



High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

Climate

Results of climate change assessments (CL-002-000)



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Environmental Statement

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Results of climate change assessments (CL-002-000)



Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

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1 Introduction

1.1.1 The climate change appendices comprise of three documents:

- Appendix CL-001-000 – Climate data and information;
- Appendix CL-002-000 – Results of climate change assessments; and
- Appendix CL-003-000 – Summary greenhouse gas calculation outputs.

1.1.2 This Appendix provides details of the results of in-combination climate change impact assessment and the climate change resilience assessment and should be read alongside the High Speed Rail (West Midlands - Crewe) Environmental Statement (ES): Volume 3, Route-wide effects.

2 In-combination climate change impacts assessment results

- 2.1.1 The results of the in-combination climate change impacts assessment are summarised for each topic in Table 1.
- 2.1.2 A summary of the assessment methodology can be found in Volume 3, Section 4.
- 2.1.3 The assessment included the identification of resources and receptors that may be impacted by the Proposed Scheme and any effects the Proposed Scheme may have on these resources and/or receptors. Table 1 sets out all the resources and receptors for each topic and the associated effects (columns 1 and 2). The table also describes the existing mitigation measures which are currently embedded into the scheme (column 3).
- 2.1.4 The assessment then identified the potential climate change impacts on the resources and receptors for each environmental topic (column 4). To categorise the likelihood and consequence (column 5) of the in-combination climate change impacts, the potential climate change impacts (column 4) were assessed with the existing and embedded mitigation measures (column 3). In-combination climate change impacts considered 'likely' and 'high' consequence were considered significant in-combination effects. Additional mitigation measures to address significant in-combination effects were then identified (column 6), and summaries of any allowances for future mitigation measures or monitoring were included where relevant (column 7).
- 2.1.5 Finally, the topics were categorised (column 8) into one of the following four categories based on the number and consequence of potential in-combination impacts:
1. many potential in-combination climate change impacts with high consequences;
 2. some or few potential in-combination climate change impacts with high consequences;
 3. few potential in-combination climate change impacts with low consequences; and
 4. no potential in-combination climate change impacts.
- 2.1.6 For more detailed information about the existing mitigation measures and monitoring strategies for each topic summarised in the Table 1, please see the respective sections and reports in the ES: Volume 2, Community area reports; Volume 3, Route-wide effects and Volume 5, Appendices.

Table 1: Results of the in-combination climate change impacts assessment

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
<i>Each resource / receptor is identified in a new row.</i>	<i>The effects of the Proposed scheme on each receptor / resource is numbered in brackets to allow for identification in later columns in the table.</i>	<i>Each mitigation measure shows the number (in brackets) of the effect in the previous column that it addresses. Each mitigation measure is given a new letter to allow for identification in later columns in the table.</i>	<i>Each climate change impact relates to the number of the resource / receptor that it could impact.</i>	<i>The likelihood and significance of each in-combination impact, given the existing mitigation measures, is considered. The relevant mitigation measures considered are referenced.</i>	<i>Additional mitigation measures are identified, and reference made to the existing mitigation measure that should / could be improved.</i>	<i>Future measures and monitoring are identified.</i>	<i>Topics are categorised into one of four categories based on the number and consequence of potential in-combination impacts.</i>

Agriculture, forestry and soils

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Soils	<p>Temporary and permanent effects from construction –</p> <p>(1) Disruption to soil, including removal and reinstatement.</p>	<p>Construction –</p> <p>(1a) Compliance with Section 6 of draft CoCP¹.</p> <p>(1b) Soil resources from areas required temporarily and permanently will be stripped and stored.</p> <p>(1c) Good practice techniques used to handle, store and reinstate soils (including careful management of heavier textured soils during the five year aftercare period to ensure no reduction in long term capacity or</p>	<p>(1) Drier / drought conditions affect the quality and capability of soils, potential risk to harvest and increased risk of soil erosion.</p>	<p>(1a, b, c, d) Likely / High consequence. Drier / drought conditions may reduce the quality of the soils and make it more difficult to reinstate soils to their previous condition.</p>	<p>(1) Where practicable, any surpluses of permanently displaced soils will be used to reinstate soils with profiles thicker than the originals. Dry soils are generally shallow and do not retain water in the profile for the crop so these could be made deeper and more moisture retentive. Higher total organic matter content (in the thicker topsoil) would make these soils more resilient. There is also the possibility of mixing soil textures to make coarse-textured soils less droughty and fine-textured soils less prone to wetness.</p>	<p>Soil moisture and texture to be monitored by HS2 Ltd during the five year after care period.</p>	<p>1 - Many potential in-combination climate change impacts with high consequences.</p>

¹ Draft Code of Construction Practice, see Volume 5: Appendix CT-003-000

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		<p>quality).</p> <p>(1d) Creation of suitable well-drained landforms, installation of field drains and borrow pits.</p> <p>(1e) Design of low lying woodland areas to absorb/retain any potential flood waters.</p> <p>(1f) Compliance with the extreme weather events clause (5.14) in the CoCP².</p>	<p>(1) Increase in frequency and intensity of heavy rainfall events / flooding - increased loss of soil.</p>	<p>(1a, b, c, d) Unlikely / Low consequence. For areas already affected by flooding it is unlikely that increased flooding will increase soil loss because good practice techniques are in place for handling the soil during construction. In addition, mitigation measures are already in place; including the creation of suitable well-drained landforms, installation of field drains and borrow pits to minimise any potential flood risk.</p> <p>(1e) Likely / Low consequence. The potential for soil loss in areas subject to new flood risk is likely, however, the soils have been designed to retain more water and, therefore, soil erosion from potential flood risk is considered to be low.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	
			<p>(1) Increase in frequency and intensity of heavy</p>	<p>(1a, b, c, d) Likely / High consequence. The potential for reduced soil quality is likely in</p>	<p>(1) Where practicable, suitable material displaced during</p>	<p>No specific monitoring requirements during</p>	

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			<p>rainfall events / flooding – increase in area of lower quality and marginal land.</p>	<p>areas of medium to poor quality land that are subject to new flood risk. Wetter soils may be less biologically active therefore reducing soil quality and functionality.</p>	<p>construction works will be used to increase storage capacity and improve drainage of wet soils along the route.</p> <p>Where practicable, opportunities to provide wider environmental benefits from displaced soils and excavated materials in the context of climate change will be sought.</p>	<p>construction of the Proposed Scheme.</p>	
			<p>(1) Increase in frequency and intensity of heavy rainfall events / flooding - leading to increased erosion.</p>	<p>(1a, b, c, d) Likely / Low consequence. Increased risk of erosion is likely due to more intense rainfall, but is of low consequence on land which will remain in HS2 Ltd ownership following the five year after care period, because new species will be planted from a range of climate zones to increase the species resilience against flood events, therefore, reducing the potential to increase soil erosion.</p>	<p>No additional mitigation measures required because assets will be designed with embedded climate change allowances.</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	

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				<p>(1a, b, c, d) Likely / Low consequence. Increased risk of soil erosion is likely due to more intense rainfall, but is considered low consequence on land handed back to farmers, following the five year aftercare period.</p> <p>This is due to the fact soil surveys have been carried out to inform soil resources plans within construction zones and farm holdings along the line of route. These plans will set out suitable target soil profiles and allocate the necessary temporarily displaced topsoils and subsoils for the successful establishment of the different restored land uses. In addition, good practice techniques will be adopted in handling, storing and reinstating soils to protect and retain soil structures for drainage and the establishment of ground cover on restored land.</p>	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
			(1) Increased wind	(1a,b,c,d) Unlikely / Low	No additional measures	No specific	

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			speed - leading to increased loss of soil.	consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. If wind speeds were to increase then there would not be a significant impact with regard to soil erosion because of the mitigation measures in place.	required as there are sufficient mitigation measures in place.	monitoring requirements during construction of the Proposed Scheme.	
Forests	Construction – (2) Permanent effects on areas of woodland.	Construction – (2a) Compliance with Section 6 of CoCP ¹ . (2b) Planting suitable species by choosing species and provenances appropriate to future conditions when planning. Provision of new native species will be pre-adapted to warmer conditions	(2) Drier / drought conditions - leads to loss of trees. (2) Hotter and wetter conditions - leads to a longer growing season and changes in tree growth. Certain	(2a,b,c,d,e) Unlikely / Low consequence. It is unlikely that drought conditions will increase the loss of trees during the construction works because any damaged and / or diseased trees, which are more susceptible to incidents of drought, will be replaced with new forest planting. (2a,b,c,d,e) Likely / Low consequence. Hotter and wetter conditions are likely to increase growing seasons. Forests will be in leaf for longer and may reduce adverse views,	No additional mitigation measures are required because ecological resilience has been built into the existing mitigation measures for the design of new woodlands and reinstatement of existing woodlands. No additional mitigation measures are required because ecological resilience has been built into the existing mitigation measures for	No specific monitoring requirements during construction of the Proposed Scheme. No specific monitoring requirements during construction of the Proposed Scheme.	

