M60/M62/M66 Simister Island Interchange

TR010064

ENVIRONMENTAL STATEMENT APPENDICES

APPENDIX 14.2 VULNERABILITY ASSESSMENT

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ENVIRONMENTAL STATEMENT APPENDICES
APPENDIX 14.2 VULNERABILITY ASSESSMENT

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Author	M60/M62/M66 Simister Island Interchange Costain Jacobs Partnership Project Team & National Highways

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1.1 Introduction

1.1.1 A qualitative risk assessment of the vulnerability of the Scheme to potential changes in climate was carried out using the assessment framework and significance criteria set out in the Design Manual for Roads and Bridges (DMRB) LA 114 Climate (Highways England, 2021a).

1.2 Methodology

1.2.1 The assessment process is summarised as follows:

- Determining existing climate conditions within the study area
- Identifying potential future changes to key baseline climate variables (e.g. rainfall) using the UK Climate Projections 2018 (UKCP18) probabilistic projections (Met Office, 2020)
- Identifying project receptors which would potentially be vulnerable to changes in climate. Such receptors include elements of the construction process (e.g. workforce, plant, machinery), Scheme assets (e.g. pavements, structures, earthworks and drainage, technology) and end-users (e.g. members of public, commercial operators)
- Identifying potential hazards/opportunities and potential climate related impacts on Scheme receptors associated with the potential changes in climate identified
- Taking embedded and essential mitigation into account, undertaking a qualitative assessment of the residual risk of each impact occurring

1.2.1 As per paragraph 3.40 of DMRB LA 114, for the construction phase, a qualitative description of disruption risk has been reported.

1.3 Assessment criteria

1.3.1 For the operational phase, a qualitative assessment of the residual likelihood and consequence of each impact has been undertaken with reference to the indicative framework set out in Table 3.39a (likelihood categories) and Table 3.39b (measure of consequence) of DMRB LA 114 (replicated in Table 1.1 and Table 1.2 below).

1.3.2 The residual likelihood and consequence of each of the potential climate related impacts identified has been combined in order to assess significance as per Table 3.41 (significance matrix) of DMRB LA 114 (replicated in Table 1.3 below).

1.3.3 Potential opportunities for enhancement relevant to each impact are also identified (where applicable).

Table 1.1 Likelihood categories

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

Table 1.2 Measure of consequence

Likelihood category	Description (probability and frequency of occurrence)
Very large adverse	Operation - national level (or greater) disruption to strategic route(s) lasting more than 1 week.
Large adverse	Operation - 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	Operation - regional level disruption to strategic route(s) lasting more than 1 day but less than 1 week.
Minor adverse	Operation - regional level disruption to strategic route(s) lasting less than 1 day.
Negligible	Operation - disruption to an isolated section of a strategic route lasting less than 1 day.

Table 1.3 Significance matrix

		Measure of likelihood				
		Very low	**Low**	**Medium**	**High**	**Very high**
Measure of consequence	**Very large**	NS	S	S	S	S
	Large	NS	NS	S	S	S
	Moderate	NS	NS	S	S	S
	Minor	NS	NS	NS	NS	NS
	Negligible	NS	NS	NS	NS	NS

NS = Not significant, S = Significant

2. Vulnerability assessment

2.1.1 In this section, receptors associated with the Scheme which are potentially vulnerable to climate hazards from potential changes in climate are identified, along with corresponding mitigation measures, and residual risks assessed.

2.1.2 Specifically, the receptors considered are:

Construction:

- Machinery and plant
- Construction workforce
- Temporary facilities (e.g. compound areas, temporary haul roads)
- Scheme operator
- Principal Contractor
- Adjacent watercourses or land

Operation and maintenance:

- Drainage infrastructure (e.g. culverts, Sustainable Drainage Systems (SuDS))
- Pavements
- Structures (including signal gantries and lighting pylons)
- Earthworks (e.g. embankments, cuttings)
- Electrical equipment (e.g. cabling, cameras, weather stations, light emitting diode (LED) luminaires)
- Soft estate (e.g. watercourses, landscaped road edges, SuDS vegetation)
- End users (e.g. members of the public, traffic officers)
- Machinery and plant (i.e. maintenance works)
- Scheme operator
- Maintenance contractor
- Maintenance workforce

2.1.3 The current and future projected climate baseline for the study area is detailed in Section 14.7 of Chapter 14: Climate of the Environmental Statement (TR010064/APP/6.1).

2.1.4 Table 2.1 sets out the assessment of potential climate change related hazards/opportunities and potential climate change related impacts on receptors with the potential to be affected during the construction phase. Corresponding measures to mitigate such impacts are also set out in Table 2.1, along with a qualitative description of the risk of disruption (following mitigation). These measures are included in the Register of Environmental Actions and Commitments (REAC), contained within the First Iteration Environmental Management Plan (EMP) (TR010064/APP/6.5)).

2.1.5 Table 2.2 sets out the assessment of potential climate change related hazards/opportunities and potential climate change related impacts on receptors with the potential to be affected during the operational phase. Relevant measures embedded within the design of the Scheme and the corresponding residual likelihood, consequence and significance of each impact are also set out in Table 2.2.

