national highways

Lower Thames Crossing

6.3 Environmental Statement Appendices
Appendix 15.3 - Climate Resilience Impacts and Effects

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Lower Thames Crossing

6.3 Environmental Statement Appendices

Appendix 15.3 - Climate Resilience Impacts and Effects

List of contents

Page number

List of tables

Page number

1 Overview

1.1.1 This appendix provides an assessment of potential climate change impacts on the resilience of the A122 Lower Thames Crossing (Project). The Project may be vulnerable to a range of potentially significant climate resilience effects during the construction and operational phases. These have been assessed in accordance with the methodology set out in Section 15.3 of Chapter 15: Climate (Application Document 6.1).

1.1.2 The assessment found that, based on the mitigation measures embedded in the Project design, good practice and essential mitigation measures and assumed management practices set out in Section 15.5 of Chapter 15: Climate (Application Document 6.1), UK Climate Projections (UKCP18) (Met Office, 2018), and information from other environmental disciplines, none of the identified impacts on climate resilience would be significant. These impacts are presented in Table 2.1 and Table 2.2, and include damage to assets, disruption to power supplies, increased incidence of pollution and increased risks to road users.

2 Assessment summary – climate change resilience

Table 2.1 Vulnerability of the Project to climate change during construction

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Design of foundations	Increased winter precipitation and decreased summer precipitation	Change in groundwater level and soil moisture. This could affect the foundation settlement. It could also generate larger ground movement and heave.	All pavement foundations will be designed in line with the Design Manual for Roads and Bridges (DMRB) CD 225 Design for New Pavement Foundations (Highways England, 2020b).	Very low	Moderate adverse	Not significant
Materials specification and construction details	Increased extreme temperatures	Project at risk from a greater degree of surface failure or deterioration. For example, for concrete pavements, thermal gradients could create uneven internal stresses, which can then give rise to curling or warping (sometimes called hogging), of the slabs. These can be compounded by loading from passing traffic, which could	Materials (e.g. concrete) will be selected in accordance with relevant standards. This would avoid the deterioration of the pavement through, for example, softening, deformation and cracking. The Contractors will pay due consideration to the impacts of potential extreme weather events and related conditions during construction. The Contractors will use a short- to medium-range weather forecasting service from the Met Office or other approved meteorological data and weather	Medium	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
		generate thermal contraction and expansion of the slabs which, if not taken into consideration at the design stage, can generate unacceptably large longitudinal internal stresses and excessive movements at joints.	forecast provider, 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.			
Construction – laying surface dressing, micro-surfacing, and other temperature-susceptible materials	Extended periods of hot and sunny conditions	Asphalt can remain workable for a considerable time, making it difficult to maintain profile during compaction.		Medium	Minor adverse	Not significant
Wind actions (loads) applied to superstructure	Increased wind speed	Minor temporary structures may have to be designed larger, to withstand larger loads. There is an increased risk of disruption to construction work (unable to operate in high winds).	The Contractors will pay due consideration to the impacts of potential extreme weather events and related conditions during construction. The Contractors will use a short- to medium-range weather forecasting service from the Met Office or other approved meteorological data and weather forecast provider, as well as tidal information from the Port of London	Very low	Moderate adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			Authority to inform short- to medium-term programme management, environmental controls and impact mitigation measures.			
Increased thermal range giving rise to increased earth pressures for bridge	Increased mean temperatures and extreme temperatures	Requirement for stronger fill material and therefore increasing the quantities of excavated material becoming waste.	Small structures and road lighting columns should not be affected as the design standards require a reduced design life (30 years on average) and it is unlikely that climate change impacts would present significant risks over this period.	Very low	Minor adverse	Not significant
Temporary works foundation settlement affected by change in ground water level	Increased winter precipitation and decreased summer precipitation	Change in the groundwater level. This could potentially lead to larger ground movement and heave, requiring more robust foundations for increased settlement. This could also mean that additional construction site drainage and stronger materials for temporary works would be required.	Through undertaking a detailed Flood Risk Assessment, 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. Climate change allowances for the assessment of flood risk, as agreed	Very low	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Design for increased scour risk for foundations	Increased extreme precipitation	Could lead to flooding, which could result in an increase in scour of foundations.	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)..	Very low	Minor adverse	Not significant