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		<p>and more resilient to climate change.</p> <p>(2c) Reinstating land for woodland with suitable soils.</p> <p>(2d) Ecological mitigation measures include information on the detailed design for planting of new woodlands and best practice to inform soil translocation for existing woodlands.</p> <p>(2e) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p>	<p>species will flourish or suffer in particular locations, fast growing species will become more dominant.</p> <p>(2) Increased wind speed - leads to risk of tree loss and consequent exposure of soils to surface water erosion.</p> <p>(3) Drier / drought conditions - leads</p>	<p>but could increase number of leaves on the line and change the trees structural capacity, therefore, increasing the stress on trees to external stressors. Suitable species will be selected to minimise these negative impacts and increase species resilience.</p> <p>(2a, b, c, d, e) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. Mitigation measures include planting native species which are pre-adapted to warmer conditions and, therefore, are more resilient to potential changes in wind reducing the potential for tree or habitat losses.</p> <p>(3a) Unlikely / Low consequence. No in-</p>	<p>the design of new woodlands and reinstatement of existing woodlands.</p> <p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>No additional mitigation measures required as</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p> <p>No specific monitoring</p>	
	Operation –	Operation –	(3) Drier / drought conditions - leads	(3a) Unlikely / Low consequence. No in-	No additional mitigation measures required as	No specific monitoring	

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	(3) Permanent effects on areas of woodland.	(3a) No measures are currently anticipated to be required to mitigate operational effects of the Proposed Scheme on agriculture, forestry and soils.	to loss of trees. (3) Hotter and wetter conditions - leads to a longer growing season this will benefit tree growth.	combination climate change impact. (3a) Unlikely / Low consequence. No in-combination climate change impact.	there is no in-combination impact. No additional mitigation measures required as there is no in-combination impact.	requirements during operation of the Proposed Scheme. No specific monitoring requirements during operation of the Proposed Scheme.	
Irrigation and water supply systems	Temporary and permanent effects from construction – (4) Disruption to soil, including removal and reinstatement.	Construction – (4a) Compliance with Section 6 of CoCP ¹ . (4b) Design appropriate water supply systems. (4c) Compliance with the extreme weather events clause (5.14) in the CoCP ¹ .	(4) Drier / drought conditions - leads to a greater need for irrigation, potential risk to harvest, affects effectiveness of water supply systems.	(4a, b) Unlikely / Low consequence. Sufficient mitigation measures in place.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
Drainage systems	Temporary and permanent effects from	Construction – (5a) Compliance with Section 6 of	(5) Drier / drought conditions - leads to dry soils damage to drainage	(5a, b) Unlikely / Low consequence. Sufficient mitigation measures in place.	No additional measures required as there are sufficient mitigation	No specific monitoring requirements during construction of the	

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	<p>construction</p> <p>(5) Loss of, or disruption to drainage systems</p>	<p>CoCP¹.</p> <p>(5b) Design appropriate replacement drainage systems.</p> <p>(5c) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p>	<p>systems.</p> <p>(5) Increase in frequency and intensity of heavy rainfall events / flooding - leads to increased need to drain lower lying areas of land, failure of drainage system could lead to flooding.</p>	<p>(5a, b) Unlikely / Low consequence. It is unlikely that increased frequency or intensity of heavy rainfall events will cause the drainage systems to fail because the Proposed Scheme's critical assets have been designed with an embedded climate change allowance to account for changes in rainfall and, therefore, potential flooding of drainage systems is considered to be low.</p>	<p>measures in place.</p> <p>No additional mitigation measures required because a climate change allowance has already been embedded into the design of drainage systems.</p>	<p>Proposed Scheme.</p> <p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	
<p>Agricultural land</p>	<p>Temporary effect from construction –</p> <p>(6) Land required temporarily from holdings.</p> <p>(7) Noise impact, significant effects for sensitive livestock.</p>	<p>Construction – (6a, 7a, 8a) Compliance with Section 6 of CoCP¹ (including the management of soils on construction sites).</p> <p>(6b, 7b, 8b) Compliance with the extreme</p>	<p>(6) Increased wind speed - increases spread of weeds and invasive species.</p> <p>(6) Variation in temperature and</p>	<p>(6b) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. Ecological mitigation measures will limit the spread of weeds and invasive species.</p> <p>(6b) Likely / Low consequence. There is likely to be changes in</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>No additional mitigation measures required</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p> <p>No specific monitoring</p>	

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	<p>Permanent effect from construction -</p> <p>(8) Quality of reinstated agricultural land may be affected.</p>	<p>weather events clause (5.14) in the CoCP¹.</p>	<p>rainfall patterns - may alter optimum growing conditions.</p>	<p>temperature and rainfall patterns during construction works. However the design of suitable well-drained landforms, installation of field drains and borrow pits will minimise the increased potential of erosion or saturation of soils which and therefore not affect optimum growing conditions.</p>	<p>because assets will be designed with embedded climate change allowances.</p>	<p>requirements during construction of the Proposed Scheme.</p>	
			<p>(8) Increase in frequency of extreme weather events (e.g. drought, flooding, heat waves) - leading to increased susceptibility of agricultural land to these events.</p>	<p>(8a, b) Likely / High consequence. The reinstatement of soil back to agricultural land may make it more vulnerable to extreme events, therefore, disrupting the soil structure.</p>	<p>(8b) Where practicable, any surpluses of permanently displaced soils will be used to reinstate soils with profiles thicker than the originals. In these situations, 'wet' soils could be better drained and so more resilient to intense rainfall; and 'dry' soils are generally shallow and do not retain water in the profile for the crop so these could be made deeper and more moisture retentive. In both cases, higher</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	

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					<p>total organic matter content (in the thicker topsoil) would make them more resilient. There is also the possibility of mixing soil textures to make coarse textured soils less droughty and fine-textured soils less prone to wetness.</p> <p>Where practicable, opportunities to provide wider environmental benefits from displaced soils and excavated materials in the context of climate change will be sought.</p>		
	<p>Operation –</p> <p>(9) Land required permanently from holdings.</p> <p>(10) Noise impact, significant effects for sensitive</p>	<p>Operation –</p> <p>(10a) Further work may be required to assess potential noise effects on livestock units and buildings close to track.</p>	<p>(11) Increased wind speed - increased spread of weeds and invasive species.</p>	<p>(11a) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. Ecological mitigation measures will limit the spread</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>No specific monitoring requirements during operation of the Proposed Scheme.</p>	

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	livestock. (11) Propensity of land to harbour noxious weeds.	(11a) Appropriate management regime for invasive species / weeds / line side vegetation.		of weeds and invasive species.			

Air quality

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Atmosphere, people and communities	Construction – (1) Increase dust and air pollutants from construction works and mineral extraction from borrow pits which will have temporary local effects.	Construction – (1a, 2a) Emissions to the atmosphere will be controlled and managed during construction through route wide implementation of the CoCP ¹ .	(1, 2) Hotter and drier / drought conditions - increase concentrations of certain air pollutants such as ozone and PM _{2.5} /10.	(1a,b 2a,b) Unlikely / Low consequence. It is unlikely that hotter and drier / drought conditions will exacerbate dust generation and concentrations of air pollutants because there are sufficient mitigation measures in the CoCP ¹ to limit the generation of dust and air pollutants.	No additional measures required as there are sufficient mitigation measures in place.	Construction related dust monitoring requirements are covered by the CoCP ¹ .	3 – Few potential in-combination climate change impacts with low consequences.
	(2) Increase in NO ₂ , NO _x and particulate matter from construction vehicles and changes in the volume, composition and location of traffic on the highway network during construction works which will have temporary local effects.	(1b, 2b) Compliance with the extreme weather events clause (5.14) in the CoCP ¹ .	(1) Increase in frequency and intensity of heavy rainfall events/flooding – could decrease concentration of air pollutants such as ozone and PM _{2.5} /10.	(1a,b) Likely / Low positive consequence. It is likely that heavy rainfall events / flooding will become more frequent in future, therefore, suppressing dust movement and reducing the amount of dust in the atmosphere during construction works.	No additional mitigation measures required as this in-combination impact has a positive effect.	Construction related dust monitoring requirements are covered by the CoCP ¹ .	
			(1) Increased wind speed – could influence local pollutant levels.	(1a, b, 2a,b) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show	No additional measures required as there are sufficient mitigation measures in place.	Construction related dust monitoring requirements are covered by the CoCP ¹ .	