Table 2.1 Potential climate impacts during construction

Parameter	Climate metrics trend	Potential climate change hazard / opportunity	Potential climate change related impact	Impacted asset / receptor	Summary of essential mitigation included in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)	Residual disruption risk (following mitigation)
Precipitation	Increase in projected winter mean accumulated precipitation. Increase in projected extreme precipitation events intensity (i.e. >99.9th percentile). Increase in projected number of heavy rain events (>25 mm). Related climate events: Floods; landslides; subsidence	Flooding of construction site, compounds, haul routes and/or excavations	Damage to equipment, materials stored on-site and/or compound facilities. Machinery and/or plant damaged or trapped. Site roads impassable. Contamination of waterbodies through runoff. Adverse impacts on health, safety and welfare of construction workforce. Delays to construction programme and increased costs. Damage to permanent works and wastage of materials.	Direct impacts on: Machinery and plant Materials Temporary facilities (construction site compounds) Earthworks Haul routes / access points Indirect impacts on: Watercourses and adjacent land Construction workforce Contractor Scheme operator End users (if construction programme delayed)	• Commitment C4 – Suitable management of site drainage, as will be specified within the Surface and Ground Water Management Plan in the Second Iteration EMP (to be developed from the Outline Surface and Ground Water Management Plan, which is Appendix H of the First Iteration EMP (TR010064/APP/6.5)). • Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the Construction Industry Research and Information Association (CIRIA) Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented. • Commitment C5 – The Second Iteration EMP will incorporate the use of weather forecasting and plans for extreme weather events (e.g. very high intensity rainfall events or heat waves).	Negligible
		Flooding of local road network and/or site access/roads	Disruption to supply of materials and goods required to support construction activities and associated delays to construction programme.	Direct impacts on: Contractor Indirect impacts on: Scheme operator End users (if construction programme delayed)	• Commitment C3 – Appropriate logistics, supply and construction site management. • Commitment C5 – The Second Iteration EMP will incorporate the use of weather forecasting and plans for extreme weather events (e.g. very high intensity rainfall events or heat waves).	Negligible
		Higher pore water pressure in embankments and / or earthworks, leading to instability and risk of failure during construction phase.	Damage to plant, equipment and/or compound facilities. Adverse impacts on health, safety and welfare of construction workforce. Delays to construction programme and increased costs.	Direct impacts on: Structures Earthworks Indirect impacts on: Machinery and plant Construction workforce Scheme operator End users (if construction programme delayed)	• Commitment C4 – Suitable management of site drainage, as will be specified within the Surface and Ground Water Management Plan in the Second Iteration EMP (to be developed from the Outline Surface and Ground Water Management Plan, which is Appendix H of the First Iteration EMP (TR010064/APP/6.5)).	Negligible

Parameter	Climate metrics trend	Potential climate change hazard / opportunity	Potential climate change related impact	Impacted asset / receptor	Summary of essential mitigation included in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)	Residual disruption risk (following mitigation)
					• Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented. • Commitment C3 – Use of ground monitoring instrumentation to monitor pore water pressure and ensure safe construction rate of earthworks embankments.	
		Reduced visibility for drivers and plant operators during periods of heavy rain	Increased health, safety and welfare risks to construction workers	Direct impacts on: Construction workforce Indirect impacts on: Machinery and plant	• Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented.	Negligible
Temperature	Increase in projected summer mean maximum temperature Increase in projected annual mean temperature Increase in projected maximum daily temperature Increase in the projected number of heat waves / hot spells Related climate events: Heat waves, drought	Inappropriate conditions to lay pavements (i.e. periods of very hot weather)	Accelerated hardening of bitumen	Direct impacts on: Pavements Indirect impacts on: Scheme operator Contractor	• Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented. • Incorporation of weather forecasting and plans for extreme weather events within the Second Iteration EMP (commitment C5 in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)).	Negligible
		Inappropriate conditions for concrete pours	Changes in properties – not compliant to specification Reduction in setting time, in turn reducing time to place concrete Increased risk of thermal cracking	Direct impacts on: Concrete structures Indirect impacts on: Contractor	• Commitment C3 – Appropriate logistics and supply management.	Negligible

Parameter	Climate metrics trend	Potential climate change hazard / opportunity	Potential climate change related impact	Impacted asset / receptor	Summary of essential mitigation included in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)	Residual disruption risk (following mitigation)
			Delay to construction programme and increased costs		• Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented. • Commitment C5 – The Second Iteration EMP will incorporate the use of weather forecasting and plans for extreme weather events (e.g. very high intensity rainfall events or heat waves).	
		Increased desiccation of soils	Slope stability reduction and earthworks failure during or immediately after summer storm events falling on desiccated soils	<u>Direct impacts on:</u> Earthworks (short-term and long-term) <u>Indirect impacts on:</u> Machinery and plant Construction workforce Contractor Pavements End users	• Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented. • Commitment C3 – Assessment of soil types from the ground investigation report to assess the risk of desiccation cracking. Earthworks and landscaping design will account for this risk.	Negligible
		Increased airborne dust contaminants	Increased health, safety and welfare risks to construction workers related to inhalation of dust	<u>Direct impacts on:</u> Construction workforce General public/road user	• Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented.	Negligible

