# A12 Chelmsford to A120 widening scheme TR010060

# 6.3 ENVIRONMENTAL STATEMENT

# APPENDIX 15.2 VULNERABILITY ASSESSMENT

APFP Regulation 5(2)(a)

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# A12 Chelmsford to A120 widening scheme

Development Consent Order 202[ ]

## ENVIRONMENTAL STATEMENT
## APPENDIX 15.2 VULNERABILITY ASSESSMENT

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|---|---|
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# 1 Methodology and assessment criteria

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

1.1.2 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), proposed 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 project receptors associated with the potential changes in climate identified
- Taking embedded and standard mitigation into account, undertaking a qualitative assessment of the residual risk of each impact occurring

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

1.1.4 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).

1.1.5 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).

1.1.6 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 project (60 years) e.g. approximately annually, typically 60 events. |
| High | The event occurs several times during the lifetime of the project (60 years) e.g. approximately once every five years, typically 12 events. |
| Medium | The event occurs limited times during the lifetime of the project (60 years) e.g. approximately once every 15 years, typically 4 events. |
| Low | The event occurs during the lifetime of the project (60 years) e.g. once in 60 years. |
| Very low | The event can occur once during the lifetime of the project (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 |

Table notes: NS = Not significant, S = Significant

# 2 Vulnerability assessment

2.1.1 In this section, receptors associated with the proposed 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
- Contractor
- Watercourses or adjacent 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 Chapter 15: Climate, Section 15.8 of the Environmental Statement [TR010060/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 proposed to mitigate such impacts are also set out in Table 2.1, along with a qualitative description of the risk of disruption (following mitigation).

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 proposed 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 | Standard mitigation | Residual disruption risk (following mitigation) |
|---|---|---|---|---|---|---|
| Precipitation | Increase in projected winter mean accumulated precipitation.<br>Increase in projected extreme precipitation events intensity (i.e. >99.9th percentile).<br>Increase in projected number of heavy rain events (>25 mm).<br>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.<br>Machinery and/or plant damaged or trapped.<br>Site roads impassable.<br>Contamination of waterbodies through runoff.<br>Adverse impacts on health, safety and welfare of construction workforce.<br>Delays and/or increased costs. | Direct impacts on:<br>Machinery and plant<br>Materials<br>Temporary facilities (construction site compounds)<br>Earthworks<br>Haul routes/access points<br>Indirect impacts on:<br>Watercourses and adjacent land<br>Construction workforce<br>Contractor<br>Scheme operator | Risk to be mitigated through:<br>• Suitable management of site drainage, as would be specified within the second iteration of the Environmental Management Plan (EMP)<br>• Implementation of good construction practice (e.g. in accordance with relevant guidance such as the CIRIA Environmental good practice on site guide (CIRIA, 2015) document and other relevant guidance)<br>• Incorporation of weather forecasting and plans for extreme weather events within the second iteration of the EMP | 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. | Direct impacts on:<br>Contractor<br>Indirect impacts on:<br>Scheme operator | Risk to be mitigated through:<br>• Appropriate logistics, supply and construction site management<br>• Incorporation of weather forecasting and plans for extreme weather events within the second iteration of the EMP | 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.<br>Adverse impacts on health, safety and welfare of construction workforce.<br>Delays and increased costs. | Direct impacts on:<br>Structures<br>Earthworks<br>Indirect impacts on:<br>Machinery and plant<br>Construction workforce<br>End users<br>Scheme operator | Risk to be mitigated through:<br>• Suitable management of site drainage, as would be specified within the second iteration of the EMP<br>• Implementation of good construction practice during the works, such as the CIRIA Environmental good practice on site guide (CIRIA, 2015) document and other relevant best practice guidance | Negligible |
| Temperature | Increase in projected summer mean maximum temperature.<br>Increase in projected annual mean temperature. | Inappropriate conditions to lay pavements (i.e. periods of very hot weather). | Accelerated hardening of bitumen. | Direct impacts on:<br>Pavements<br>Indirect impacts on:<br>Scheme operator<br>Contractor | Risk to be mitigated through:<br>• Implementation of good construction practice during the works, such as the CIRIA Environmental good practice on site guide (CIRIA, 2015) document and other relevant best practice guidance<br>• Incorporation of weather forecasting and plans for extreme weather events within the second iteration of the EMP | Negligible |

