessment of Effects

Construction Effects

Carbon assessment

14.11.1 As discussed in Section 14.3, an assessment of the capital carbon for the scheme has been undertaken using the factors from the Highway's England carbon emissions calculation tool and, where these do not provide sufficient information, the Bath ICE database.

14.11.2 The carbon emissions from the construction of the scheme are estimated to be 79,920tCO_2e.

14.11.3 These are split into the categories listed in Table 14-9, and show that the majority of the carbon is produced in the creation of the materials used to build the scheme. Earthworks form the second largest amount.

Table 14-9 Components of capital carbon for construction of the scheme

Component	tCO_2e	Contribution to total carbon emissions (%)
Materials	41,500	52%
Transport (exc. earthworks)	7,470	9%
Waste	2,070	3%
Labour	6,900	9%
Plant (exc. earthworks)	11,140	14%
Earthworks (transport + plant)*	10,840	14%
Total	**79,920**	
*Earthworks carbon includes the material and transport carbon associated with geotextiles		

14.11.4 As detailed in Sections 14.9 and 14.10, 25% of the earthworks carbon is associated with the disposal of contaminated fill at a specialist facility.

14.11.5 A breakdown of the materials component of the capital carbon is included in Table 14-10. This shows that the largest single component by a large margin is the pavement, which accounts for 52% of the material carbon. As a proportion of the transport carbon, the pavement makes up an even larger proportion, 68%. This is largely due to the relatively low material carbon but high transport volume of the unbound sub-base. The second largest component is the civil structures, which collectively account for 28% of the materials embodied carbon for the scheme.

Table 14-10 Components of carbon for materials used to construct the scheme

Component	tCO_2e	Percentage (%)
Fencing	420	1%
Road Restraint System	1,340	3%
Drainage	3,440	8%
Pavement	21,780	52%
Kerbs	490	1%
Traffic Signs and Road Markings	640	2%
Electric Work	50	0%
Piling and Embedded Retaining Walls	380	1%
Landscape & Ecology (incomplete)	370	1%
Accommodation Works	1,170	3%
Civil Structure	11,430	28%

14.11.6 A fixed yearly carbon emission associated with maintenance of the **new** road has been included in the capital carbon, which has been assumed on the basis that 100% of the road surface will resurfacing every ten years and 100% of the full road depth will require rebuilding once within the study period. Over the study period, this equates to **28,410**tCO_2e.

CCR assessment

14.11.7 As a result of the recommended mitigation measures during construction, summarised in Section 14.10, the CCR assessment has identified no significant climate change resilience effects during the construction stage. Further details of the assessed climate change resilience effects are presented in **Climate change resilience** (Volume 6 Document Reference 6.4 ES Appendix 14.2).

Operation and User Effects

Carbon assessment – Operation

14.11.8 Unlike capital carbon, the components of operational and user carbon are from the same sources as those discussed in Section 14.7; however, their magnitudes are changed by the construction of the scheme.

14.11.9 Up to 2023, both user and operational carbon for the 'Do Something' scenario are identical to the "Do Minimum" scenario as it has been assumed for this assessment that the study area is unaffected until the scheme opens in 2023.

14.11.10 For operational carbon, as discussed in 14.9.4 the power usage associated with the proposed new lighting (from 2023) is expected to be negligible in the context of the scheme. The total operational carbon for the scheme is therefore 140tCO_2e.

Carbon assessment – User

14.11.11 The user carbon results highlight that through constructing the scheme, the user carbon decreases. This is down to the traffic model which, despite showing an

increase in total number of kilometres travelled as a result of the scheme compared to the baseline case, also predicts a reduction in congestion in the study area. The benefit from this reduction in congestion outweighs the carbon associated with the extra distance travelled.

14.11.12 Over the study period, the difference in user carbon between the 'Do minimum' and 'Do something' scenarios is 397,110t CO_2e. This is four times larger than the calculated capital carbon change. However, this assumes that the vehicle fleet emissions factors remain constant beyond 2030. Further decarbonisation of the vehicle fleet beyond 2030 would lead to capital carbon representing a larger proportion of total carbon. This difference may decrease beyond 2050 as discussed in 14.2.10.

14.11.13 Table 14-11 summarises the carbon emissions from all sources, comparing them to the baseline 'Do Minimum' scenario. The decrease in total carbon emitted over the study period is 299,130t CO_2e.

14.11.14 As constructing the scheme results in a reduction in user carbon emissions, the capital carbon used to construct the scheme is gradually offset by this reduction after opening year. This is expected to occur by the end of 2026; however, emissions factors dropping faster than predicted by IAN 185/15 would cause this offset to occur later.

14.11.15 Although the constructing the scheme provides a reduction in carbon compared to the 'Do Minimum' scenario, both the 'Do Minimum' and 'Do Something' schemes show yearly increases in user carbon emissions throughout the study period.

Table 14-11 Summary of 'Do Something' carbon for study area

Carbon component	Estimated carbon over study period – 'Do Something' Scenario (tCO_2e)	Estimated carbon over study period – 'Do Minimum' Scenario (tCO_2e)	Net change in carbon resulting from the scheme (tCO_2e)
Cap carbon	108,330	10,180	98,150
Op carbon	140	310	-170
Use carbon	8,719,700	9,116,810	-397,110
Total carbon	**8,828,170**	**9,127,300**	**-299,130**

14.11.16 The total carbon emissions exhibit a spike in yearly carbon emissions in the years 2020-2022, to ~265,000tCO_2e/year, associated with the construction of the scheme. From 2023, the trend of total carbon emissions follows a very similar steady upward trend to the user carbon results, as these dominate.