Parameter	Climate metrics trend	Potential climate change hazard / opportunity	Potential climate change related impact	Impacted asset / receptor	Summary of essential mitigation included in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)	Residual disruption risk (following mitigation)
		Very high summer temperatures and increased number of hot spells	Increased risk of heat stress or sunstroke for outdoor construction workers. Increased UV exposure for outdoor construction workers Risk of mechanical failure of equipment due to overheating. Increased risk of fire from flammable materials.	<u>Direct impacts on:</u> Machinery and plant Construction workforce Contractor	• Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented.	Negligible
	Increase in the projected winter mean minimum temperature Decrease in the projected number of air frost days Related climate events: Frost	Frost (freeze-thaw action)	Reduced risks from extreme cold weather (e.g. freeze-thaw occurring to construction of pavements and structures causing cracks and cavities, need for gritting/salting and frost formation warnings during construction works in the winter period) Reduced health, safety and welfare risks to construction workers associated with icy conditions or very cold temperatures. Conditions for some construction activities/ processes/equipment more likely to be favourable, benefiting construction programme.	<u>Direct impacts on:</u> Pavements Structures Construction workforce Machinery and plant Haul routes and access points Compound areas <u>Indirect impacts on:</u> Scheme operator Contractor	• Commitment C3 – Good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental Good Practice on Site Guide (CIRIA, 2015) document, guidance on health and safety in construction (Health and Safety Executive, 2006) and other relevant guidance), including determining appropriate locations for site offices and facilities and storage areas for materials, will be implemented. Potential impacts from extreme cold weather are not considered further as the temperature metrics are projected to increase in the future leading to higher winter temperatures and less frost.	No additional risk from climate change

Table 2.2 Potential operational impacts on asset receptors (including their operation, maintenance and refurbishment) and on end users