| Parameter | Climate metrics trend | Potential climate change hazard/opportunity | Potential climate change related impact | Impacted asset/receptor | Standard mitigation | Residual disruption risk (following mitigation) |
|---|---|---|---|---|---|---|
| | Increase in projected maximum daily temperature.<br>Increase in the projected number of heat waves/hot spells.<br>Related climate events: Heat waves, drought. | Increased desiccation of soils. | Slope stability reduction and earthworks failure during or immediately after summer storm events falling on desiccated soils. | Direct impacts on:<br>Earthworks<br>Indirect impacts on:<br>Machinery and plant<br>Construction workforce<br>Pavements<br>End users | Risk to be mitigated through:<br>• Implementation of good construction practice, such as the CIRIA Environmental good practice on site guide (CIRIA, 2015) document and other relevant best practice guidance | Negligible |
| | Increase in the projected winter mean minimum temperature.<br>Decrease in the projected number of air frost days.<br>Related climate events: Frost. | Frost (freeze-thaw action). | Potential risks from extreme cold weather (e.g. freeze-thaw occurring to construction of pavements and structures causing cracks and cavities and need for gritting/salting along haul routes and site access roads). | Direct impacts on:<br>Pavements<br>Structures<br>Haul routes and access points<br>Compound areas<br>Indirect impacts on:<br>Scheme operator<br>Contractor | • Good construction practice, such as the CIRIA Environmental good practice on site guide (CIRIA, 2015) document and other relevant best practice guidance will be implemented during the construction phase<br>• 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 with embedded mitigation (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.<br><br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 21%. 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.<br><br>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.<br><br>Such impacts could also result in indirect impacts for the scheme operator in terms of increased management/maintenance requirements/costs. | • The proposed highway drainage system is designed to Design Manual for Roads and Bridges (DMRB) CG 501 'Design of highway drainage systems' (Highways England, 2020a). 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. The current requirement for a 20% uplift of peak rainfall intensities in the design of drainage systems and a sensitivity test for a 40% uplift in rainfall intensities is in line with the uplift factors included in the national Environment Agency Climate Change guidance (Environment Agency, 2021).<br>• 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, 2020b) and materials will be laid to Manual of Contract Documents for Highways Works (MCHW) standards (Highways England, 2021c). | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (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 A12, lasting less than one day. | Not significant | None identified |
| | Rise in ground water level could result in flooding (particularly in winter).<br><br>This could result in damage to/accelerated degradation of road pavements.<br><br>Such impacts could also result in indirect impacts for the scheme operator in terms of increased maintenance requirements/costs. | • Site specific ground water monitoring over a 12-month period 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, 2020a) to allow for ground water interception. | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (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 A12, 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 with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
|---|---|---|---|---|---|---|
| | Flooding of roads, hard shoulders, verges and access routes.<br>This could result in direct impacts to the contractor through challenges for the maintenance regime (e.g. delays, failures).<br>This could also lead to indirect impacts to the scheme operator through increased maintenance requirements/costs. | • Edge of pavement drains would be as detailed in pavement drainage design guidance DMRB CD 524 'Edge of pavement details' (Highways England, 2021d) to mitigate the risk of standing water/flooding of the carriageway areas.<br>• The design of edge pavement drainage will incorporate the current climate change allowance requirements in accordance with DMRB CG 501 'Design of highway drainage systems' (Highways England, 2020a). The current requirement for a 20% uplift of peak rainfall intensities in the design of drainage systems and a sensitivity test for a 40% uplift in rainfall intensities is in line with the uplift factors included in the national Environment Agency Climate Change guidance (Environment Agency, 2021). | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (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 A12, 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.<br>This could lead to indirect impacts to road users through increased safety risks and increased maintenance requirements/costs to the scheme operator. | • The Contractor would, 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.<br>• The Contractor would programme, where practicable, the laying and compaction of the sub-base and the subsequent pavement courses for the carriageway works and other steps considered, if necessary, to afford protection to the base, sub-base and subgrade to changes in climatic conditions, such as increases in heavy rainfall periods. | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (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 A12, 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 with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
|---|---|---|---|---|---|---|
| | Increased rainfall during winter months resulting in potholing, rutting and cracking from moisture entering and remaining in pavements (particularly in combination with frost formation).<br>This could lead to indirect impacts to road users through damage to vehicles and increased maintenance requirements/costs to the scheme operator.<br>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, 2020b) and materials laid to MCHW standards (Highways England, 2021c).<br>• The design of a sub-surface drainage system in accordance with DMRB CG 501 'Design of highway drainage systems' (Highways England, 2020a) 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 project (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 A12, lasting less than one day. | Not significant | None identified |
| Increase in maximum summer temperatures and number/duration of hot days, hot spells and heatwaves.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +5.3°C warmer and that hot spells and heatwaves will potentially increase from seven and five events per year during 1981-2000, to up to 57 and 47 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).<br>Indirect impacts to the pavement surface through soil shrinkage and/or subsidence and increased desiccation of soils.<br>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.<br>• The surface will be laid as per DMRB CD 236 'Surface course materials for construction' (Highways England, 2021e) to ensure adequate Polished Stone Value (PSV) is adopted to reduce risk of skidding caused by increased rainfall, especially for high-risk areas.<br>• 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 project (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 A12, lasting less than one day. | Not significant | Special material such as polymer modified bitumen would be considered for areas subject to rutting. |