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				statistically insignificant variation in wind speed. The CoCP ¹ states that soil stockpiles will be positioned to account for prevailing wind direction and, therefore, aim to minimise the dispersion of potential air pollutants from sensitive receptors.			
	Operation – (3) Impacts from the operation of the Proposed Scheme could arise from vehicle emissions due to changes in the volume, composition and distribution of traffic in the area.	Operation – (3a) There will be no direct atmospheric emissions from the operation of trains that will cause an impact on air quality and, therefore, no assessment is required. Indirect emissions from sources such as rail wear and brakes have been assumed to be negligible.	(3) Hotter and drier / drought conditions could increase concentrations of certain air pollutants such as ozone and PM _{2.5} /10. (3) Increase in frequency and intensity of heavy rainfall events/flooding – could decrease concentration of air pollutants such as ozone	(3a) Unlikely / Low consequence. There is no in-combination impact as there will be no direct atmospheric emissions during operation and the indirect emissions have been considered to be negligible. (3a) Unlikely / Low consequence. There is no in-combination impact as there will be no direct atmospheric emissions during operation and the indirect emissions have been considered to be negligible.	No additional mitigation measures required as there is no in-combination impact. No additional mitigation measures required as there is no in-combination impact.	There are no specific monitoring requirements during operation of the Proposed Scheme. There are no specific monitoring requirements during operation of the Proposed Scheme.	

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			and PM _{2.5} /10.				
			(3) Increased wind speed – could influence local pollutant levels.	(3a) Unlikely / Low consequence. There is no in-combination impact as there will be no direct atmospheric emissions during operation and the indirect emissions have been considered to be negligible.	No additional mitigation measures required as there is no in-combination impact.	There are no specific monitoring requirements during operation of the Proposed Scheme.	

Community

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Residential property	<p>Construction –</p> <p>(1) Land take - residential property (including gardens) lost in part or whole to land required for construction (temporary loss) or operation (permanent loss) of the Proposed scheme.</p> <p>(2) Isolation of residential properties from other properties and infrastructure. This could be physical or psychological isolation; e.g. islanding or isolation of resource.</p> <p>(3) In-combination effects -</p>	<p>Construction –</p> <p>(1a, 2a, 3a) No major effects identified for construction phase that will not be dealt with by the CoCP¹.</p> <p>(3b) Mitigation measures for in-combination effects are proposed by individual topics.</p>	(2) Increase in frequency and intensity of heavy rainfall events / flooding – exacerbate isolation of properties.	(2a) Unlikely / Low consequence. An increase in extreme rainfall events is likely, however, there are sufficient flood risk mitigation measures in place.	No additional mitigation measures required because assets will be designed with embedded climate change allowances.	No specific monitoring requirements during construction of the Proposed Scheme.	3 - Few potential in-combination climate change impacts with low consequence.
			(3) Increased temperatures and occurrence of heat waves leads to a negative effect on thermal comfort which may increase need to open windows increasing effect of noise and poor air quality for example.	(3a, b) Unlikely / Low consequence. A temperature increase is likely, however, in-combination with climate change this effect is not significant. Relevant mitigation measures are proposed by the Sound, noise and vibration topic (Volumes 2 and 3, Section 13).	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
			(3) Drier/drought conditions – could lead to loss of vegetation and defoliation,	(3a, b) Unlikely / Low consequence. Drier/drought conditions are likely which could cause these effects, however, in-combination	No additional measures required as there are sufficient mitigation measures	No specific monitoring requirements during construction of the	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	combination of significant residual effects, such as noise, vibration, poor air quality and visual intrusion.		drought tolerant trees may become more prevalent (therefore also changing landscape character), and wetlands may disappear.	with climate change, these effects are not significant. Relevant mitigation measures are proposed by the Landscape and visual topic (Volume 2, Section 11, Volume 3, Section 10).	in place.	Proposed Scheme.	
			(3) Hotter and wetter conditions - could lead to an increase in pests and diseases and could lead to a longer growing season.	(3a, b) Unlikely / Low consequence. Hotter and wetter conditions are likely, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are also proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
	Operation – (4) Isolation of residential properties from other properties and infrastructure. This could be physical or	Operation – (5a) Mitigation measures for in-combination effects are proposed by individual topics.	(5) Increased temperatures and occurrence of heat waves – negative effect to thermal comfort - may increase need to open windows	(5a) Unlikely / Low consequence. A temperature increase is likely, however, in-combination with climate change, this effect is not significant. Relevant mitigation measures are proposed by the Sound, noise and vibration topic	No additional measures required as there are sufficient mitigation measures in place.	There are no area-specific community monitoring requirements during operation of the Proposed Scheme. Any area-specific operational monitoring	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	<p>psychological isolation; e.g. islanding or isolation of resource.</p> <p>(5) In-combination effects – a combination of significant residual effects, such as noise, vibration, poor air quality and visual intrusion.</p>		<p>increasing effect of noise for example.</p> <p>(5) Drier/drought conditions – could lead to loss of vegetation and defoliation, drought tolerant trees may become more prevalent (therefore also changing landscape character), wetlands may disappear.</p> <p>(5) Hotter and wetter conditions - could lead to an increase in pests and diseases and could lead to a longer growing season.</p>	<p>(Volumes 2 and 3 Section 13).</p> <p>(5a) Unlikely, low consequence. Drier/drought conditions are likely which could cause these effects, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).</p> <p>(5a) Unlikely, low consequence. Hotter and wetter conditions are likely, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are also proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>requirements in relation to air quality effects, noise and vibration effects, traffic effects and visual effects that have contributed to the in-combination assessments are described in the relevant topic Sections.</p>	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Community and recreational facilities	<p>Construction –</p> <p>(6) Land take, community and recreational facilities lost due to land required for construction or operation of the Proposed Scheme in part or whole.</p> <p>(7) Isolation of community infrastructure from other properties and infrastructure.</p> <p>(8) In-combination effects – a combination of significant residual effects, such as noise, vibration, poor air quality and visual intrusion.</p>	<p>Construction –</p> <p>(6a) All facilities lost are to be replaced, preferably within the local area and/or along route but possibly beyond.</p> <p>(7a,8a) No major effects identified for construction phase that will not be dealt with by the CoCP¹.</p> <p>(8b) Mitigation measures for in-combination effects are proposed by individual topics.</p>	<p>(7) Increase in frequency and intensity of heavy rainfall events / flooding - exacerbate isolation of facilities.</p>	<p>(7a) Unlikely / Low consequence. An increase in extreme rainfall events is likely, however, there are sufficient flood risk mitigation measures in place.</p>	<p>No additional mitigation measures required because assets will be designed with embedded climate change allowances.</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	
			<p>(8) Increased temperatures and occurrence of heat waves lead to a negative effect to thermal comfort which may increase need to open windows increasing effect of noise and poor air quality for example.</p>	<p>(8a, b) Unlikely / Low consequence. A temperature increase is likely, however, in-combination with climate change this effect is not significant. Relevant mitigation measures are proposed by the Sound, noise and vibration topic (Volumes 2 and 3 Section 13).</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	