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
Road surfaces and pavements						
Increased precipitation during winter months and more frequent and intense rainfall events. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 14%. This increase is likely to occur as result of a combination of more wet days, as well as an increase in the intensity of rainfall events.	Rivers flooding the road surface and / or drainage capacity being exceeded resulting in the flooding of the road surface. This could result in direct impacts to end users through delay / disruption to the network and safety risks to road users, together with damage to / deterioration of road pavements. Such impacts could also result in indirect impacts for the scheme operator in terms of increased management / maintenance requirements / costs.	• The highway drainage system will comply with the current Design Manual for Roads and Bridges (DMRB) CG 501 'Design of highway drainage systems' (Highways England, 2022). The design will include the assessment of and mitigation against the potential impacts of climate change as required by this standard to reduce safety risks to road users. A 30% uplift of peak rainfall intensities will be used in the design of drainage systems and a sensitivity test for a 40% uplift in rainfall intensities undertaken, in line with the uplift factors included in the national Environment Agency Climate Change guidance (Environment Agency, 2022). • The pavement is designed to DMRB CD 226 'Design for new pavement construction' (Highways England, 2021b), the foundation designed to DMRB CD 225 'Design for new pavement foundations' (Highways England, 2020a) and materials will be laid to Manual of Contract Documents for Highways Works (MCHW) standards (National Highways, 2023). • A road widening design approach that utilises a restricted or performance design approach to assure the performance of the foundation whilst considering the additional requirements to provide sub-surface drainage continuity between the existing pavement and the widening. • For road widening schemes, the depth at which the design subgrade surface modulus is determined may be dependent on any requirements to maintain drainage continuity between the existing carriageway and the scheduled widening.	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Both localised flooding of the network and additional maintenance/repair works could result in road closures and associated traffic delays. These impacts are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
	Rise in ground water level could result in flooding (particularly in winter). This could result in damage to / accelerated degradation of road pavements. Such impacts could also result in indirect impacts for the scheme operator in terms of increased maintenance requirements / costs.	• Site-specific ground water monitoring has been carried out to determine the seasonal ground water level fluctuation. The hydrogeological model will determine the maximum ground water level to be used in the designs and worse case conditions will be used for the design of drainage. The most appropriate drainage type will be selected and designed to meet the requirements of DMRB CG 501 'Design of highway drainage systems' (Highways England, 2022) to allow for ground water interception.	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Both localised flooding of the network and additional maintenance/repair works could result in road closures and associated traffic delays. These impacts/activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
	Flooding of roads, hard shoulders, verges, and access routes etc. This could result in direct impacts to the contractor through challenges for the maintenance regime (e.g., delays, failures). This could also lead to indirect impacts to the scheme operator through increased maintenance requirements / costs.	• Edge of pavement collection system would be as detailed in design guidance DMRB CD 524 'Edge of pavement details' (Highways England, 2021c) to mitigate the risk of standing water / flooding of the carriageway areas. • A 30% uplift in peak rainfall intensities will be used in the design of drainage systems and a sensitivity test undertaken for a 40% uplift in rainfall intensities, in line with the uplift factors included in the national Environment Agency Climate Change guidance (Environment Agency, 2022).	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Both localised flooding of the network and additional maintenance/repair works could result in road closures and associated traffic delays. These impacts/activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
	Increased number of heavy rain days resulting in a higher stripping rate of pavements leading to texture depth reduction. This could lead to indirect impacts to road users through increased safety risks and increased maintenance requirements / costs to the scheme operator.	• The Principal Contractor will, in the choice of permitted materials for sub-bases and bases, and in accordance with DMRB CD 226 (Highways England, 2021b), have regard to the nature of those materials and of the sub-grade or any capping and the need to protect them from deterioration due to the ingress of water, the adverse effects of weather and the use of construction plant for pavement construction activities (commitment C6 in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5).	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Additional maintenance/repair works could result in road closures and associated traffic delays. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
		• The Principal Contractor will programme the laying and compaction of the sub-base and the subsequent pavement courses for the carriageway works and take such other steps as may be considered necessary, to afford protection to the base, sub-base, and subgrade to changes in climatic conditions, such as increases in heavy rainfall periods (commitment C7 in the REAC, contained within the First Iteration EMP (TR010064/APP/6.5)).				
	Increased rainfall during winter months resulting in potholing, rutting, and cracking from moisture entering and remaining in pavements (particularly in combination with frost formation). This could lead to indirect impacts to road users through damage to vehicles and increased maintenance requirements / costs to the scheme operator. There is the potential, however, that the effect on pothole formation may be wholly or partially offset by summers being drier and winters being warmer (i.e., less freeze thaw erosion and less frost heaving, which are both significant contributors to pothole formation).	• The pavement is designed to DMRB CD 226 'Design for new pavement construction' (Highways England, 2021b) and foundation designed to CD 225 'Design for new pavement foundations' (Highways England, 2020a) and materials would be laid to MCHW standards (Highways England, 2023). • The design of a sub-surface drainage system in accordance with DMRB CG 501 'Design of highway drainage systems' (Highways England, 2022) will drain the sub-base pavement layers from any water ingress.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse** – Additional maintenance/repair works could result in road closures and associated traffic delays. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
Increase in maximum summer temperatures and number / duration of hot days, hot spells, and heatwaves. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +4.8°C warmer and that hot spells and heatwaves will potentially increase from four and three events per year during 1981-2010, to up to 25 and 18 events per year, respectively, during 2061-2080.	Could result in permanent deformation of asphalt (part of the paving mixture, i.e., flexible surfacing), particularly during prolonged hot weather conditions, together with surface rutting leading to water ponding in ruts and reduced skid resistance due to fatting (accumulation of bituminous mix on the surface of the pavement). Indirect impacts to the pavement surface through soil shrinkage and / or subsidence and increased desiccation of soils. This could lead to potential indirect impacts on road users through increased safety risks and increased maintenance requirements / costs to the scheme operator.	• Best practice construction techniques and appropriate material quality standards will be followed to ensure the design lives specified can be met. • The surface will be laid as per DMRB CD 236 'Surface course materials for construction' (Highways England, 2021d) to ensure adequate Polished Stone Value (PSV) is adopted to reduce risk of skidding caused by increased rainfall, especially for high-risk areas. • Furthermore, the Scheme design will ensure the bound material is constructed on a sound foundation that should perform at its optimum over the design life.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse** – Additional maintenance/repair works could result in road closures and associated traffic delays. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	Special material such as polymer modified bitumen will be considered for areas subject to rutting.
	Could lead to an acceleration of bitumen binder hardening resulting in direct impacts to the pavements through cracking and fretting with age and traffic loads. This could lead to increased maintenance requirements / costs to the scheme operator.	• The pavement is designed to DMRB CD 226 'Design for new pavement construction' (Highways England, 2021b) and foundation designed to CD 225 'Design for new pavement foundations' (Highways England, 2020a) and materials would be laid to MCHW standards (Highways England, 2023).	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse** – Additional maintenance/repair works could result in road closures and associated traffic delays. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	The pavement design will consider the use of special material selection, such as EME2 binder course (high strength, long life asphalt base and binder course), to mitigate against cracking and fretting of the carriageway.