| Climate trend | Potential climate event/impact(s) | Embedded mitigation | Likelihood with embedded mitigation (from Table 1.1) | Consequence with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
|---|---|---|---|---|---|---|
| | 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.<br>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 materials laid to MCHW standards (Highways England, 2021c). | **Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the project (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 A12, 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.<br>This could lead to increased maintenance requirements/costs to the scheme operator.<br>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. | • DMRB LD 117 'Landscape design' (Highways England, 2020c) 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 project (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 A12 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 with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
|---|---|---|---|---|---|---|
| **Structures (including embankments, earthworks, bridges)** | | | | | | |
| Increased precipitation during winter months and more frequent and intense rainfall events.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 21%. 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. | Bridge scouring which could lead to direct impacts to structures within the scheme extents through bridge foundation failure.<br>This could also lead to increased maintenance requirements/costs for the scheme operator. | • New and extended existing crossings over watercourses will have suitable scour protection measures applied in accordance with DMRB CD 356 'Design of highway structures for hydraulic action' (Highways England, 2020d) on their approaches and through the structures, in the form of flexible stone mattresses or similar to mitigate against scour and undermining of the foundations. Flexible methods are preferred as they accommodate bed movement and are thus more environmentally beneficial than rigid methods. Revetments in these areas will also be suitably protected by concrete slabs or in situ concrete. | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (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 A12, lasting less than one day. | Not significant | None identified |
| | Rivers flooding road infrastructure (e.g. bridges, underpasses).<br>This could lead to direct impacts to the end user through delay/disruption to the network and safety risks to the road users, together with damage to/accelerated degradation of scheme structures and assets.<br>This could also result in indirect impacts to the scheme operator in terms of increased management/maintenance requirements/costs. | • New structure designs undertaken to account for 1 in 100 year flood events and an allowance for climate change. Deck soffit levels are designed so that this level plus a minimum allowance of 600mm freeboard is achieved in accordance with CD 356 'Design of highway structures for hydraulic action' (Highways England, 2020d) such that in extreme flood events, debris build up/impact forces and uplift forces do not detrimentally affect the structure and its elements (bearings where provided).<br>• The proposed drainage systems for underpasses are to be designed to DMRB CG 501 'Design of highway drainage systems' (Highways England, 2020a). The design will include the assessment of and mitigation against the potential impacts of climate change as required by the document to ensure the safety of users. The current requirement for a 20% uplift of peak rainfall intensities in the design of drainage systems and a sensitivity test for a 40% uplift in rainfall intensities is in line with the uplift factors included in the national Environment Agency Climate Change guidance (Environment Agency, 2021). | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (e.g. once in 60 years). | **Minor adverse** – Both localised flooding of road infrastructure 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 A12, 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 with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
|---|---|---|---|---|---|---|
| | Rise in groundwater level affecting earth pressures for retaining walls causing direct damage to retaining walls and subsequent ground movement.<br>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 project (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 A12, lasting less than one day. | Not significant | None identified |
| | Rise in groundwater level could result in the flooding of underpasses (particularly in winter), which could result in damage to/accelerated degradation of scheme structures and assets.<br>This could lead to increased maintenance requirements/costs for the scheme operator. | • Structure abutments and foundations are designed using the worst-case parameters from drained and undrained ground conditions.<br>• Positive drainage will be installed behind all abutments with accessible maintenance rodding points. Weepholes will also be provided as an additional drainage measure.<br>• Positive drainage will be installed at underpasses with accessible maintenance rodding points. | **Very Low -** Such impacts could possibly occur once during the lifetime of the project (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 A12, 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.<br>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.<br>• Drainage system 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 project (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 A12, lasting less than one day. | Not significant | None identified |
| | Rise in groundwater level affecting earth pressures causing impact to earthwork structures through subsequent ground movement.<br>This could lead to indirect impacts to the scheme operator through increased maintenance requirements/costs. | • Earthworks and retaining structures to be designed for the worst-case groundwater conditions considering climate change. Raking drains to be installed if groundwater is required to be lowered to increase slope stability. | **Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the project (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 A12, 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 with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
|---|---|---|---|---|---|---|
| | Higher pore water pressure in embankments and/or earthworks, leading to instability and risk of failure.<br>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.<br>• 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 project (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 A12, lasting less than one day. | Not significant | None identified |
| | Increased groundwater level changes resulting in variations in groundwater levels causing softening of embankment fill through capillary action and accelerated weathering effects, weakening embankments.<br>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. | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (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 A12, lasting less than one day. | Not significant | • Consideration of drainage blanket layer to be installed to aid drainage of formation.<br>• Consideration of use of granular materials that are less susceptible to weathering.<br>• 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. |