			<p>(8) Drier/drought conditions – could lead to loss of vegetation and defoliation, drought tolerant trees may become</p>	<p>(8a, b) Unlikely / Low consequence. Drier/drought conditions are likely which could cause these effects, however, in-combination with climate change, these effects are not significant.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
			more prevalent (therefore also changing landscape character), and wetlands may disappear.	Relevant mitigation measures are proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).			
			(8) Hotter and wetter conditions - could lead to an increase in pests and diseases and could lead to a longer growing season.	(8a ,b) Unlikely / Low consequence. Hotter and wetter conditions are likely, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are also proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
	Operation – (9) Isolation of community and recreational facilities from other properties and infrastructure. This could be physical or psychological isolation; e.g.	Operation – (10a) Mitigation measures for in-combination effects are proposed by individual topics.	(10) Increased temperatures and occurrence of heat waves – negative effect to thermal comfort - may increase need to open windows increasing effect of noise for	(10a) Unlikely / Low consequence. A temperature increase is likely, however, in-combination with climate change this effect is not significant. Relevant mitigation measures are proposed by the Sound, noise and vibration topic (Volumes 2 and 3, Section	No additional measures required as there are sufficient mitigation measures in place.	There are no area-specific community monitoring requirements during operation of the Proposed Scheme. Any area-specific operational monitoring requirements in relation to air quality	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	<p>islanding or isolation of resource.</p> <p>(10) In-combination effects – a combination of significant residual effects, such as noise, vibration, poor air quality and visual intrusion.</p>		<p>example.</p> <p>(10) Drier/drought conditions – could lead to loss of vegetation and defoliation, drought tolerant trees may become more prevalent (therefore also changing landscape character), wetlands may disappear.</p> <p>(10) Hotter and wetter conditions - could lead to an increase in pests and diseases and could lead to a longer growing season.</p>	<p>13).</p> <p>(10a) Unlikely / Low consequence. Drier/drought conditions are likely which could cause these effects, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).</p> <p>(10a) Unlikely / Low consequence. Hotter and wetter conditions are likely, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are also proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>effects, noise and vibration effects, traffic effects and visual effects that have contributed to the in-combination assessments are described in the relevant topic sections.</p>	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Open space and public rights of way (PROW)	<p>Construction –</p> <p>(11) Land take - open space and PROW lost due to land required for construction (temporary loss) or operation of the Proposed Scheme (permanent loss).</p> <p>(12) In-combination effects – a combination of significant residual effects, such as noise, vibration, poor air quality and visual intrusion.</p>	<p>Construction –</p> <p>(11a, 14a) No major effects identified for construction phase that will not be dealt with by the CoCP¹.</p> <p>(12a) Mitigation measures for in-combination effects are proposed by individual topics.</p>	(11) Hotter and drier / drought conditions exacerbate loss of grassland.	(11a) Likely / Low consequence. A temperature increase and increases in the number of extreme weather events are likely. In combination with HS2 this could increase pressure on remaining areas of grassland. However, vegetation replacement in open spaces is included in existing mitigation measures for the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10) and Ecology and biodiversity (Volume 2 Section 8, Volume 3 Section 7) topics.	No additional measures required as there are sufficient mitigation measures in place.	Monitoring is included in the existing mitigation measures for the Landscape and visual and Ecology and biodiversity topics.	
			(11, 12) Increase in frequency of extreme weather events (e.g. drought, flooding, heat waves) may impact quality and patterns of use of open spaces.	(11a, 12a) Likely / Low consequence. An increase in extreme weather events is likely. In combination with HS2 this could increase pressure on remaining areas of open space. However, vegetation replacement in open spaces is included in existing mitigation measures for the Landscape and visual topic (Volume 2 Section 11,	No additional measures required as there are sufficient mitigation measures in place.	Monitoring is included in the existing mitigation measures for the Landscape and visual and Ecology and biodiversity topics.	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				Volume 3 Section 10) and Ecology and biodiversity (Volume 2 Section 8, Volume 3 Section 7) topics.			
			(12) Drier/drought conditions – could lead to loss of vegetation and defoliation, drought tolerant trees may become more prevalent (therefore also changing landscape character), wetlands may disappear.	(12a, b) Unlikely / Low consequence. Drier/drought conditions are likely which could cause these effects, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
			(12) Hotter and wetter conditions - could lead to an increase in pests and diseases and could lead to a longer growing season.	(12a, b) Unlikely / Low consequence. Hotter and wetter conditions are likely, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are also proposed by the Landscape and visual topic (Volume 2 Section 11,	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				Volume 3 Section 10).			
	Operation- (13) In-combination effects – a combination of significant residual effects, such as noise, vibration, poor air quality, visual intrusion and traffic and transport.	Operation – (13a) Mitigation measures for in-combination effects are proposed by individual topics.	(13) Hotter and drier / drought conditions may exacerbate loss of grassland.	(13a) Likely / Low consequence. A temperature increase is likely. In combination with HS2 this could increase pressure on remaining areas of grassland. However, vegetation replacement in open spaces is included in existing mitigation measures for the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10) and Ecology and biodiversity (Volume 2 Section 8, Volume 3 Section 7) topics.	No additional measures required as there are sufficient mitigation measures in place.	Monitoring is included in the existing mitigation measures for the Landscape and visual and Ecology and biodiversity topics.	
			(13) Increase in frequency of extreme weather events (e.g. drought, flooding, heat waves) may impact quality of open spaces and green spaces.	(13a) Unlikely / Low consequence. An increase in extreme weather events is likely. In combination with HS2 this could increase pressure on remaining areas of open space. However, vegetation replacement in open spaces is included in existing mitigation measures for the Landscape and visual topic (Volume 2 Section 11,	No additional measures required as there are sufficient mitigation measures in place.	There are no area-specific monitoring requirements during operation of the Proposed Scheme for the Community topic. Any area-specific operational monitoring requirements in relation to air quality	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				Volume 3 Section 10) and Ecology and biodiversity (Volume 2 Section 8, Volume 3 Section 7) topics.		effects, noise and vibration effects, traffic effects and visual effects that have contributed to the in-combination assessments are described in the relevant topic sections.	
			(13) Drier/drought conditions – could lead to loss of vegetation and defoliation, drought tolerant trees may become more prevalent (therefore also changing landscape character), wetlands may disappear.	(13a) Unlikely / Low consequence. Drier/drought conditions are likely which could cause these effects, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are proposed by the Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10).	No additional measures required as there are sufficient mitigation measures in place.		
			(13) Hotter and wetter conditions - could lead to an increase in pests and diseases and could lead to a longer growing season	(13a) Unlikely, low consequence. Hotter and wetter conditions are likely, however, in-combination with climate change, these effects are not significant. Relevant mitigation measures are also proposed by the Landscape and visual topic (Volume 2 Section 11,	No additional measures required as there are sufficient mitigation measures in place.		