Work site surface water drainage systems	Increased extreme precipitation	Overwhelming of the work site drainage system leading to construction site flooding.	Surface water drainage is to provide for all surfaced roads and yards, buildings and any other hard or impermeable surfaces within construction compounds or worksites (Register of Environmental Actions and Commitments (REAC) Ref. RDWE006). Work site drainage systems would be inspected and maintained regularly to ensure that they continue to operate to their design standard, safeguarding surface and groundwater quality (REAC Ref. RDWE002).	Very low	Minor adverse	Not significant
Earthworks erosion	Increased precipitation	Erosion of stockpiled site-won materials and cut earthworks.	Chapter 10: Geology and Soils (Application Document 6.1) specifies the protection of stockpiles from erosion through establishment	Very low	Moderate adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			of a grass cover unless the soil materials are to be reused in a short timeframe (<60 days), in which case alternative erosion control measures may be required, such as silt fencing or the use of geotextile blankets.			
Instability of earthworks		Risk to the earthworks stability, resulting in the need for new/acceptable fill to be imported.	Appendix 10.2: Stability Report (Application Document 6.3) specifies that for specific materials /locations, appropriate designs are required to reduce construction hazards, risk and potential costs. In addition, the earthworks and exposed areas (e.g. soil stockpiles) will be covered with topsoil and re-vegetated to stabilise surfaces. The Project will follow National Highways' Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works (Highways Agency, 2014). In accordance with the Manual of Contract Documents for Highway Works, the height of topsoil stockpiles will not exceed 2m. In addition, stable side slopes for all stockpiled material will be determined during the construction phase.	Very low	Moderate adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Earthworks compaction	Increased extreme temperature and decreased summer precipitation	Reduction in soil moisture. Risks to compaction relate to the need for greater compactive effort being required with potential increased costs, delays etc.	Standard National Highways practice and documentation already allows for variations to compaction processes during construction.	Very low	Moderate adverse	Not significant
Instability of earthworks in areas of pre-existing ground movement	Increased winter precipitation and extreme precipitation	Change in the ground water level. Unstable ground from geological units or made ground/fill could result in ground movement in landfill areas and around the A2. Instability of weakened ground/earthworks triggered by high groundwater or porewater pressures due to increased precipitation.	The earthworks will be designed to Eurocode 7 (BS EN 1997-1) (British Standards Institution, 2004) and BS 6031:2009: Code of Practice for Earthworks (British Standards Institution, 2009). Accordingly, any pre-existing ground movement will be considered along with the most unfavourable groundwater conditions that could occur during the construction phase.	Very low	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			The vulnerability of the Project to groundwater flooding and its potential to exacerbate flooding have been considered in Appendix 14.6: Flood Risk Assessment (Application Document 6.3) and in Chapter 14: Road Drainage and the Water Environment (Application Document 6.1). This issue has also been considered in Appendix 10.4: Agricultural Land Classification Assessment Report (Application Document 6.3). Drainage would be designed and engineered accordingly, and the Project would be designed to relevant standards.			
Workforce	Increased projected mean daily rainfall, especially in winter months	Increased safety risk of slips, trips and falls to construction workers.	The Contractors will pay due consideration to the impacts of potential extreme weather events and related conditions during construction. The Contractors will use a short- to medium-range weather forecasting service from the Met Office or other approved meteorological data and weather forecast provider to inform short- to medium-term programme management, environmental controls and impact mitigation	Very low	Minor adverse	Not significant
	Increased summer temperatures, humidity and frequency of hot days and heatwaves	Increased heat stress/heat exhaustion for workers.		Very low	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Construction site	Increased projected mean daily rainfall, especially in winter months	Construction site or excavation flooding. Site roads may also become impassable as a result of flooding. Mitigation measures have already been embedded within the Project's design.	measures. The Contractors will ensure that the relevant measures within the Code of Construction Practice (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 will also consider extreme weather events where risks have been identified.	Very low	Minor adverse	Not significant
Plant and equipment	Increased projected mean daily rainfall, especially in winter months	Water ingress to critical equipment, including traction power distribution sites, leading to signalling or other electronic equipment failures, which would require switch off or possibly causing damage.		Very low	Minor adverse	Not significant