| Climate trend | Potential climate event/impact(s) | Embedded mitigation | Likelihood with embedded mitigation (from Table 1.1) | Consequence with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
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| | Accumulation of excess water on overbridges.<br>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. | • Positive drainage will be installed over all bridge decks in the form of combined kerb drainage units or flush drainage units to prevent build-up of water over the deck.<br>• Sub-surface 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 project (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 A12, lasting less than one day. | Not significant | None identified |
| Lower rainfall during summer and more frequent drought events and dry spells.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean summer precipitation will potentially decrease by 35%. 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, embankments will be designed from slope-stability analysis using site specific soil parameters and compacted and constructed in line with best practice including alignment with DMRB standards.<br>Other design measures include:<br>• Completing stability assessments as part of design<br>• Undertaking an appropriate ground investigation<br>• Design of the temporary and permanent works to minimise movement<br>• Appropriate analysis to predict magnitude of movements | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (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 A12, lasting less than one day. | Not significant | The following may be recommended during later design stages when further information is available:<br>• Inspection of existing infrastructure and assessment of movements which can be tolerated<br>• Monitoring during the construction works to measure movements, with agreed trigger level and action plan |

| Climate trend | Potential climate event/impact(s) | Embedded mitigation | Likelihood with embedded mitigation (from Table 1.1) | Consequence with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
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| | 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.<br>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.<br>• 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 project (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 A12, lasting less than one day. | Not significant | None identified |
| Increase in maximum summer temperatures and number/duration of hot days, hot spells and heatwaves.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +5.3°C warmer and that hot spells and heatwaves will potentially increase from seven and five events per year during 1981-2000, to up to 57 and 47 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.<br>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 and underpasses are designed as fully integral structures where possible, meaning there are no bridge bearings or deck movement joints. Temperature effects in the structure will be taken into account 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 proposed scheme.<br>• 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 project (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 A12, lasting less than one day. | Not significant | None identified |
| | Increased annual and summer mean temperature may lead to longer growing season which could result in stability impacts on structures.<br>This may result in increased maintenance requirements for the scheme operator.<br>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.<br>• DMRB LD 117 ‘Landscape design’ (Highways England, 2020c) 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 project (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 A12 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 with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
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| **Drainage infrastructure** | | | | | | |
| Increased precipitation during winter months and more frequent and intense rainfall events.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 21%. 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. | Culvert scouring could lead to failure of the culvert infrastructure and/or increased maintenance requirements/costs. | • New and extended existing culverts have been designed in accordance with the CIRIA (C786) Culvert, screen and outfall manual (CIRIA, 2019), which supplements the outfall and culvert design standards set out in DMRB.<br>• New and extended existing culvert crossings over watercourses will have suitable scour protection measures on their approaches, in the form of flexible stone mattresses or similar to mitigate against scour. Flexible methods are preferred as they accommodate bed movement and are thus more environmentally beneficial than rigid methods. | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (e.g. once in 60 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 A12, lasting less than one day. | Not significant | None identified |
| | Increased debris and sediment runoff resulting in direct impacts to the drainage system through a reduction in capacity of SuDS over time due to sediment build-up.<br>This could also lead to indirect impacts to the soft estate. | • The additional storage capacity provided as sediment forebays at attenuation 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 attenuation ponds.<br>• The drainage design measures will require periodic inspection for sediment build up within attenuation ponds (at pond inlets and outlets) including sediment 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 project (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 A12, 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.<br>This could also lead to indirect impacts of delay/disruption to road users (end user) and increased maintenance requirements/costs (scheme operator). | • The drainage design will consider operational maintenance aspects by including accessible sediment traps (catchpits) that will be regularly cleared. Catchpits will have sumps where silt can be trapped and more easily removed than manholes.<br>• Gullies and catchpits forming part of the surface water drainage systems will further add to the silt-trapping capacity of the attenuation ponds.<br>• The drainage design measures will require periodic inspection for sediment build up within attenuation ponds (at pond inlets and outlets) including sediment 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 project (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 A12, 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 with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