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				Volume 3 Section 10).			

Cultural heritage

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Built heritage	(1) Temporary and permanent disruption to the setting of built heritage assets.	<p>Construction –</p> <p>(1a) Section 8 of the CoCP¹.</p> <p>(1b) Planting suitable species for future climate conditions.</p> <p>(1c) Identification of suitable locations for advance planting, to reduce impacts on the setting of assets.</p> <p>(1d) Landscape planting would increasingly reduce impacts on the setting.</p> <p>(1e) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p>	(1) Increased wind speed - impact on settings due to trees lost.	(1a,b,c,d,e) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. There are sufficient mitigation measures in place (see column 3).	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	3 - Few potential in-combination climate change impacts with low consequences.
			(1) Hotter and wetter conditions - lead to increase in growing season and increased rate of growth of vegetation.	(1a,b,c,d,e) Likely / Low consequence. An increase in temperatures and frequency and intensity of rainfall is likely, however, this will lead to a positive impact. The potential increased rate of growth is beneficial to reducing impacts on the setting of assets.	No additional mitigation measures required as this in-combination impact has a positive effect.	No specific monitoring requirements during construction of the Proposed Scheme.	
			(1) Drier/drought conditions - exacerbate the risks of ground	(1a) Unlikely / Low consequence. No in-combination effect identified as the Proposed Scheme will not impact on	No additional mitigation measures required as there is no in-combination	No specific monitoring requirements during construction of the	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	Operation – (2) Noise and vibration impacts.	Operation – (2a) Noise mitigation barriers have been included within the Proposed Scheme. (2b) It is understood that vibration impacts will not be significant or cause harm to historic buildings.	settlement. (2) Drier/drought conditions - exacerbate the risks of ground settlement.	the stability of the archaeological sites during construction. (2a,b) Unlikely / Low consequence. No in-combination effect identified as the Proposed Scheme will not impact on the stability of the archaeological sites during operation.	impact. No additional mitigation measures required as there is no in-combination impact.	Proposed Scheme. No specific monitoring requirements during operation of the Proposed Scheme.	
Palaeo-environmental sites and remains, e.g. Madeley palaeolake	Construction – (3) Complete and partial removal of palaeo-environmental remains. (4) Potential temporary adverse effects on landscape settings (local flora and fauna, including	Construction – (3a, 4a) Section 8 of the CoCP ¹ . (3b) Identification of locations where the physical impact on below ground assets can be reduced through the design of earthworks. (3c, 4b) Compliance	(3, 4) Increase in frequency and intensity of heavy rainfall events/flooding – changes to water courses.	(3a, b, 4a,b) Likely / Low consequence. Flash flooding could cause diversions to water courses and, therefore, cause drying out to palaeo-environmental sites. Given that the location and condition of remains is unknown, it is uncertain how likely and significant this impact might be.	No additional mitigation measures required due to uncertainty in location and condition of assets.	No specific monitoring requirements during construction of the Proposed Scheme.	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	protected species).	<p>with the extreme weather events clause (5.14) in the CoCP¹.</p> <p>(4c) Planting suitable species for future climate conditions.</p> <p>(4d) Identification of suitable locations for advance planting, to reduce impacts on the setting of assets.</p>	<p>(3) Increase in frequency and intensity of heavy rainfall events/flooding – stabilising of palaeo-environmental sites.</p> <p>(3) Drier/drought conditions - drying out of waterlogged remains.</p>	<p>(3a, b, c) Likely / Low consequence. It is likely that there will be an increase in the frequency and intensity of heavy rainfall and extreme rainfall events such as flooding. However, this could have a positive impact.</p> <p>(3a,b,c) Likely / Potentially high consequence. Potentially significant in-combination effect with insufficient mitigation. It is currently unknown what palaeo-environmental sites and remains exist and so it is uncertain how significant this impact might be.</p>	<p>No additional mitigation measures required as this in-combination impact has a positive effect.</p> <p>No additional mitigation measures required due to uncertainty in location and condition of assets.</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p> <p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	
	Operation – any effects arising during operation are expected to be adequately mitigated and are no considered further.	n/a	n/a	n/a	n/a	n/a	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Designed landscapes e.g. Essex Bridge Shugborough National Trust property	(5) Impacts on significance due to changes in setting.	Construction – (5a) Section 8 of the CoCP ¹ . (5b) Planting suitable species for future climate conditions. (5c) Identification of suitable locations for advance planting, to reduce impacts on the setting of assets.	(5) Increased wind speed - impact on settings due to trees lost.	(5a, b, c) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. There are sufficient mitigation measures in place (see column 3).	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
			(5) Hotter and wetter conditions - lead to a longer growing season and increased rate of growth of vegetation.	(5a, b, c) Likely / Low consequence. An increase in temperatures and frequency and intensity of rainfall is likely, however, this will lead to a positive impact. The potential increased rate of growth is beneficial to reducing impacts on the setting of assets.	No additional mitigation measures required as this in-combination impact has a positive effect.	No specific monitoring requirements during construction of the Proposed Scheme.	
	(6) Impacts on significance due to changes in setting.	Operation – (6a) Advance planting to reduce the impacts on the setting.	(6) Increased wind speed - impact on settings due to trees lost.	(6a) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during operation of the Proposed Scheme.	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				variation in wind speed. There are sufficient mitigation measures in place (see column 3).			
			(6) Hotter and wetter conditions may lead to a longer growing season and increased rate of growth of vegetation.	(6a) Likely / Low consequence. An increase in temperatures and frequency and intensity of rainfall is likely, however, this will lead to a positive impact. The potential increased rate of growth is beneficial to reducing impacts on the setting of assets.	No additional mitigation measures required as this in-combination impact has a positive effect.	No specific monitoring requirements during operation of the Proposed Scheme.	
Buried archaeology	Construction – (7) Permanent removal of buried archaeological features due to construction of the Proposed Scheme.	n/a	n/a	n/a	n/a	n/a	

Ecology

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Habitats and wildlife species	<p>Construction –</p> <p>(1) Disruption to breeding, feeding and migration patterns of species.</p> <p>(2) Decline of species populations.</p> <p>(3) Permanent loss, removal, degradation of habitats.</p>	<p>Construction –</p> <p>(1a, 2a, 3a) Compliance with Section 9 of CoCP¹.</p> <p>(1b, 2b, 3b) Choose species and provenances appropriate to future conditions when planning.</p> <p>Provision of new native species will be pre-adapted to warmer conditions and more resilient to climate change.</p> <p>(1c, 2c, 3c) Create larger habitat areas; providing more robust and resilient ecosystems.</p> <p>(1d, 2d, 3d) Identification of</p>	<p>(1, 2, 3) Drier/drought conditions - low flows and decrease in water levels. May lead to increased need for species to adapt and migrate.</p>	<p>(1a,b,c,d,e, 2a,b,c,d,e, 3a,b,c,d,e) Likely / High consequence.</p> <p>Drier drought conditions are more likely in future and, therefore, lower water levels will increase the need for species migration and adaptation. Mitigation measures will include habitat creation and restoration to increase species resilience to change in climate.</p>	<p>No additional mitigation measures required. Ecological resilience is embedded within the design and mitigation measures.</p>	<p>Ecological monitoring of habitats and species will be carried out at a route wide level. This will monitor the effectiveness of existing ecological mitigation measures at maintaining and enhancing ecological conditions.</p>	<p>3 - Few potential in-combination climate change impacts with low consequences</p>
		<p>(1, 2, 3) Increased wind speed – increased tree loss, habitat loss and/or fragmentation.</p>	<p>(1a,b,c,d,e, 2a,b,c,d,e, 3a,b,c,d,e) Unlikely / Low consequence.</p> <p>There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed.</p> <p>Mitigation measures include planting native species which are pre-adapted to warmer conditions and, therefore, likely to be more resilient to potential changes in wind, reducing the potential for</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Ecological monitoring of habitats and species will be carried out at a route wide level. This will monitor the effectiveness of existing ecological mitigation measures at maintaining and enhancing ecological conditions.</p>		

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		<p>sites along route and off route for habitat creation enhanced landscape connectivity (i.e. green bridges.</p> <p>(1e, 2e, 3e) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p> <p>(1f, 2f) Enact plans for protection of species.</p>	<p>(1, 2, 3) Increase in frequency and intensity of heavy rainfall events/flooding - habitat loss.</p> <p>(1, 2, 3) Increase in temperature - may exceed thresholds for certain habitats and species.</p>	<p>tree or habitat losses.</p> <p>(1a, b, c, d, e, 2a, b, c, d, e, 3a, b, c, d, e) Likely / Low consequence. It is likely that the intensity and frequency of rainfall events will increase, however, mitigation measures will limit habitat loss by maintaining and enhancing ecological conditions. Mitigation measures will also include the creation and restoration of habitats to increase species resilience to changes in climate.</p> <p>(1a, b, c, d, e, 2a, b, c, d, e, 3a, b, c, d, e) Likely / Low consequence. It is likely that temperature changes will cause some species to exceed thresholds. However, the potential to reduce species extent or loss of species numbers is low because habitat design for the Proposed Scheme will increase species connectivity along the route which will enable habitat and species migration.</p>	<p>No additional mitigation measures required. Ecological resilience is embedded within the design and mitigation measures.</p> <p>No additional mitigation measures required. Ecological resilience is embedded within the design and mitigation measures.</p>	<p>Ecological monitoring of habitats and species will be carried out at a route wide level. This will monitor the effectiveness of existing ecological mitigation measures at maintaining and enhancing ecological conditions.</p> <p>Ecological monitoring of habitats and species will be carried out at a route wide level. This will monitor the effectiveness of existing ecological mitigation measures at maintaining and enhancing ecological conditions.</p>	
	Operation – (4) Incidental	Operation – (4a) Provide green	(4) Drier/drought conditions - leads to low flows and	(4a) Unlikely / Low consequence. Drier/drought conditions are unlikely to cause habitat	No additional mitigation measures required. Ecological	Ecological monitoring of habitats and species will be carried	

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	mortality of species.	bridges and underpasses to enhance landscape connectivity and maintain species.	decreases in water levels, habitat loss and/or fragmentation.	fragmentation or increase habitat loss because the ecological design for the Proposed Scheme will increase species connectivity along the route and encourage species resilience.	resilience is embedded within the design and mitigation measures.	out at a route wide level. This will monitor the effectiveness of existing ecological mitigation measures at maintaining and enhancing ecological conditions.	
			(4) Increased wind speed - increase tree loss, habitat loss and/or fragmentation, and reduction in woodland blocks.	(4a) Unlikely / Low consequence - There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. Mitigation measures include planting native species which are pre-adapted to warmer conditions and, therefore, likely to be more resilient to potential changes in wind, reducing the potential for tree or habitat losses.	No additional measures required as there are sufficient mitigation measures in place.	Ecological monitoring of habitats and species will be carried out at a route wide level. This will monitor the effectiveness of existing ecological mitigation measures at maintaining and enhancing ecological conditions.	
			(4) Increase in temperature - may exceed thresholds for certain habitats and species.	(4a) Likely / Low consequence. It is likely that temperature changes will cause some species to exceed thresholds. The potential to reduce species extent or loss of species numbers is low because habitat design for the Proposed	No additional mitigation measures required. Ecological resilience is embedded within the design and mitigation	Ecological monitoring of habitats and species will be carried out at a route wide level. This will monitor the effectiveness of	

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				Scheme will increase species connectivity along the route which will enable habitat and species migration.	measures.	existing ecological mitigation measures at maintaining and enhancing ecological conditions.	