Table 2.2 Vulnerability of the Project to climate change during operation

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Pavement – foundation	Increased mean daily rainfall	Pavement has a typical design life of 40 years and could therefore be affected by changes in climate. The moisture content of soils could be altered. This could lead to ground movements and soil settlement, as well as expansion and contraction. This could also cause the Project's pavements and foundations to heave.	All pavement foundations will be designed in accordance with DMRB CD 225 Design for New Pavement Foundations (Highways England, 2020b). Maintenance will be carried out when the standards of service provided to the road user and the integrity of the foundations will be affected. Maintenance will be carried in accordance with DMRB CS 230 Pavement Maintenance Assessment Procedure (Highways England, 2020k).	Very low	Moderate adverse	Not significant
Pavement – surface	Large changes in temperature	Thermal contraction and expansion of the slabs which, if not taken into consideration at the design stage, could generate unacceptably large longitudinal internal stresses and	Structures will be designed in accordance with DMRB CD 350 The Design of Highway Structures (Highways England, 2020c), DMRB CD 354 Design of Minor Structures (Highways England, 2020d), and DMRB CD 368 Design of Fibre Reinforced Polymer Bridges and	Very low	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
		excessive movements at joints.	Highway Structures (Highways England, 2020e). Deterioration models will be used to identify appropriate maintenance regimes. In addition, structures will be inspected in line with DMRB CS 450 Inspection of Highway Structures (Highways England, 2021b) and DMRB CS 451 Structural Review and Assessment of Highway Structures (Highways England, 2020l). In accordance with the Routine and Winter Service Code (RWSC) (Highways Agency, 2009a) and the Network Management Manual (NMM) (Highways Agency, 2009b), the Road Operator will: ensure effective and essential winter maintenance have in place emergency response and contingency plans in the form of a Severe Weather Plan prepare standard operating procedures to be used in the event of a necessary road closure and/or traffic diversion			
	Maintained high temperatures	The newly laid surfacing layers of a pavement may also maintain temperatures after opening to traffic that are high enough to allow excessive rutting and the rapid embedment of any chippings, with the latter again causing a reduction of texture depth.		Very low	Minor adverse	Not significant
	An increase in frequency of heavy rainfall, an increase of average temperatures and an increase in frequency of hot days and heatwaves	Reduced pavement friction coefficient.		Low	Minor adverse	Not significant
	Increased mean	Reduced need for snow clearing.		Low	Negligible	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
	temperature and daily rainfall					
Superstructure	Increased heavy rainfall	Flooding, deterring users from their journey.	Peak rainfall intensity for drainage assets other than carriageways would normally be calculated in accordance with the Environment Agency's guidance on climate change for flood risk assessments (Environment Agency, 2022). Since the storage design was undertaken, the guidance has been updated with higher uplifts on peak rainfall intensity. As the revised guidance was published after the 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[1]. With this departure taken into account, a 20% and 40% uplift on the 1 in 100-year storm event were deemed to be	Low	Moderate adverse	Not significant

[1] The departure on peak rainfall intensity is recorded in a Statement of Common Ground between National Highways and the Environment Agency (see Application Document 5.4).

