Lower Thames Crossing

6.3 Environmental Statement Appendices
Appendix 15.2 Climate Resilience Baseline

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Lower Thames Crossing

Appendix 15.2 Climate Resilience Baseline

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1 Current baseline

1.1.1 The A122 Lower Thames Crossing (Project) sits within the Met Office 'South East and Central Southern' and 'East Anglia' districts. Climate observations for this district, presented as 10-year averages between 1970 and 2019, identify gradual warming, with an increase of 1.17°C in mean maximum annual temperatures between the periods 1970–1979 and 2010–2019. Mean annual rainfall has decreased by 4.09% between the same periods.

Table 1.1 Historic 10-year averages for temperature and rainfall for the 'South East and Central Southern' and 'East Anglia' districts

Climate period	Climate variables	
	Mean maximum annual temperatures (°C)	Mean annual rainfall (mm)
1970–1979	13.66	767.23
1980–1989	13.73	810.02
1990–1999	14.41	750.56
2000–2009	14.81	782.01
2010–2019	14.83	735.83

1.1.2 As noted by the Independent Assessment of UK Climate Risk – Advice to Government for the UK's third Climate Change Risk Assessment (CCRA3) (Committee on Climate Change, 2021), adopted by the Government in the UK Climate Change Risk Assessment 2022 (HM Government, 2022), the UK's transport infrastructure is already facing climate challenges from flooding, heat, erosion, subsidence and extreme weather.

1.1.3 Local Climate Impacts Profiles (LCLIPs) have been developed by local authorities to assess the vulnerability of council services to severe weather events for Kent County Council, Essex County Council, Thurrock Council and the London Borough of Havering. Medway, Gravesham and Brentwood local authorities have not produced separate LCLIPs but have contributed towards their respective county profiles.

1.1.4 A summary of the key findings from the LCLIPs for Kent, Essex, Thurrock and Havering is provided below and in Table 1.2 Lack of consistency of key findings presented is due to differences in the datasets and reporting timelines.

1.1.5 The LCLIP for Kent County Council was developed by reviewing media stories in the local press over a 14-year period between 1996 and 2010. The LCLIP review found that Kent County Council is already experiencing major weather events and that 52 highly significant events occurred over the 14-year LCLIP period. The most frequent impacts of these events were heavy rain and resultant flood events, heatwaves, droughts, freezing temperatures and snow, as well as multiple storms.

1.1.6 The LCLIPs for Essex County Council, Thurrock Council and the London Borough of Havering also assessed the vulnerability of council services to severe events. The LCLIP for Essex County Council (2010) is based on a review of media stories in the local press over a six-year period between January 2004 and December 2009. The LCLIP from Thurrock Council is based on a 48-year period from 1959 to 2007, and the LCLIP from London Borough of Havering is based on a five-year period between 2005 and 2009.

1.1.7 All four LCLIPs show a pattern with regards to frequency and severity of extreme weather events and highlight the impacts these have on services, including spending pressures, across the counties.

Table 1.2 Summary of Kent County Council, Essex County Council, Thurrock Council and the London Borough of Havering LCLIPs

Climate event	Kent County Council	Essex County Council	Thurrock Council	London Borough of Havering
Heavy rainfall and flooding	A total of 22 heavy rain and flooding events were reported over the 14-year study period (August 1996 – January 2010).	Over 160 incidents caused by heavy rain and flooding were reported from January 2004 to December 2009.	Approximately 11,000 properties are at risk of flooding within the unitary authority. Frequency of major flooding events is likely to increase.	There were five significant events of heavy rainfall during the study period. Two of the events took place over the winter months of November and February, while the other three took place over June and July.
Storms (increase in wind speed for worst gales)	Kent experienced 10 severe storms. The impacts due to storms included loss of power for thousands of homes.	The LCLIP does not present the number of severe storms. However, the annual frequency of strong winds has increased during the six-year study period.	The annual frequency of strong winds has increased over the 10-year period between 2000 and 2010. This increased frequency and intensity has caused greater damage, transport disruption, tree falls and power cuts.	Havering reported four significant high-wind events (storms and gales). These events saw winds of up to 90 miles per hour and lightening.

Climate event	Kent County Council	Essex County Council	Thurrock Council	London Borough of Havering
Extreme summer temperatures and precipitation	Over seven heatwave events were reported over the study period. Impacts reported included a 20-year low in the River Stour's levels and road surfaces melting.	The LCLIP does not present the number of heatwave events. However, it notes that extreme summer events had impacts on health and agricultural difficulties, as well as the long-term effects on buildings and infrastructure in Essex.	The east of England is the driest region in England. Predicted scenarios for climate change show that more frequent drought conditions are expected.	A total of three periods of high temperatures, severe dry weather and heatwaves were reported during the study period for the LCLIP.