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| Lower rainfall during summer and more frequent drought events and dry spells.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean summer precipitation will potentially decrease by 35%. 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. | • Any steep embankments will be compacted and planted, and topsoil retention systems may be used, if deemed necessary.<br>• Attenuation 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 attenuation ponds (treatment). | **Low** – Such impacts are considered to have the potential to occur during the lifetime of the project (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 A12, lasting less than one day. | Not Significant | None identified |
| Increase in maximum summer temperatures and number/duration of hot days, hot spells and heatwaves.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +5.3°C warmer and that hot spells and heatwaves will potentially increase from seven and five events per year during 1981-2000, to up to 57 and 47 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 project (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 A12 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 with embedded mitigation (from Table 1.2) | Significance (from Table 1.3) | Potential opportunity for enhancement |
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| **Road technology and street furniture (including signs, signals and lighting)** | | | | | | |
| Increased precipitation during winter months and more frequent and intense rainfall events.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 21%. 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.<br>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.<br>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.<br>• 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.<br>• The scheme design will include the specification of suitable Ingress Protection ratings for both feeder pillars and luminaires to protect from water ingress.<br>• 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 project (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, CCTV or Stationary Vehicle Detection (SVD) blind spots 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 A12, lasting less than one day. | Not significant | None identified |
| | Lightning strikes to electrical equipment (e.g. signage), which could result in direct impacts through damaging the electrical infrastructure equipment.<br>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.<br>• Calculations will be carried out at the detailed design stage for electrical equipment on the new A12 route as part of the risk assessment detailed in section 443 of BS7671:2018 (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 proposed 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 project (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, CCTV or SVD blind spots 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 A12, 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 with embedded mitigation (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.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +5.3°C warmer and that hot spells and heatwaves will potentially increase from seven and five events per year during 1981-2000, to up to 57 and 47 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. | • 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).<br>• For feeder pillar locations the design will ensure there is sufficient free space to dissipate heat and passive cooling as required.<br>• Luminaires selected for the proposed scheme design are tested to withstand heat in extreme weather climates such as the United Arab Emirates.<br>• 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 project (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 A12 lasting less than one day. | Not significant | None identified |
| **Landscaping** | | | | | | |
| Hotter and drier summers.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, summer mean daily maximum temperatures could be +5.3°C warmer and mean summer precipitation will potentially decrease by 35%. | Hotter and drier summers will increase soil moisture deficits in the future which could negatively impact the landscape design measures and planting for the proposed scheme. The landscaping has aesthetic benefits but also prevents excessive soil erosion and protects structures from surface water runoff scour. | The proposed landscape design will futureproof the proposed 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. It will also adhere to best ecological practice.<br>Species mixes are selected following consideration of:<br>• Published landscape character assessments<br>• Essex County Council: Essex Tree Palette<br>• Scheme ecology surveys<br>• Scheme arboricultural assessment<br>• Forest Research Publication: Tree species suitability in a future climate in South-East England | **Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the project (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 A12 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 with embedded mitigation (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.<br>UKCP18 projections (for the RCP 8.5 high emissions scenario) suggest that by the 2080s, mean winter precipitation will potentially increase by 21%. 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 proposed scheme. | • The proposed landscape design will futureproof the proposed scheme with regards to flooding by including species tolerant of flooding, such as willow and alder, on floodplains and next to watercourses. These species are characteristic on the existing floodplains which are noted for their distinctive cricket bat willow plantations. | **Medium** – Such impacts are considered to have the potential to occur limited times during the lifetime of the project (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 A12 lasting less than one day. | Not significant | None identified |