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			accepted and applied for storage design. Full details of the surface water drainage proposals for the Project are set out in Part 7 of Appendix 14.6: Flood Risk Assessment (Application Document 6.3).			
Tunnels	Increased mean temperature and increased frequency of hot days and heatwaves	Overheating of tunnel portal areas and a potential fire risk.	In accordance with the RWSC (Highways Agency, 2009a) and the NMM (Highways Agency, 2009b), the Road Operator will: • have in place emergency response and contingency plans in the form of a Severe Weather Plan • prepare standard operating procedures to be used in the event of a necessary road closure and/or traffic diversion In addition, adequate space would be provided within the tunnels to account for anticipated cooling and ventilation requirements. Maintenance of the tunnels will be carried out in accordance with DMRB CM 430 Maintenance of Road Tunnels (Highways England, 2020i). The ventilation in the tunnel would be	Low	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			designed in accordance with DMRB CD 352 Design of Road Tunnels (Highways England, 2020s).			
Tunnels	Increased heavy rainfall	Flooding, deterring users from their journey.	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). Sensitivity testing has been undertaken to consider the potential impacts on the Project of the credible maximum climate change scenario (Environment Agency, 2022). In addition, the drainage in the tunnel would be designed in accordance with DMRB CD 352 Design of Road Tunnels (Highways England, 2020s).	Low	Moderate adverse	Not significant
Foundations and substructure	Increased mean daily rainfall	Changes in groundwater levels could lead to ground movements and soil settlement, causing damage to	Peak rainfall intensity for drainage assets other than carriageways would normally be calculated in accordance with the Environment Agency's guidance on climate change for flood	Low	Moderate adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
		foundations and substructures.	risk assessments (Environment Agency, 2022). Since the storage design was undertaken, the guidance has been updated with higher uplifts on peak rainfall intensity. As the revised guidance was published after the 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[2]. With this departure taken into account, a 20% and 40% uplift on the 1 in 100-year storm event were deemed to be accepted and applied for storage design. Full details of the surface water drainage proposals for the Project are set out in Part 7 of Appendix 14.6: Flood Risk Assessment (Application Document 6.3).			

[2] The departure on peak rainfall intensity is recorded in a Statement of Common Ground between National Highways and the Environment Agency (see Application Document 5.4).

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Carriageway Drainage	Increased frequency and intensity of heavy rainfall, flooding, and storm events	Overwhelming the drainage system and inundation of the highway.	The Project's drainage will be designed in accordance with CG 501 Design of Highway Drainage Systems (Highways England, 2020g).	Low	Minor adverse	Not significant
Drainage	Increased mean daily rainfall	Increased risk of pollution mobilisation from accidental spillages leading to an increased risk of contaminates entering the water environment.	Drainage infrastructure would be inspected and maintained regularly in accordance with DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020q) and DMRB GM 701 Asset Delivery Asset Maintenance Requirements (Highways England, 2020n), as applicable, to ensure that they continue to operate to their design standard to safeguard surface and groundwater quality. This is described within Chapter 14: Road Drainage and the Water Environment (Application Document 6.1) and secured through the Code of Construction Practice (CoCP) (REAC Ref. RDWE012).	Low	Minor adverse	Not significant
Earthworks instability	Increased winter precipitation	Instability of embankments and cuttings.	The earthworks side slopes have been designed to Eurocode 7 (BS EN 1997-1) (British Standards Institution, 2004) and BS 6031:2009: Code of	Very low	Large adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
	and extreme precipitation		Practice for Earthworks (British Standards Institution, 2009). Accordingly, the most unfavourable groundwater conditions that could occur during the design life of the Project in accordance with UKCP18 have been considered. As a result, the slope design is considered to be robust in terms of climate change and will provide a future-proof, low-maintenance design.			
Earthworks	Increased frequency and intensity of heavy rainfall, flooding, and storm events	Road network becoming inaccessible due to submergence in flood water.	The Project has been designed to remain functional in extreme rainfall events – for example by elevating the proposed vertical alignment above the 1 in 100-year flood level, and by not siting key infrastructure (communications, lighting power supplies) where it would be prone to flooding. Measures have been secured to maintain floodplain connectivity and prevent embankments forming continuous barriers to floodplain flow conveyance at West Tilbury Main and at the proposed viaduct spanning the Mardyke and Golden Bridge Sewer, as described in Appendix 14.6: Flood Risk Assessment (Application	Very low	Large adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			Document 6.3) (REAC Ref. RDWE040 and RDWE046). The proposed embankments included within the Project's design could reduce rainfall recharge and cause compaction of the underlying geology, further reducing the aquifer's ability to recharge. Potential groundwater lowering could affect unconfined and semi-confined aquifers, and impact groundwater abstractions and watercourses. A simple assessment, in line with DMRB LA 113 Road Drainage and the Water Environment (Highways England, 2020r) is presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). The geotechnical assets will be designed in accordance with DMRB CD 622 Managing Geotechnical Risk (Highways England, 2020f) and managed in accordance with DMRB CS 641 Managing the Maintenance of Highway Geotechnical Assets (Highways England, 2020m). A suite of flood alleviation measures to prevent increases in flood risk elsewhere have been designed to include allowances for climate change			