Electromagnetic interference (EMI)

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<p>The levels of generated electromagnetic field (EMF) and electromagnetic interference (EMI) are dependent on the traction power, which has been calculated for a worst case scenario based on the maximum number of trains running per hour. Any change in climate is unlikely to affect the output from the traction power and cause any significant increase in EMF or EMI and therefore will be discounted for this assessment.</p>	n/a	n/a	n/a	n/a	n/a	n/a	4 - No potential in-combination climate change impacts

Health

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People and communities	<p>Temporary and permanent effects from construction -</p> <p>(1) Neighbourhood quality; life, mental health and wellbeing of residents i.e. visual and noise impacts, loss of property, disturbance from construction traffic.</p> <p>(2) Access to services, health and social care; including direct and indirect impacts of services and community facilities and reduced access from changes in journey times.</p> <p>(3) Access to green space and physical</p>	<p>Construction – (1, 2, 3, 4, 5, 6, 7a) Compliance with CoCP¹.</p> <p>(1, 2, 3, 4, 5, 6, 7b) Consideration of potential health issues is an integral part of the planning and design of the Proposed Scheme.</p> <p>(1, 2, 3, 4, 5, 6, 7c) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p> <p>(1, 2, 4, 5, 6, 7d) Construction and operation of new highways prior to permanent closure of any existing highways, where reasonably practicable.</p> <p>(3d, 1, 2, 4, 5, 6, 7e) Maintain or locally divert the majority of roads crossing the Proposed Scheme to limit traffic diversions onto alternative</p>	<p>(1, 2, 7) Changes in humidity and increase in temperature – greater number of people sleeping with windows open, may alter propagation characteristics of sound through air.</p>	<p>(1a,b,c,h,i 2a,b,c,f 7a,b,c,f) Unlikely / Low consequence. It is unlikely that changes in humidity and hotter temperatures will increase noise levels in the local area during construction works because mitigation measures include control of noise and vibration at source, by using quiet and low vibration equipment; and screening, by constructing perimeter hoarding or use of temporary stockpiles.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>HS2 Ltd will continue to engage with the owners and occupiers of sensitive receptors directly affected by the Proposed Scheme to develop mitigation measures that will reduce or avoid impacts.</p>	<p>Noise and vibration monitoring will be carried out during construction.</p>	3 - Few potential in-combination climate change impacts with low consequences
			<p>(1, 2, 4, 6, 7) Increase in frequency of extreme weather events (e.g. drought, flooding, heat waves) - may create stress for people.</p>	<p>(1a,b,c,d,e,f,g,i 2a,b,c,d,e,f 4a,b,c,d,e,f,g,i 7a,b,c,d,e,f) Unlikely / Low consequence. It is unlikely that an increase in the frequency of extreme weather events will</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>HS2 Ltd will continue to engage with the owners and occupiers</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	

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	<p>activity.</p> <p>(4) Social capital; including changes in community connectivity from road diversions, creation of barriers between communities, direct impacts on community facilities and impacts to construction workforce.</p> <p>(5) Education.</p> <p>(6) Employment and income.</p> <p>(7) Housing.</p>	<p>routes.</p> <p>(1, 4f) Restrict road closures to overnight and weekends where reasonably practicable.</p> <p>(1, 4g) A number of measures will be implemented to reduce the impact of HGV traffic; including construction of borrow pits, rerouting HGVs along the strategic/primary road network, transporting materials and equipment via a haul route instead of the public highway and creating a temporary railhead to reduce HGV road movements.</p> <p>(6f, 1,4h) Provide worker accommodation at the Trent south viaduct main compound to reduce the traffic impact of daily worker trips.</p> <p>(6g) Facilitate access to training and employment</p>	<p>(1, 2, 3) Hotter and drier/drought conditions - may exacerbate loss of grassland/green space, reduced health and wellbeing of communities.</p>	<p>create additional stress for people because the extreme weather events clause in the CoCP² states that programme management, environmental control and impact mitigation measures will be influenced and informed by a short to medium-range weather forecasting service; therefore ensuring the Proposed Scheme is resilient against extreme weather which will result in negligible stress to local residents.</p> <p>(1a,b,c,g,i 2a,b,c,f 3a,b,c,e) Unlikely / Low consequence. It is unlikely that hotter and drier/drought conditions will exacerbate the loss of grassland/green spaces during construction</p>	<p>of sensitive receptors directly affected by the Proposed Scheme to develop mitigation measures that will reduce or avoid impacts.</p> <p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>HS2 Ltd will continue to engage with the owners and occupiers</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	

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		<p>opportunities along the route for local residents including apprenticeships and education initiatives.</p> <p>(6h) Provide additional support over statutory requirements to reduce the effects of the Proposed Scheme on businesses who are required to relocate.</p> <p>(1, 4, i 2, 5, 7f 3e, 6i) Reducing the loss of property and community assets.</p>		<p>because the CoCP¹ states that planting and other landscape measures will be carried out early in the construction programme. This will mitigate the adverse effects on sensitive and valued landscape features and characteristics, therefore, providing green spaces that can adapt to changes in climate conditions.</p>	<p>of sensitive receptors directly affected by the Proposed Scheme to develop mitigation measures that will reduce or avoid impacts.</p>		
	<p>Operation –</p> <p>(8) Health effects from noise.</p> <p>(9) Possible impact on health of altered landscape due to changed perception of local environment.</p>	<p>Operation –</p> <p>(8a) Design of track and track bed to avoid or reduce ground-borne noise and vibration.</p> <p>(8b, 9a) Provision of noise fence barriers and bunds to provide acoustic screening.</p> <p>(8c, 9b) Design of landscaped earthworks and planting to provide</p>	<p>(8) Changes in humidity and increase in temperature – greater number of people sleeping with windows open, may alter propagation characteristics of sound through air.</p>	<p>(8a, b, c) Unlikely / Low consequence. It is unlikely that changes in humidity and hotter temperatures will increase noise levels in the local area during construction works because mitigation measures such as noise barriers will be constructed. HS2 Ltd is also committed to providing trains that</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>HS2 Ltd will continue to engage with the owners and occupiers of sensitive receptors directly affected by the Proposed Scheme to develop mitigation measures</p>	<p>No specific monitoring requirements during operation of the Proposed Scheme.</p>	

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		screening of the Proposed Scheme and help the infrastructure to blend into the existing landscape and reduce airborne noise effects.		are quieter than the relevant current European Union specifications therefore health effects from noise and warmer weather conditions is low.	that will reduce or avoid impacts.		
			(g) Increase in frequency of extreme weather events (e.g. flooding) - may create stress for people.	(9b) Unlikely / Low consequence. Whilst it is likely that the frequency of extreme weather events will increase over the operational period of the Proposed Scheme, it is unlikely that increased flooding will create additional stress for local residents because of the climate change allowance built into the design of critical infrastructure assets. This will minimise the impacts of flooding events and therefore reduce the potential stress on people during these	No additional measures required as there are sufficient mitigation measures in place. HS2 Ltd will continue to engage with the owners and occupiers of sensitive receptors directly affected by the Proposed Scheme to develop mitigation measures that will reduce or avoid impacts.	No specific monitoring requirements during operation of the Proposed Scheme.	

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				events.			
			(g) Increase in frequency of extreme weather events (e.g. drought, heat waves) - may create stress for people.	(9b) Unlikely / Low consequence. Even though it is likely that the frequency of extreme weather events will increase over the operational period of the Proposed Scheme, there are no in-combination climate change impacts and, therefore, no additional stress to sensitive receptors.	No additional measures required as there are sufficient mitigation measures in place. HS2 Ltd will continue to engage with the owners and occupiers of sensitive receptors directly affected by the Proposed Scheme to develop mitigation measures that will reduce or avoid impacts.	No specific monitoring requirements during operation of the Proposed Scheme.	
			(g) Hotter and drier/drought conditions - might affect the effectiveness of landscape planting.	(9c) Unlikely / Low consequence. It is unlikely that hotter and drier/drought conditions will cause stress to plants because species will be chosen based on their ability to adapt to climate change and ability to cope with changes in soil moisture conditions	No additional measures required as there are sufficient mitigation measures in place. HS2 Ltd will continue to engage with the owners and occupiers of sensitive receptors directly affected by the Proposed	No specific monitoring requirements during operation of the Proposed Scheme.	