	Increased temperatures may lead to longer growing seasons which could lead to deformation of pavements due to overgrown tree roots. This could lead to increased maintenance requirements / costs to the scheme operator.	• DMRB LD 117 'Landscape design' (Highways England, 2020b) requires large trees to be planted 9m from the edge of carriageway, medium trees 7m from the edge of carriageway and shrubs 4.5m from edge of carriageway.	**Very Low** – Such impacts could possibly occur once during the lifetime of the Scheme (e.g. once in 60 years).	**Negligible** – Additional maintenance/repair works could result in lane closures and associated traffic disruption. These activities are considered to have the potential to result in disruption to an isolated section of the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
	The growing season is a response to day length not just temperature, and trees in a stressed state from either drought or waterlogging are likely to experience restricted growth.					
Structures (including embankments, earthworks, bridges)						
Increased precipitation during winter months and more frequent and intense rainfall events. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 14%. This increase is likely to occur as result of a combination of more wet days, as well as an increase in the intensity of rainfall events.	Rise in groundwater level affecting earth pressures for retaining walls causing direct damage to retaining walls and subsequent ground movement. This could lead to indirect impacts to the scheme operator through increased maintenance requirements / costs.	• Retaining structures to be designed for the worst-case groundwater conditions considering climate change. Positive drainage measures will be installed behind all walls with accessible maintenance rodding points. Weepholes will also be provided as an additional drainage measure.	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Emergency repairs and more regular maintenance interventions may be required. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
	Erosion at toe of embankments which could potentially lead to direct impacts on earthworks due to embankment failure. This could lead to indirect impacts to the scheme operator in terms of increased maintenance requirements / costs.	• Slopes to be designed for the worst-case groundwater conditions considering climate change. • Drainage measures to be installed to prevent water build-up at toes of slopes. Erosion protection measures to be installed where risk of erosion of the slope surface has potential to lead to shallow slip failures.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse** – Emergency repairs and more regular maintenance interventions may be required. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
	Higher pore water pressure in embankments and / or earthworks, leading to instability and risk of failure. This could lead to indirect impacts on road users through delay / disruption to the network, together with increased maintenance requirements / costs to the scheme operator.	• Earthwork embankments to be designed for the worst-case groundwater conditions considering climate change. Raking drains to be installed if ground water is required to be lowered to increase slope stability. • Provide adequate drainage at pavement level to prevent surface water build-up and infiltration into the embankment fill.	**Very low -** Such impacts could possibly occur once during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Emergency repairs and more regular maintenance interventions may be required. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
	Increased groundwater level changes resulting in variations in groundwater levels causing softening of embankment fill through capillary action and accelerated weathering effects, weakening embankments. This could lead to indirect impacts on road users through delay / disruption to the network, together with increased maintenance requirements / costs to the scheme operator.	• Earthwork embankments to be designed for the worst-case groundwater conditions considering climate change. • A drainage blanket will be installed on a portion of the route around the Northern Loop to aid drainage of formation.	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Emergency repairs and more regular maintenance interventions may be required. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	• Consideration of use of granular materials that are less susceptible to weathering. • If capillary action is considered an issue, additional drainage or sub-surface drainage would be considered where groundwater levels are close to the base of embankments.
	Accumulation of excess water on over bridges. This could lead to indirect impacts on road users through delay / disruption to the network, together with increased maintenance requirements / costs to the scheme operator.	• Adequate long and crossfalls will be provided on all new bridge decks and positive drainage will be installed in the form of combined bridge deck drainage units to prevent build-up of water over the deck. • Subsurface deck drainage systems will be installed on top of deck waterproofing systems at low points adjacent to deck joints to collect and dispose of seeping water through the surfacing material.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse** – Excess water on overbridges could result in traffic delays. Emergency repairs and more regular maintenance interventions may be required for the bridge deck drainage systems, in response to silt build-up. These impacts/activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
Lower rainfall during summer and more frequent drought events and dry spells. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean summer precipitation will potentially decrease by 31%. This decrease is likely to be accompanied by more frequent dry spells and drought events.	Soil shrinkage and / or subsidence could lead to adverse impacts on foundations, including for bridges and other structures, which may result in increased maintenance requirements or failure for the scheme operator.	Risk will be managed by best practice design. For example, embankment stability will be analysed using site specific soil parameters and embankments will be compacted and constructed in line with best practice, including alignment with DMRB standards. Other design measures include: • Completing stability assessments as part of design. • Undertaking an appropriate ground investigation.	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** - Emergency repairs and more regular maintenance interventions may be required. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
		• Design of the temporary and permanent works to minimise movement; and, • Appropriate analysis to predict magnitude of movements.				
	Increased desiccation of soils resulting in direct impacts through slope stability reduction and earthworks failure during or immediately after summer storm events falling on desiccated soils. This may result in increased maintenance requirements for the scheme operator.	• Water filled tension cracks that have an impact to the retaining wall or slope stability would be considered for the design. The side slopes will be designed to be shallower in gradient or appropriately engineered fill material properties will be used to mitigate global stability concerns. • Note: consideration will be given to the landscaping/vegetation and choice of topsoil materials included in these areas.	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** - Emergency repairs and more regular maintenance interventions may be required. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
Increase in maximum summer temperatures and number / duration of hot days, hot spells, and heatwaves. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +4.8°C warmer and that hot spells and heatwaves will potentially increase from four and three events per year during 1981-2010, to up to 25 and 18 events per year, respectively, during 2061-2080.	Heating and thermal expansion beyond the design capability of structures which could result in the damage or failure of structures. This may result in increased maintenance requirements for the scheme operator.	• The structures will be designed in accordance with the current version of Eurocode standard EN 1991-1-5 and its associated National Annex. The bridges are designed as fully integral structures where possible, meaning there are no bridge bearings or mechanical movement joints. Temperature effects in the structure will be considered through the soil and structure interaction in accordance with Eurocode 7: Geotechnical Design (British Standards Institution, 2004) and DMRB standards. Structures will be routinely monitored by the operator throughout the life of the Scheme. • Where bearings and deck movement joints are required, they will be routinely inspected and maintained at periodic General and Principal Inspections.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse** - Emergency repairs and more regular maintenance interventions may be required, in response to changes in deterioration rates. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