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			for the assumed 100-year design life from the opening year. These include providing compensation storage for any permanent losses of floodplain storage volume associated with the West Tilbury Main, Mardyke and Mardyke West tributary. As presented in Figure 2.4: Environmental Masterplan (Application Document 6.2), the existing topography would be lowered to create depressions that are hydraulically connected to the neighbouring floodplain, allowing their inundation during flood events. Additionally, the road geometry has set the vertical alignment of the carriageways above the design flood level, inclusive of freeboard and allowance for climate change resilience, and flood bunds or walls have been provided to protect areas where the vertical alignment of the road is lower than the design flood level, to make the development safe from flooding over its design lifetime in line with the requirements of the National Planning Policy Framework (Ministry of Housing, Communities and Local Government, 2021).			

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Earthworks	Increased mean temperature and daily rainfall	Impact on soils reinstated for agricultural use. This could alter the productivity of the land.	Reinstatement of soils affected by temporary works would aim to avoid any reduction in soil function. For agricultural land this will be measured by the quality of the land as defined by the Agricultural Land Classification system (with a soil profile recreated to 1.2m below ground level where this was the pre-construction soil depth). For areas of landscape planting or habitat creation, this will be measured by the successful restoration of the soil profile (both physical and chemical characteristics) defined for that particular habitat in the soils management procedures suitable to allow the establishment and long-term health of the habitat. This commitment is described within Chapter 10: Geology and Soils (Application Document 6.1) and secured through REAC Ref. GS012.	Low	Negligible	Not significant
Signs and signals	Increased frequency and intensity of storms	Reduction of the design life of a number of key assets such as signage, lighting, road surface and road markings. This could increase maintenance costs	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	Low	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
		over the lifespan of the road.	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).			
Road markings	Increased mean temperature and daily rainfall	Faster deterioration rate of road markings, reducing road user safety.		Low	Minor adverse	Not significant
Signs	Increased wind speed and frequency of extreme wind events	The stability of signals and signs may be affected by increased wind loads reducing their design life.		Low	Minor adverse	Not significant
Lighting columns and fencing	Increased wind speed and frequency of extreme wind events	Could affect the stability of the lighting columns as well as highway signage and fencing.		Low	Minor adverse	Not significant
Signals and lighting columns	Increased extreme weather events	Damage and disruption to power supply and other linked infrastructure.	In accordance with the RWSC (Highways Agency, 2009a) and the NMM (Highways Agency, 2009b), the Road Operator will: • ensure effective and essential winter maintenance • have in place emergency response and contingency plans in the form of a Severe Weather Plan	Medium	Minor adverse	Not significant
Information and communication systems	Increased mean temperature and increased	Overheating of electrical equipment leading to failure and/or fire.		Medium	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
	frequency of hot days and heatwaves		• prepare standard operating procedures to be used in the event of a necessary road closure and/or traffic diversion Furthermore, in accordance with DMRB GM 704 Operational Requirements for Severe Weather (Highways England, 2020p), the Road Operator will: • undertake health and safety risk assessments to cover the operational aspects of severe weather • develop and continually review a Severe Weather Plan, detailing precautionary and reactive procedures In addition, Variable Message Signs (VMS) will be specified as part of the design and suitable diversion routes will be identified, especially during planned maintenance of tunnel bores. Inspection and maintenance of signs will be carried out in accordance with DMRB CS 125 Inspection of Traffic Signs (Highways England, 2020j) and DMRB CM 125 Maintenance of Traffic Signs (Highways England, 2020h), respectively.			