1.1.8 In addition, since 2012, Kent County Council has been using the Severe Weather Impacts Monitoring System (SWIMS). This is a decision-support tool that enables partners across Kent County Council to record how they have been impacted by, and are responding to, severe weather events, as and when they occur.

1.1.9 The Kent SWIMS assessed the vulnerability of local authority services in Kent and Medway to severe weather events over a seven-year period between 2013 and 2019. The SWIMS review found that Kent and Medway are already experiencing major weather events and that several highly significant events occurred over the seven-year SWIMS period.

1.1.10 Evidence suggests that the number of severe weather events is increasing, with intense rainfall events occurring more frequently over the SWIMS analysis period. Heavy snow and strong winds are also noted as severe weather events known to cause disruption.

1.1.11 Specifically relating to highways, flooding, snow and ice have been the biggest weather-related issues recorded over the seven-year SWIMS analysis period. Flooding on major roads into the city on numerous occasions has resulted in accessibility problems and has created extra workload for Kent Fire and Rescue Service by, for example, rescuing stranded motorists. Storms have resulted in large numbers of fallen trees and freezing temperatures, and heavy snow has caused disruption and road accidents.

Table 1.3 SWIMS severe weather events

Climate event	Number of events during seven-year period (2013–2019)
Heavy rainfall and flooding	No severe climate events related to heavy rainfall and flooding were reported in Kent. The highest rainfall intensity recorded by the Met Office was at Sandhurst in Kent, where 29.4mm of rain fell within a 24-hour period on 14–15 January 2015. In addition, between 7–26 June 2016, 103.6mm of rain fell; more than double the 30-year average. In addition, 20 properties across Dover District were affected by flooding, and 12 properties in the Paddock Wood area had water pumped away.
Storms (increase in wind speed for worst gales)	Kent experienced 18 severe storms. Wind speeds reached 59.9mph at Manston in Kent on 17 November 2015. Transport impacts due to storms included the blockage of the railway line between Swanley & Sevenoaks and Swanley & Borough Green for three hours. Transport impacts due to storms in 2016 included train delays of up to 60 minutes during storms in February. However, services were maintained across the county. In addition, Storm Katie also caused the closure of the Sheppey Crossing and the Queen Elizabeth II Bridge due to the high winds. In 2018, Storm Emma greatly disrupted travel across the county, with many main roads closing. Many l rail services were also suspended, leaving residents stranded on trains and at stations.
Extreme summer temperatures and precipitation	Five heatwave events were reported. The hottest day of 2015 in Kent was recorded during the heatwave where air temperature averaged 34.7°C over a 12-hour period on 1 July. During 2016, in July and August, the average temperature was 5°C higher than the national average. The maximum temperature recorded was 35.3°C in Faversham on 26 July 2016. During the 23–28 July 2018 heatwave, the Eurotunnel Shuttles experienced air-conditioning unit failures, which resulted in large tailbacks on the coast-bound M20 carriageway.
Extreme winter low temperatures	Two events related to low temperatures were reported. Kent experienced an extended period of cold as a result of Storm Emma between 28 February and 3 March 2018; the minimum temperature recorded was -14.2°C, 21°C lower than the 7°C average Kent temperature for February. Very low temperatures of -15°C to -20°C in the UK tend to be associated with periods of light winds, clear skies and lying snow cover. Storm Emma greatly disrupted travel across the county, with many main roads closing, and rail services were suspended, leaving residents stranded on trains and at stations. Kent experienced an extended period of cold weather between 22 and 31 January 2019; the minimum temperature recorded was -4.9°C, 9.9°C lower than the 5°C average Kent temperature for January. As a result of the cold weather, power outages, disruption to internet access, and damage to property were reported.

1.1.12 Met Office historic climate data (Met Office, 2010) has been obtained from the Stanford-le-Hope, Writtle, Gillingham No2 and East Malling weather stations (the closest weather stations to the Project) and is presented in Table 1.4 for the period 1981–2010.