	Increased annual and summer mean temperature may lead to longer growing season which could result in stability impacts on structures. This may result in increased maintenance requirements for the scheme operator. The growing season, however, is a response to day length not just temperature, and trees in a stressed state from either drought or waterlogging are likely to experience restricted growth.	• Good practice methods such as appropriate planting mix near structures with consideration of impact of roots close to structural foundations, and suitable planting offset distances from structures both to safeguard structure integrity and for future inspection / maintenance purposes. • DMRB LD 117 'Landscape design' (Highways England, 2020b) requires large trees to be planted 9m from the edge of carriageway, medium trees 7m from the edge of carriageway and shrubs 4.5m from edge of carriageway.	**Very Low -** Such impacts could possibly occur once during the lifetime of the Scheme (e.g. once in 60 years).	**Negligible** – Additional maintenance/repair works could result in lane closures and associated traffic disruption. These activities are considered to have the potential to result in disruption to an isolated section of the M60/M62/M66, lasting less than one day.	Not significant	None identified
Maximum wind gusts and wind speeds. The intensity of the 90th percentile of maximum wind gusts is projected to remain the same at 19.7m/s (upper limits used) both during 1981–2010 and 2061–2080, indicating that higher wind speeds will potentially occur at the same frequency in the future. UKCP18 projections (for the RCP 8.5 high emissions scenario) also suggest that by the 2080s, the annual number of days with wind gust events exceeding 45mph will potentially remain the same at up to 32 days	Maximum wind gusts and wind speeds resulting in impacts to gantry structures etc.	• Loading due to wind actions will be in accordance with British Standard (BS) EN 1991-1-4:2005 as modified by the National Annex, using partial safety factors which takes account of climate change and the location and local topography of individual gantry sites.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse** - Emergency repairs and more regular maintenance interventions may be required, in response to impacts from increased wind speeds / gusts impacts on gantry structures etc. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
Drainage infrastructure						
Increased precipitation during winter months and more frequent and intense rainfall events. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 14%. This increase is likely to occur as result of a combination of more wet days, as well as an increase in the intensity of rainfall events.	Increased debris and sediment runoff resulting in direct impacts to the drainage system through a reduction in capacity of Sustainable Drainage Systems (SuDS) over time due to sediment build-up. This could also lead to indirect impacts to the soft estate.	• The additional storage capacity provided as sediment forebays at ponds will allow sediment to settle out from surface water runoff. Gullies and catchpits forming part of the surface water drainage systems will further add to the silt-trapping capacity of the ponds. • The drainage design measures will require periodic inspection for sediment build up within ponds (at pond inlets and outlets) including sediments removal, as and when required, to maintain the operational functionality (for the attenuation storage capacity and treatment) over its design life.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse -** Both flooding and additional maintenance/repair could cause road closures and associated traffic delays. These impacts/activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
	Increased debris washing into drainage infrastructure (e.g., gullies and culverts) could lead to direct impacts through blockages of the drainage system. This could also lead to indirect impacts of delay / disruption to road users (end user) and increased maintenance requirements / costs (scheme operator).	• The drainage system will be designed to achieve a minimum flow velocity complying with self-cleansing design criterion to mitigate the continuous deposition of sediments at the channel bottom. • The drainage design will consider operational maintenance aspects by including accessible sediment traps (catchpits) that will be regularly cleared. Catch pits will have sumps where silt can be trapped and more easily removed than manholes. • Gullies and catch pits forming part of the surface water drainage systems will further add to the silt-trapping capacity of the attenuation ponds. • The drainage design measures will require periodic inspection for sediment build up within ponds (at pond inlets and outlets) including sediments removal, as and when required, to maintain the operational functionality (for attenuation storage capacity and treatment) over its design life.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse -** Both flooding and additional maintenance/repair could cause road closures and associated traffic delays. These impacts/activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
Lower rainfall during summer and more frequent drought events and dry spells. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean summer precipitation will potentially decrease by 31%. This decrease is likely to be accompanied by more frequent dry spells and drought events.	Reduced inflow into SuDS resulting in direct impacts to drainage and the soft estate through failure of planting / seeding reducing SuDS functional capacity.	• Embankments will be compacted and grassed, and topsoil retention systems may be used, if deemed necessary. • Ponds will be designed to include a pool of water at the base of the pond (to create a wetland) that would retain the operational functionality of the ponds (treatment).	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse -** Additional maintenance/repair could cause road closures and associated traffic delays. These impacts/activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not Significant	None identified
Increase in maximum summer temperatures and number / duration of hot days, hot spells, and heatwaves. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +4.8°C warmer and that hot spells and heatwaves will potentially increase from four and three events per year during 1981-2010, to up to 25 and 18 events per year, respectively, during 2061-2080.	Increased annual and summer mean temperature may lead to longer growing season which could lead to direct impacts on drainage and the soft estate where additional maintenance needs for soft estate and SuDS could potentially be required due to overgrown vegetation.	• The drainage design measures will require periodic inspection for overgrown grass and vegetation including maintenance cutting / removal, where necessary, to maintain the ponds operational functionality (for attenuation storage capacity and treatment) over its design life.	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Negligible** - More regular maintenance of the soft estate may be required. These activities are considered to have the potential to result in disruption to an isolated section of the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
Road technology and street furniture (including signs, signals, and lighting)						
Increased precipitation during winter months and more frequent and intense rainfall events. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 14%. This increase is likely to occur as result of a combination of more wet days, as well as an increase in the intensity of rainfall events.	Water ingress to cables and electrical equipment (e.g., signage), which could result in direct impacts through damaging the electrical infrastructure equipment. This could also lead to indirect impacts on the end users through increased risk and / or delay / disruption, together with increased maintenance requirements / costs for the scheme operator. During wet conditions and on wet roads the greater light output required (increased driver current) will increase energy consumption.	• Key electrical components will be regularly checked by their operators, and replacement cycles may be shortened if deterioration rates increase. • Cabinet and equipment housings are designed to mitigate and minimise water ingress, with vegetation cleared and maintenance of the assets undertaken to ensure this is upheld. • The scheme design will include the specification of suitable Ingress Protection ratings for both feeder pillars and luminaires to protect from water ingress. • Cables will be specified correctly including a Medium Density Polyethylene (MDPE) sheath where there is a risk of being located in water.	**Low** - The likelihood of water ingress into electrical equipment or cabinets is deemed to be low due to the tested and British Standard certified equipment used which is tested and installed in a safe manner fit for its safe operation. Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Extreme weather could result in assets and associated connected devices becoming non-operational. This could lead to gaps in driver information and loss of ability to view and manage the road network through CCTV or to monitor traffic flows using Motorway Incident and Detection and Automatic Signaling (MIDAS), thus preventing the protection of road users at the back of queuing traffic. Roadside technology could become unsafe which could be harmful to those coming into contact with the equipment including maintainers or road users. These impacts are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