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
Landscape design	Decreased mean rainfall	Drought tolerant trees could become more prevalent. This may cause a change in the landscape character of the area and would likely affect biodiversity.	During detailed design, further detail would be developed within the Landscape and Ecology Management Plan (LEMP), substantially in accordance with the requirements set out within the outline LEMP (Application Document 6.7). The purpose of the LEMP would be to provide information relating to existing and future 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, 2020n) and DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020q). The appointed Contractors would be responsible for undertaking landscape management within the rectification period (for up to five years after	Medium	Negligible	Not significant
Landscape design	Increased mean temperature and daily rainfall	Alteration of growing characteristics such as soil properties and length of growing season. This may impact the species identified as part of the landscape strategy and thus alter the character of the landscape. This could also lead to tree fall and increased maintenance and management requirements.		Medium	Negligible	Not significant
Landscape design	Increased wind speed and frequency of	Increased tree loss, habitat loss and/or fragmentation and reduction in woodland blocks.		Medium	Negligible	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
	extreme wind events		Project opening), after which the longer-term maintenance and management of the soft estate responsibilities would transfer to National Highways.			
Landscape design	Increased wind speed and frequency of extreme wind events	Loss of valued landscape features, opening up new views of the Project that were previously shielded.		Medium	Negligible	Not significant
Landscape design	Increased mean daily rainfall	Changes in hydrology may lead to landscape planting failing.		Low	Negligible	Not significant
Safety barriers (vehicle restraint systems)	More frequent extreme weather and changes in temperature and rainfall	Steel safety barriers have a design life of approximately 25 years. Increase in rate of deterioration of vehicle restraint systems.	Safety barriers will be designed in accordance with DMRB CD 377 Requirements for Road Restraint Systems (Highways England, 2021a).	Low	Minor adverse	Not significant
End-users	Increased extreme weather events	An increase in the rate of deterioration of assets could lead to an increased requirement for maintenance workers and traffic officers working within the carriageway.	The Project would utilise a broad range of techniques and tools as safety measures during the development and delivery of the Project as detailed in the Lower Thames Crossing Health, Safety, Security and Wellbeing Strategy (Cascade, 2020). The road would be designed, delivered, operated and maintained with the aim that it is the best highways project globally in	Medium	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			terms of health, safety, security and the well-being of workforce, employees and road users. Measures would include, but not be limited to, behavioural safety techniques, training, physical measures (such as lane closures, speed restrictions and enforcement), and planning for and provision of adequate time, space and resources to deliver the required works safely. Furthermore, in accordance with DMRB GM 704 Operational Requirements for Severe Weather (Highways England, 2020p), the Road Operator will: • undertake health and safety risk assessments to cover the operational aspects of severe weather • develop and continually review a Severe Weather Plan, detailing precautionary and reactive procedures			
End-users (WCH)	Increased frequency and intensity of storms	Could discourage the use of WCH facilities to complete journeys. This may lead to more road users.	In accordance with the RWSC (Highways Agency, 2009a) and the NMM (Highways Agency, 2009b), the Road Operator will:	Medium	Negligible	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
End-users (WCH)	Increased heavy rainfall	Flooding, closures and diversions of footpaths.	• ensure effective and essential winter maintenance • have in place emergency response and contingency plans in the form of a Severe Weather Plan • prepare standard operating procedures to be used in the event of a necessary road closure and/or traffic diversion In addition, Variable Message Signs (VMS) will be specified as part of the design. The Project's drainage will be designed in accordance with DMRB CG 501 Design of Highway Drainage Systems (Highways England, 2020g). Drainage infrastructure and treatment systems would be inspected and maintained regularly in accordance with DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020q) and DMRB GM 701 Asset Delivery Asset Maintenance Requirements (Highways England, 2020n), as applicable, to ensure that they continue to operate to their design standard to safeguard surface and groundwater quality. This is described within Chapter 14: Road Drainage and the Water Environment (Application	Low	Negligible	Not significant