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				to minimise the impact of drought.	Scheme to develop mitigation measures that will reduce or avoid impacts.		

Land quality

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People	<p>Construction –</p> <p>(1) Potential impact on human health on-site (direct contact, ingestion, inhalation of dusts and vapours from contaminated soils and groundwater and inhalation of ground gases).</p> <p>(2) Potential impact on human health off-site (direct contact, ingestion, inhalation of dusts and vapours from contaminated soils and groundwater and inhalation of ground gases).</p>	<p>Construction –</p> <p>(1a,2a) Compliance with the CoCP¹.</p> <p>(1b, 2b) In the event that unexpected contamination is encountered during the construction of the route, this will be remediated as described in the draft CoCP¹ resulting in an overall beneficial effect.</p> <p>(1c,2c) Additional site-specific remediation measures will be developed at the detailed design stage if required. These measures will ensure that risks to people and property from gas and vapours in the ground, the principal risk in this area, will be controlled to</p>	<p>(1,2) Increased temperatures and occurrence of heat waves - may enhance landfill gas production, but this may be ameliorated by lower moisture content associated with dry weather.</p>	<p>(1a,b,c,2a,b,c) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing mitigation measures are also in place (see column 3).</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.</p>	<p>3 - Few potential in-combination climate change impacts with low consequences.</p>
		<p>(1,2) Increased temperatures and occurrence of heat waves - may cause increased volatility of organic compounds (VOC) causing unpleasant odours locally.</p>	<p>(1a,b,c,2a,b,c) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.</p>		

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		<p>an acceptable level.</p> <p>(1d,2d) No additional measures are considered necessary to mitigate risks from land contamination during the construction stage beyond those that are set out in the draft CoCP¹ and/or instigated as part of the site specific remediation strategies that will be developed at the detailed design stage, if required.</p>	<p>(1,2) Increased wind speed - wind-blown dusts.</p>	<p>(1a,b,c,2a,b,c) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing mitigation measures are also in place (see column 3).</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.</p>	
	<p>Operation –</p> <p>(3) Users of the Proposed Scheme (i.e. rail passengers) are at all routine times within a controlled environment (i.e. within trains), and have, therefore, been scoped out of</p>	<p>Operation –</p> <p>(3a) Maintenance and operation of the Proposed Scheme will be in accordance with environmental legislation and good practice. Spillage and pollution response procedures similar to those to be outlined in</p>	<p>(3) Increased temperatures and occurrence of heat waves - may enhance landfill gas production, but this may be ameliorated by lower moisture content associated with</p>	<p>(3a) Unlikely / Low consequence. Unlikely because users of the Proposed Scheme have been scoped out and low consequence because mitigation measures are in place to prevent harm in the case of unexpected incidents.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed</p>	

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	the assessment.	the draft CoCP ¹ will be established for all high risk activities and employees will be trained in responding to such incidents.	dry weather. (3) Increased temperatures and occurrence of heat waves - may cause increased volatility of organic compounds (VOC) causing unpleasant odours locally. (3) Increased wind speed - wind-blown dusts.	 (3a) Unlikely / Low consequence. Unlikely because users of the Proposed Scheme have been scoped out and low consequence because mitigation measures are in place to prevent harm in the case of unexpected incidents. (3a) Unlikely / Low consequence. Unlikely because users of the Proposed Scheme have been scoped out and low consequence because mitigation measures are in place to prevent harm in the case of unexpected incidents.	 No additional measures required as there are sufficient mitigation measures in place. No additional measures required as there are sufficient mitigation measures in place.	design process. Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process. Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.	

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Ground and surface water	<p>Construction –</p> <p>(4) Potential impact on groundwater quality (leaching, vertical and lateral migration from soils and water).</p> <p>(5) Potential impact on surface water quality (lateral migration through groundwater, direct run-off from site).</p>	<p>Construction –</p> <p>(4a,5a) Compliance with CoCP¹.</p> <p>(4b,5b) May also be necessary to install ground (landfill) gas and leachate control systems within affected old landfill sites, on a temporary or permanent basis, to ensure that ground (landfill) gas and leachate migration pathways are controlled.</p> <p>(4c,5c) Where piling through contaminated soils is required, preventative measures will be adopted to mitigate the potential for contaminant migration down pile bores.</p>	(4,5) Increase in frequency and intensity of heavy rainfall events/flooding may cause an increased risk of run-off of sediments.	(4a,b,c,5a,b,c) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing mitigation measures are also in place (see column 3).	No additional measures required as there are sufficient mitigation measures in place.	Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.	
	<p>Operation –</p> <p>(6) The operation of the trains may give rise to minor contamination</p>	<p>Operation –</p> <p>(7a) In common with other modern substations, secondary containment appropriate</p>	(6,7) Increase in frequency and intensity of heavy rainfall events/flooding	(7a) Unlikely / Low consequence. Soil is unlikely to be a significant contaminant to ground and surface water receptors and mitigation measures in place to	No additional measures required as there are sufficient mitigation measures in place.	Requirements for monitoring will be determined as part of the site investigation,	

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	<p>through leakage of hydraulic or lubricating oils.</p> <p>(7) An auto-transformer station can, in principle, be a source of contamination through accidental discharge or leaks of coolant.</p>	<p>to the level of risk will be included in the installed design.</p> <p>No significant residual effects associated with operation of the Proposed Scheme are anticipated.</p>	<p>- may cause an increased risk of run-off of sediments.</p>	<p>protect ground and surface water from sediment runoff during heavy rainfall events or flooding.</p>		<p>treatment and validation of contamination on a site specific basis as part of the detailed design process.</p>	
Built and natural environment	<p>Construction –</p> <p>(8) Potential impact on property receptors on-site and off-site (direct contact with soils and water, exposure to explosive gases).</p>	<p>Construction –</p> <p>(8a) Compliance with CoCP¹.</p> <p>(8a) May also be necessary to install ground (landfill) gas and leachate control systems within affected old landfill sites, on a temporary or permanent basis, to ensure that ground (landfill) gas and leachate migration pathways are controlled.</p>	<p>(8) Increased wind speed - wind-blown dusts.</p>	<p>(8a,b) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing mitigation measures are also in place (see column 3).</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.</p>	

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			(8) Increase in frequency and intensity of heavy rainfall events/flooding - may cause an increased risk of run-off of sediments.	(8a,b) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing mitigation measures are also in place (see column 3).	No additional measures required as there are sufficient mitigation measures in place.	Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.	
			(8) Increased temperatures and occurrence of heat waves - may enhance landfill gas production, but this may be ameliorated by lower moisture content associated with dry weather.	(8a,b) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing mitigation measures are also in	No additional measures required as there are sufficient mitigation measures in place.	Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.	

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				place (see column 3).			
			(8) Increased temperatures and occurrence of heat waves - may cause an increased volatility of organic compounds (VOC) causing unpleasant odours locally.	(8a,b) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing mitigation measures are also in place (see column 3).	No additional measures required as there are sufficient mitigation measures in place.	Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.	
	Operation – (9) The operation of the trains may give rise to minor contamination through leakage of hydraulic or lubricating oils. (10) An auto-transformer station can, in principle, be	Operation – (10a) In common with other modern substations, secondary containment appropriate to the level of risk will be included in the installed design. No significant residual effects associated with operation of the	(9, 10) Increase in frequency and intensity of heavy rainfall events/flooding – lead to an increased risk of run-off of sediments.	(10a) Unlikely / Low consequence. Soil is unlikely to be a significant contaminant to ground and surface water receptors and mitigation measures in place to protect ground and surface water from sediment runoff during heavy rainfall events or flooding.	No additional measures required as there are sufficient mitigation measures in place.	Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.	