Table 1.4 Climate change baseline

Climate variable	Stanford-le-Hope	Writtle	Gillingham No2	East Malling	Average
Average annual maximum daily temperature (°C)	14.6	14.6	15.1	14.7	14.75
Mean maximum daily temperature (°C)	22.2 (August)	22.9 (July)	23.3 (July)	22.6 (July)	23.3 (July)
Mean minimum daily temperature (°C)	1.6 (February)	1.0 (February)	2.0 (February)	1.7 (February)	1.0 (February)
Average total annual rainfall (mm)	571.3	591.8	594.2	647.8	601.275
Average rainfall of wettest month (mm)	64.9 (October)	64.1 (October)	66.6 (January)	73.9 (October)	73.9 (October)
Average rainfall of driest month (mm)	36.7 (February)	39.2 (February)	38.3 (July)	40.2 (July)	40.2 (July)

1.1.13 The Met Office historic 10-year averages for the South East and Central Southern district (Met Office, 2019) identify gradual warming (although not uniformly so) between 1970 and 2019, and a decrease in rainfall. Information on average annual maximum daily temperatures (°C) and average total annual rainfall (mm) is summarised in Table 1.4.

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

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

b. One surface water flooding incident at the A13 junction, which is recorded as having low impact. It is assumed that any legacy issues at the incident location would be addressed by the new drainage provisions.

c. Two flooding incidents on the section of the M25 that would be upgraded as part of the Project. The first of these events occurred in November 2009 at a location approximately 900m south of M25 junction 29 and was of low severity. The second occurred in May 2010 at a location approximately 2.5km south M25 junction 29 and was of moderate severity.

1.1.15 Further data has been obtained for long-term flood risk from the Environment Agency. The Environment Agency's (2022a) map for long-term flood risk from rivers or the sea shows the extents of fluvial and tidal flooding with existing flood defences considered. This map indicates that the section of the Project road to the south of the River Thames (Catchment EFR-1) would lie in areas that are not at risk of fluvial or tidal flooding. There are areas at low and medium risk of fluvial flooding to the north of Catchment EFR-1, but the Project road would be in tunnel in these areas and therefore not affected.

1.1.16 Fluvial flooding would occur when the flow through West Tilbury Main exceeds its capacity. West Tilbury Main discharges to the River Thames via Bowaters Sluice and is subject to tide locking. Contrary to normal expectations, tide locking at the point where West Tilbury Main discharges to the River Thames does not unduly impact fluvial flooding in Catchment EFR-2, which comprises the North Portal approach, Tilbury Viaduct and the link road to the A13/A1089/A122 Lower Thames Crossing junction.

1.1.17 The Environment Agency's (2022a) long-term flood risk map shows the extents of fluvial and tidal flooding with existing flood defences considered. This map indicates that most of the section of Project road in Catchment EFR-2 would lie in areas that are not at risk of fluvial or tidal flooding. The exception to this is towards the southern part of the catchment, where the Project road would traverse areas at low and very low risk of fluvial or tidal flooding.

1.1.18 The section of the Project road in Catchment EFR-3, which comprises the split-level interchange between the A122, A13 and A1089[1], would also lie in areas that are at low risk of fluvial or tidal flooding.

1.1.19 The section of the Project road in Catchment EFR-4 crosses three main rivers – Mardyke, Orsett Fen Sewer and Golden Bridge Sewer. Fluvial flooding will occur when the flow through these main rivers exceeds their capacities. Tide locking at the point where the Mardyke discharges to the Thames could exacerbate fluvial flooding. When the Mardyke is tide locked, flooding in the tributaries will also be effectively tide locked and thus further exacerbating fluvial flooding.

1.1.20 The Environment Agency's (2022a) long-term flood risk map indicates that most of the section of Project road in Catchment EFR-4 would lie in areas that are not at risk of fluvial or tidal flooding. The exceptions to this are as follows:

a. The Project road would traverse areas at low and very low risk of fluvial or tidal flooding towards the southern part of Catchment EFR-4.

b. Where the Project road crosses the Mardyke floodplain, it will traverse areas at medium and high risk of fluvial or tidal flooding.

[1] The existing junction between the A13 and the A1089 is sometimes referred to as the Baker Street Interchange.

2 Future baseline – climate resilience assessment

2.1.1 The future baseline is expected to differ from the present-day baseline. The UK Climate Projections 2018 (UKCP18) (Met Office, 2018) have been developed to provide projections for future climate scenarios and trends. The UKCP18 data is considered to be the most robust source of information on the UK's future climate.