14.11.17 The yearly saving in carbon emissions on opening year (2023) are larger, at 27,500t CO_2e/year, than those in the modelled year of 2038 (12,700t CO_2e/yr). This suggests that the yearly benefit for user carbon of constructing the scheme reduces over time, possibly due to increased traffic flows in the 2038 forecast year (compared to 2023) causing increased congestion.

14.11.18 Emissions are compared against the 3rd, 4th and 5th UK Carbon Budgets in Table 14-12.

Table 14-12 Comparison of predicted carbon emission relative to UK Carbon Budgets

Project Stage/Activity	Estimated carbon over Carbon Budget – 'Do Something' Scenario (tCO_{2e})	Estimated carbon over Carbon Budget – 'Do Minimum' Scenario (tCO_{2e})	Net CO2 increase (tCO_{2e})	Relevant Carbon Budgets
Construction of asset	79,920	-	79,920	3rd carbon budget period (2,544MtCO2e)
Operational life of asset	1,150,640	1,147,990	2,650	3rd carbon budget period (2,544MtCO2e)
	1,116,490	1,241,520	-125,030	4th carbon budget period (1,950MtCO2e)
	1,187,900	1,288,270	-100,370	5th carbon budget period (1,725MtCO2e)

14.11.19 The user carbon assessment has been updated since PEIR based on further refinement of the traffic model. The base year model network has been further developed, the speed banding applied to modelled links adjusted to better reflect the performance of the network and has been revised in line with IAN 185/15 carbon factors provided by Highways England. These adjustments have resulted in a switch from a net increase to a net decrease in user carbon through construction of the scheme, whilst the changing carbon factors have led to a general increase in user carbon for all modelled scenarios ('Baseline', 'Do Minimum', 'Do Something').

CCR assessment

14.11.20 The CCR assessment has identified no significant climate change resilience effects during the operation stage.

14.11.21 As discussed in Section 14.10, during the preliminary CCR assessment undertaken for the PEIR[53], three potential CCR effects during operation were identified, which may benefit from additional resilience measures:

- the effect of projected increases in peak summer temperatures on bridge expansion and resulting risk to structures;
- the effect of projected increases in summer temperature on road surface degradation and resulting disruption to traffic; and
- the effect of potential increases in lightning strike occurrence to roadside electrical equipment and the result of resulting disruption to traffic.

14.11.22 Following further exploration of these risks, these have been confirmed as not significant. No additional mitigation measures are necessary to account for these risks, as discussed in Section 14.10. Further details of the assessed climate

[53] A30 Chiverton to Carland Cross Improvement Scheme Preliminary Environmental Information Report. Available online at: https://highwaysengland.citizenspace.com/he/a30-chiverton-cross-to-carland-cross-statutory-con/supporting_documents/Preliminary%20Environmental%20Information%20Report.pdf

change resilience effects are presented in **Climate change resilience** (Volume 6 Document Reference 6.4 ES Appendix 14.2).

14.12 Monitoring

Carbon assessment

14.12.1 The scheme construction will be required to measure and report outturn emissions as part of standard Highways England requirements. It would be an objective within this process to review performance against that estimate in this ES and drive or increase reductions over those estimated in the 'Do Something' scenario.

CCR assessment

14.12.2 No additional monitoring measures are proposed as part of the climate change resilience assessment.

14.13 Summary

14.13.1 The climate change chapter in this ES describes two separate assessments: the carbon assessment and the CCR assessment.

14.13.2 The carbon assessment has identified that the scheme would result in a net reduction in carbon for the assessed period. Although the total number of kilometres travelled as a result of the scheme would increase, compared to the baseline, it is predicted that congestion in the study area would reduce. The benefit from the reduction in congestion would outweigh the carbon associated with the extra distance travelled and the carbon associated with construction of the scheme. The capital carbon for the scheme is 108,330 tonnes CO_{2e} and the operational carbon of the scheme is 140 tonnes CO_{2e}.User carbon summed over the whole study period would decrease by 397,110 tonnes CO_{2e} by 2050, leading to a total carbon reduction of 299,130 tonnes CO_{2e} by 2050.

14.13.3 Thus, the A30 scheme would not have a long-term detrimental impact on the Government's ability to meet its carbon targets and the effect is assessed as not significant for the purposes of this ES. The scheme will, however, result in a short-term increase in carbon caused by emissions associated with construction. A list of carbon reduction measures implemented within this scheme is presented in Section 14.10.

14.13.4 The CCR assessment has identified no significant effects. No additional detailed climate change resilience studies are recommended.

Table 14-13 Summary of Likely Climate Change Effects

Description of impact	Sensitivity of receptor	Duration of impact (short / medium / long term)	Magnitude of impact (without mitigation)	Magnitude of impact (with mitigation)
Whole life carbon emissions to the atmosphere, contributing to the global warming effect (Not significant, beneficial)	High	Long term	n/a	Total carbon reduction of 299,130 tonnes CO_2e by 2050 (capital, user and operational)
No significant climate change resilience effects have been identified.	High	n/a	n/a	n/a

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