End-users (motorised users)	Increased frequency and intensity of heavy rainfall, flooding, and storm events	Higher rate of vehicle collisions causing severe disruption to highway and major accidents, causing harm to highways users and adjacent receptors. It could also cause damage to roads, tunnels, cuttings and drainage systems due to flooding.		High	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			Document 6.1) and secured through REAC Ref. RDWE012. Road drainage design includes future climate change allowances to improve its resilience. Attenuation features would be designed to detain runoff from a 1% annual probability rainfall event." Full details of the surface water drainage proposals for the Project are set out in Part 7 of Appendix 14.6: Flood Risk Assessment (Application Document 6.3). Regular sweeping and cleaning to remove debris. Regular maintenance of assets to detect deterioration and damage.			
End-users (motorised users)	Increased mean temperature and increased frequency of hot days and heatwaves	Increase the risk of more incidents due to: • vehicles having broken down/overheated • a higher frequency of vehicle fires • smoke drifting across carriageways from wildfires	In accordance with the RWSC (Highways Agency, 2009a) and the NMM (Highways Agency, 2009b), the Road Operator will: • ensure effective and essential winter maintenance • have in place emergency response and contingency plans in the form of a Severe Weather Plan • prepare standard operating procedures to be used in the event	High	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
		• HGV blow-overs and flying debris • decrease of skid resistance	of a 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, 2020o).			
End-users (motorised users)	Increased frequency of dry spells and heavy rainfall	Could lead to 'summer ice'. This occurs after a prolonged period of no rain when dirt and oil residues build up on the road. When a first rain event occurs, this material becomes very slippery and dangerous (similar to ice on the road). This could also lead to an inadequate skid resistance.	The Project's drainage will be designed in accordance with DMRB CG 501 Design of Highway Drainage Systems (Highways England, 2020g). Drainage infrastructure and treatment systems would be inspected and maintained regularly in accordance with DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020q) and DMRB GM 701 Asset Delivery Asset Maintenance Requirements (Highways England, 2020n), as applicable, to ensure that they continue to operate to their design standard to safeguard surface and groundwater quality. This is described within Chapter 14: Road Drainage and the Water Environment (Application Document 6.1) and secured through REAC Ref. RDWE012.	Medium	Minor adverse	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
End-users (motorised users)	Increased frequency and intensity of heavy rainfall, flooding, and storm events	Reduced safety and visibility as a result of standing water.	The Project's drainage will be designed in accordance with DMRB CG 501 Design of Highway Drainage Systems (Highways England, 2020g). Drainage infrastructure and treatment systems would be inspected and maintained in accordance with DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020q) and DMRB GM 701 Asset Delivery Asset Maintenance Requirements (Highways England, 2020n), as applicable, to ensure that they continue to operate to their design standard. This is described within Chapter 14: Road Drainage and the Water Environment (Application Document 6.1) and secured through REAC Ref. RDWE012. In accordance with the RWSC (Highways Agency, 2009a) and the NMM (Highways Agency, 2009b), the Road Operator will: • ensure effective and essential winter maintenance • have in place emergency response and contingency plans in the form of a Severe Weather Plan	High	Minor adverse	Not significant
End-users (motorised users)	Increased mean temperature and increased frequency of hot days and heatwaves	Increased stress for users and maintenance workers (e.g. within the tunnel).		Low	Negligible	Not significant

Receptor/aspect	Climate event	Potential effect to Project (impact)	Mitigation (embedded, good practice and essential)	Likelihood of impact (post-mitigation)	Consequence of impact	Significance (including mitigation)
			• prepare standard operating procedures to be used in the event of a necessary road closure and/or traffic diversion			

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