2.1.2 UKCP18 provides probabilistic projections for pre-defined 20-year time periods (e.g. 2020–2039, 2040–2059, 2060–2079 and 2080–2099). For the purposes of the Project assessment, UKCP18 projections for the following climate variables have been obtained and analysed:

a. Mean annual temperature

b. Mean summer temperature

c. Mean winter temperature

d. Maximum summer temperature

e. Minimum winter temperature

f. Mean annual precipitation

g. Mean summer precipitation

h. Mean winter precipitation

2.1.3 A range of possible Representative Concentration Pathways (RCPs), selected from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2014), have been used by UKCP18 to inform differing future emission trends. The four scenarios are RCP2.6, RCP4.5, RCP6.0 and RCP8.5. Scenario RCP8.5 is the closest to the UKCP09 high emissions scenario previously used as best practice for climate assessment.

Table 2.1 RCP description

RCP	Description
RCP2.6	Represents a pathway where greenhouse gas (GHG) emissions are strongly reduced, resulting in a best estimate global average temperature rise of 1.6°C by 2100 compared with the pre-industrial period.
RCP4.5	Medium stabilisation pathway, with some level of mitigation, resulting in a best estimate global average temperature rise of 2.4°C by 2100 compared with the pre-industrial period.
RCP6.0	Medium stabilisation pathway, with some level of mitigation, resulting in a best estimate global average temperature rise of 2.8°C by 2100 compared with the pre-industrial period.
RCP8.5	A pathway where GHG emissions continue to grow unmitigated, leading to a best estimate global average temperature rise of 4.3°C by 2100 compared with the pre-industrial period.

2.1.4 The IPCC provides evidence to suggest that current global population and urbanisation trends, slow uptake of renewable energy sources, delay in nuclear power growth, and slow development of international climate change policy means that it is most likely that global emissions will follow the predicted RCP8.5 pathway.

2.1.5 UKCP18 allows for future climate projections across a range of probability levels to be assessed, ranging from 10% probability to 90% probability:

a. 10% probability level – this demonstrates what the future change is unlikely to be less than. There is a 90% chance the projected change will be more than this.

b. 50% probability level – this is known as the central estimate, with an even chance of it occurring and not occurring.

c. 90% probability level – this demonstrates what the future change is unlikely to be more than. There is a 10% chance the projected change will be more than this.

2.1.6 Projected temperature, and precipitation variables are presented in Table 2.2 and Table 2.3. UKCP18 probabilistic projections for RCP8.5 have been analysed for the two 25km*25km grid squares where the Project would be located. These figures are expressed as temperature and precipitation anomalies in relation to the 1981–2000 baseline. The 50% probability level has been presented.

Table 2.2 Projected changes to temperature variables

Climate variable	Time period			
	2020–2039	2040–2059	2060–2079	2080–2099
Mean annual air temperature anomaly at 1.5m (°C)	+0.9	+1.7	+2.8	+3.7
Mean summer air temperature anomaly at 1.5m (°C)	+1.2	+2.2	+3.7	+5.0
Mean winter air temperature anomaly at 1.5m (°C)	+0.8	+1.6	+2.4	+3.2
Maximum summer air temperature anomaly at 1.5m (°C)	+1.4	+2.5	+4.1	+5.6
Minimum winter air temperature anomaly at 1.5m (°C)	+0.8	+1.6	+2.5	+3.2

Table 2.3 Projected changes to precipitation variables

Climate variable	Time period			
	2020–2039	2040–2059	2060–2079	2080–2099
Annual precipitation rate anomaly (%)	-0.6	-3.5	-4.0	-3.7
Summer precipitation rate anomaly (%)	-10.1	-20.2	-28.8	-35.9
Winter precipitation rate anomaly (%)	+6.1	+9.5	+15.4	+20.8

2.1.7 These UKCP18 projections represent average climate conditions and do not capture the full range of possible future severe weather events (e.g. droughts, heatwaves and prolonged heavy rainfall).

2.1.8 UKCP18 climate change projections have been used qualitatively to identify how events associated with climatic variables change over time. Baseline climatic conditions (as identified through Met Office datasets) can subsequently be compared against climate change projections to indicate the direction and degree of change. This approach allows these events to be prioritised over the duration of the Project and the requirement for mitigation and adaptation responses to be identified and programmed accordingly.

2.1.9 For the Flood Risk Assessment, Appendix 14.6: Flood Risk Assessment (FRA) (Application Document 6.3), hydraulic modelling has been undertaken to define the future baseline. Hydraulic models have been developed to assess fluvial and tidal flood risk in the River Mardyke and Tilbury Main catchments. The hydraulic modelling applies the climate change allowances for flood risk assessments (Environment Agency 2022b), as detailed in Appendix 14.6: FRA (Application Document 6.3).

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