	Lightning strikes to electrical equipment (e.g., signage), which could result in direct impacts through damaging the electrical infrastructure equipment. This could also lead to indirect impacts on the end users through increased risk and / or delay / disruption, together with increased maintenance requirements / costs for the scheme operator.	• Electrical equipment will be protected against main electrical supply surge and lightning current by Surge Protection Devices. • Calculations will be carried out at the detailed design stage for electrical equipment as part of the risk assessment detailed in section 443 of BS 7671:2018 (standards for electrical installations) to determine if protection against transient overvoltage (lighting strike) is required. In advance of this, based on professional judgement and consideration of the location of the lighting power supplies/feeder pillars, it is expected at this stage that transient overvoltage protection will be included in the final design.	**Low** – The likelihood of a lightning strike is low due to the low level and flat nature of the Scheme. This issue becomes more prominent on elevated sections or on routes with viaducts or similarly raised structures. Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Minor adverse** – Extreme weather could result in assets and associated connected devices becoming non-operational. This could lead to gaps in driver information, closed circuit television (CCTV) or Motorway Incident Detection and Automatic Signalling (MIDAS) or potentially lead to unsafe roadside technology which could be harmful to those coming into contact with the equipment including maintainers or road users. These impacts are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
Increase in maximum summer temperatures and number / duration of hot days, hot spells, and heatwaves. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +4.8°C warmer and that hot spells and heatwaves will potentially increase from four and three events per year during 1981-2010, to up to 25 and 18 events per year, respectively, during 2061-2080.	Increased maximum (summer) temperatures may impact on performance of electrical equipment including reduced efficiency and lifespan of LED luminaires etc.	• For excessive temperatures, such as heat waves / hot spells, this is more difficult to control and will include a design specification of suitable equipment to meet the requirements. This specification shall be provided by the manufacturer regarding the design measures taken to mitigate this as much as possible (e.g. thermal cut offs, thermally protected electronics). • For feeder pillar locations the design will ensure there is sufficient free space to dissipate heat and passive cooling as required. • Luminaires selected for the Scheme design are tested to withstand heat in extreme weather climates such as the United Arab Emirates. • Use of LED units with breather glands to remove heat to maintain a ‘constant ambient’, keeping the heat-sink free of debris which is essential in keeping the LED within the required temperature range.	**Low** – Such impacts are considered to have the potential to occur during the lifetime of the Scheme (e.g. once in 60 years).	**Negligible** – This could result in increased maintenance frequency and replacements/cost. These activities are considered to have the potential to result in disruption to an isolated section of the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
Maximum wind gusts and wind speeds. The intensity of the 90th percentile of maximum wind gusts is projected to remain the same at 19.7m/s (upper limits used) both during 1981–2010 and 2061–2080, indicating that higher wind speeds will potentially occur at the same frequency in the future. UKCP18 projections (for the RCP 8.5 high emissions scenario) also suggest that by the 2080s, the annual number of days with wind gust events exceeding 45mph will potentially remain the same at up to 32 days.	Maximum wind gusts and wind speeds resulting in impacts to signage, lighting etc.	• Technology equipment enclosures and mounting arrangements are designed to standards that will withstand wind gusts. All electrical equipment is required to confirm with BS EN60068 and BS EN12966.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse** - Emergency repairs and more regular maintenance interventions may be required, in response to impacts from increased wind speeds / gusts impacts on signage, lighting etc. These activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified
Landscaping						
Hotter and drier summers UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +4.8°C warmer and mean summer precipitation will potentially decrease by 31%.	Hotter and drier summers will increase soil moisture deficits in the future which could negatively impact the landscape design measures and planting for the Scheme. The landscaping has aesthetic benefits but also prevents excessive soil erosion and protects structures from surface water runoff scour.	The landscape design (see the Environmental Masterplan (Figure 2.3 of the Environmental Statement Figures (TR010064/APP/6.2))) will futureproof the Scheme in terms of climate change as well as in terms of pests/diseases by adhering to best practice. This will include diversifying planting species as much as possible, including using drought tolerant species, whilst still having regard to the local character, and generally planting only native species.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Negligible** – Additional maintenance, including replacement of failed species may be required e.g. in areas where it is critical to provide screening. Depending on where these are located, lane closures maybe required to facilitate the replacement of these failed species. These activities are considered to have the potential to result in disruption to an isolated section of the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
Increased precipitation during winter months and more frequent and intense rainfall events. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 14%. This increase is likely to occur as result of a combination of more wet days, as well as an increase in the intensity of rainfall events.	Extreme rainfall and localised flooding events in the future have the potential to impact on the landscaping design measures and planting for the Scheme	The landscape design (see the Environmental Masterplan (Figure 2.3 of the Environmental Statement Figures (TR010064/APP/6.2))) will futureproof the Scheme with regards to flooding by including species tolerant of flooding, such as willow and alder, on floodplains and next to watercourses.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Negligible** – Additional maintenance including replacement planting on floodplains and next to watercourses is unlikely to require lane closures. These activities are considered to have the potential to result in disruption to an isolated section of the M60/M62/M66, lasting less than one day.	Not significant	None identified
Road users						
Increase in maximum summer temperatures and number / duration of hot days, hot spells, and heatwaves. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +4.8°C warmer and that hot spells and heatwaves will potentially increase from four and three events per year during 1981-2010, to up to 25 and 18 events per year, respectively, during 2061-2080.	Increased in summer temperatures in the future leading to hotter and drier summer months (with increased hot spells / days and heatwaves) in the future could result in scheme wide impacts on road users, particularly in relation to traffic congestion, traffic incidents and vehicle breakdowns.	The Scheme MIDAS would monitor the motorway/road for incident and congestion. A prime aim of MIDAS is to protect the back of traffic queues, which have formed or are about to form, by automatically setting suitable signs and signals to warn approaching traffic. MIDAS uses road detectors which are installed in road pavements or on masts in the verge to gather the data on traffic flows, speeds, and vehicle categories. If it detects an incident (slow moving or stationary vehicles), it alerts the Regional Operations Centre (ROC), and automatically set signs and signals on the road to give advance warning of queues and incidents enabling drivers to seek	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse –** Increases in summer temperatures in the future including hotter and drier summer months (with increased hot spells / days and heatwaves) could cause scheme wide impacts and delays, particularly in relation to road closures, traffic congestion, traffic incidents and vehicle breakdowns. These impacts/activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Climate trend	Potential climate event / impact(s)	Embedded mitigation	Likelihood with embedded mitigation (from Table 1.1)	Consequence (from Table 1.2)	Significance (from Table 1.3)	Potential opportunity for enhancement
Increased precipitation during winter months and more frequent and intense rainfall events. UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 14%. This increase is likely to occur as result of a combination of more wet days, as well as an increase in the intensity of rainfall events.	Increased precipitation during winter months (including increased intensity in rainfall events) in the future could result in scheme wide impacts on road users, particularly in relation to traffic congestion, traffic incidents and vehicle breakdowns.	alternate routes if they so choose. It also helps reduce secondary incidents/accidents. ROC then further verify the incident with the help of CCTV and determine the response plan, if required. MIDAS also helps keep the traffic flowing on the motorways by using its congestion monitoring functionality which results in less road user time spent and fuel consumed on the journey.	**Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the Scheme (60 years) e.g. approximately once every 15 years.	**Minor adverse –** Increases in precipitation during winter months (including increased intensity in rainfall events) in the future could cause scheme wide impacts and delays, particularly in relation to road closures, traffic congestion, traffic incidents and vehicle breakdowns. These impacts/activities are considered to have the potential to result in regional level disruption to strategic route(s), including the M60/M62/M66, lasting less than one day.	Not significant	None identified