# References

British Standards Institution (2004). Designers' Guide to EN 1997-1:2004+A1:2013 Eurocode 7: Geotechnical Design – Part 1: General Rules. April 2004.

CIRIA. (2015). Environmental good practice on site, 4th Edition (C741).

CIRIA. (2019). Culvert, screen and outfall manual, (C786).

Environment Agency (2021). Flood risk assessments: climate change allowances. Online. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. Accessed May 2022.

Highways England (2020a). Design Manual for Roads and Bridges, CG 501 Design of highway drainage systems.

Highways England (2020b). Design Manual for Roads and Bridges, CD 225 Design for new pavement foundations.

Highways England (2020c). Design Manual for Roads and Bridges, LD 117 Landscape design.

Highways England (2020d). Design Manual for Roads and Bridges, CD 356 Design of highway structures for hydraulic action.

Highways England (2021a). Design Manual for Roads and Bridges, LA 114 Climate.

Highways England (2021b). Design Manual for Roads and Bridges, CD 226 Design for new pavement construction.

Highways England (2021c). Manual of Contract Documents for Highways Works (MCHW).

Highways England (2021d). Design Manual for Roads and Bridges, CD 524 Edge of pavement details.

Highways England (2021e). Design Manual for Roads and Bridges. CD 236 Surface Course Materials for Construction.

Met Office (2020). UK Climate Projections. Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp. Accessed May 2022.