Acronyms and initialisms

Acronym or initialism	Term
BS	British Standard
CCTV	Closed circuit television
CIRIA	Construction Industry Research and Information Association
DMRB	Design Manual for Roads and Bridges
EMP	Environmental Management Plan
HSE	Health and Safety Executive
LED	Light emitting diode
MDPE	Medium density polyethylene
MHCW	Manual of Contract Documents for Highways Works
MIDAS	Motorway Incident Detection and Automatic Signalling
PSV	Polished Stone Value
REAC	Register of Environmental Actions and Commitments
RCP	Receptor Concentration Pathway
ROC	Regional Operations Centre
SuDS	Sustainable drainage systems
UKCP	UK Climate Projections

Glossary

Term	Definition
Climate	Long-term weather conditions prevailing over a region.
Climate scenario	UKCP18 uses emissions scenarios, called Representative Concentration Pathways (RCPs). RCPs specify the concentrations of greenhouse gases that would result in target amounts of radiative forcing at the top of the atmosphere by 2100, relative to pre-industrial levels. Four forcing levels have been set: 2.6, 4.5, 6.0 and 8.5 W/m^2. These create four RCPs that are used in UKCP18: RCP2.6, RCP4.5, RCP6.0 and RCP8.5.
Pore water pressure	The pressure exerted on its surroundings by water held in pore spaces in rock or soil, an increase in which can result in a decrease in the shear strength of a slope material, reducing slope stability.

Term	Definition
RCP8.5	RCP8.5 refers to the concentration of carbon that delivers global warming at an average of 8.5 watts per square meter across the planet. The RCP8.5 pathway delivers a temperature increase of about 4.3°C by 2100, relative to pre-industrial temperatures.
UKCP18	The UK Climate Projections 2018 (UKCP18) are a set of UK climate projection tools designed to help decision-makers assess their risk exposure to climate change. The UKCP18 project uses cutting-edge climate science to provide climate change projections out to 2100. UKCP18 provides probabilistic projections over land and a set of high-resolution, spatially coherent future climate projections for the UK at 25km and 12km scale. The 12km climate model has been further downscaled to 2.2km scale – a level previously only used for short-term weather forecasts, allowing realistic simulation of high impact events such as localised heavy rainfall in summer.
Vulnerability	The degree to which a system/asset is exposed and resilient to adverse effects of climate change.

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