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	a source of contamination through accidental discharge or leaks of coolant.	Proposed Scheme are anticipated.					
Mining and mineral sites	<p>Construction - The majority of effects on mining and mineral sites will be permanent.</p> <p>(11) There may be a temporary sterilisation of the resource during construction works.</p> <p>(12) There may be permanent sterilisation of resources (i.e. direct excavation, severance, isolation of resource).</p>	<p>Construction –</p> <p>(11a,12a) Compliance with CoCP¹.</p> <p>(11b,12b) Mitigation of the effects on mineral resources could include extraction of the resource, for use within the Proposed Scheme, or elsewhere.</p>	(11,12) Increase in frequency of extreme weather events (e.g. drought, flooding, heat waves) - may exacerbate isolation of resource.	(11a,b,12a,b) Unlikely / Low consequence. The construction phase is expected to have a neutral to minor beneficial effect on the receptors overall (although there may be temporary worsening during the construction phase, occasionally leading to temporary minor to moderate adverse effects) and is not considered to be significant in relation to potential land contamination. Existing mitigation measures are also in place (see column 3).	No additional measures required as there are sufficient mitigation measures in place.	Requirements for monitoring will be determined as part of the site investigation, treatment and validation of contamination on a site specific basis as part of the detailed design process.	
	Operation - any effects arising during operation are expected to be adequately	n/a	n/a	n/a	n/a	n/a	

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	mitigated by the application of good practice in terms of materials handling and railway operation, and are not considered further.						

Landscape and visual

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Landscape character and visual receptors	<p>Construction –</p> <p>(1) Presence of construction sites, cranes, compounds etc. affecting the view.</p> <p>(2) Temporary removal of trees, hedgerows and vegetation to build compounds during construction and to build track.</p> <p>(3) Permanent loss or gain of trees, hedgerows or vegetation.</p>	<p>Construction – (1a, 2a) Compliance with Section 12 of CoCP¹.</p> <p>(1b, 2b) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p> <p>(1c, 2c, 3a) Selection of native plant and tree species from a range of latitudes/climate zones/provinces to future proof the project for climate resilience.</p> <p>(1d, 3b) Advance planting as part of the design buffers the impact on sensitive receptors during construction by enhancing connectivity; it can be used as a screen during construction works.</p> <p>(2d, 3c) Traceability</p>	(1, 2, 3) Drier/drought conditions - could lead to loss of vegetation and defoliation and receptors could become more vulnerable to stress.	(1b,c,e, 2b,c,f, 3a,d,e,f) Likely / High consequence. Drier/drought conditions could increase loss of vegetation and defoliation. Existing mitigation measures will aim to minimise impacts of drought on native plant species. They include undertaking post-construction monitoring and choosing species for replacement planting lost during construction to align with soil profiles, therefore, increasing ecological resilience.	(1b,c,e, 2b,c,f, 3a,d,e,f) Where practicable, any surpluses or permanently displaced soils will be used to reinstate soils with profiles thicker than the originals. In these situations, 'wet' soils could be better drained and so more resilient to intense rainfall; and 'dry' soils are generally shallow and do not retain water in the profile so they could be more moisture retentive. In both cases, higher organic matter content (in the topsoil) would make them more resilient. There is also the possibility of mixing soil textures to make coarse-textured soils less droughty and fine-textured soils less prone to wetness and, therefore, provide greater flexibility for plant and tree species to be more resilient to drought.	Operational monitoring to take place in the form of cross-checking works undertaken with contractor specification documents.	2 - Some or few potential in-combination climate change impacts with high consequences
			(1, 2, 3) Drier/drought conditions - drought tolerant	(1b,c,e, 2b,c,f, 3a,d,e,f) Likely / High consequence. Drier/drought conditions	(1b,c,e, 2b,c,f, 3a,d,e,f) Where practicable, any surpluses or permanently displaced soils will be used to reinstate soils with	Operational monitoring to take place in the form of	

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		<p>studies will be carried out to minimise risk of spreading diseases and encourage good practice when planting.</p> <p>(1e, 2e, 3d) During detailed design provide definition of appropriate planting palettes for replacement planting lost during construction to align with soil profiles.</p> <p>(3e) Surveying of the existing tree and species mix will be completed prior to construction works to provide estimated age of tree and life span, helping to identify tree risk and inform the tree strategy.</p> <p>(3f) Adequate water supply to support replacement habitat will be set out in the</p>	<p>trees may become more prevalent (therefore also changing landscape character).</p> <p>(1, 2, 3) Drier/drought conditions - wetlands may disappear (also dependent on elevation and spilt type) and certain soil types may be less</p>	<p>could increase loss of vegetation and defoliation. Existing mitigation measures will aim to minimise impacts of drought on native tree species. They include undertaking post-construction monitoring and choosing species for replacement planting lost during construction to align with soil profiles, therefore, increasing ecological resilience of species.</p> <p>(1b,c,e, 2b,c,f, 3a,d,f) Likely / Low consequence. Drier/drought conditions could encourage the drying out of wetlands, however, there are a number of mitigation measures in place to reduce these potential</p>	<p>profiles thicker than the originals. In these situations, 'wet' soils could be better drained and so more resilient to intense rainfall; and 'dry' soils are generally shallow and do not retain water in the profile so they could be more moisture retentive. In both cases, higher organic matter content (in the topsoil) would make them more resilient. There is also the possibility of mixing soil textures to make coarse-textured soils less droughty and fine-textured soils less prone to wetness and, therefore, provide greater flexibility for plant and trees species to be more resilient to drought.</p> <p>(1b,c,e, 2b,c,f, 3a,d,f) Potential to include deeper soil profiles or more moisture retentive textures to mitigate longer term drought effects on soils and associated tree species or vegetation.</p> <p>The current good practice is to separate different soil types during the restoration process.</p>	<p>cross-checking works undertaken with contractor specification documents.</p> <p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	

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		works contract with the design and build contractors and will form part of the contractor's work scope.	readily available.	impacts and, therefore, the consequence is low.	However, this measure may not be sufficient following any potential climate change impacts. To combat this, soil types may be mixed to provide greater flexibility for plant and trees species to be more resilient to drought.		
			(1, 2, 3) Hotter and wetter conditions - could lead to an increase in pests and diseases, leading to loss of vegetation and defoliation making species more susceptible to external stress.	(1b,c,d, 2b,c,d,e 3a,b,c,d) Likely / Low consequence. Hotter and wetter conditions are likely but increased risk of pests and diseases is low because traceability studies will be used to minimise risk of spreading diseases during planting.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
			(1, 2, 3) Increase in frequency and intensity of heavy rainfall events/flooding - loss of species in certain areas, because soils become water-	(1b,c,d,e, 2b,c,e, 3a,b,d) Likely / Low consequence. Heavy rainfall events and flooding are more likely to occur in the future, however, the loss of species is low because planting will be designed	(1b,c,d,e, 2b,c,e, 3a,b,d) To further reduce the impact of flood risk on plant/tree species the drainage profile of the soil could be increased.	No specific monitoring requirements during construction of the Proposed Scheme.	

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			saturated and can no longer support existing species.	in advance to increase species resilience and adaptability.			
			(1, 2, 3) Hotter and wetter conditions - leads to a longer growing season and an increased rate of growth of vegetation.	(1b,c,d,e, 2b,c,e,f 3a,b,d) Likely / Low consequence. Longer growing seasons have both positive and negative impacts. Vegetation will be in leaf for longer and reduce adverse views; but it may increase the number of leaves on the line and change the trees structural capacity, which could increase the stress on trees from external factors. These negative impacts will be minimised by selecting trees from a range of latitudes/climate zones to increase species resilience against hotter and wetter conditions.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	

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			(1, 2, 3) Increased wind speed – impact on landscape through potential tree losses.	(1a,b,c,d,e, 2a,b,c,e 3a,b,d,e) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. If wind speed does increase then it is more likely to affect more mature, existing trees. Tree surveys will assess risks to trees in proximity to construction sites and work in combination with tree protection works to minimise tree damage.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
	Operation – (4) Existence of railway line. Specific elements taken into account in assessing visual impact include: cuttings and embankments,	(4a) Create a landscape mosaic including creation of grassland habitats along field boundaries and planted strips to enhance both wildlife and woodland connectivity. (4b) Advanced	(4) Drier/drought conditions - could lead to loss of vegetation and defoliation and receptors could become more vulnerable to stress.	(4a,b,c) Likely / High consequence. Drier/drought conditions could increase loss of vegetation and defoliation. Existing mitigation measures will aim to minimise impacts of drought on native tree species. They include	(4a,b,c) Where practicable, any surpluses or permanently displaced soils will be used to reinstate soils with profiles thicker than the originals. In these situations, 'wet' soils could be better drained and so more resilient to intense rainfall; and 'dry' soils are generally shallow and do not retain water in the	Operational monitoring to take place in the form of cross-checking works undertaken with contractor specification	

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	viaducts, and the loss of vegetation and landscape features such as ponds, streams, soils, hills and plains.	<p>planting: Effects in year one of operation may be further reduced by establishing planting in appropriate locations early in the construction programme, which will be considered during the detail design stage. This would provide additional screening and greater integration of the Proposed Scheme into the landscape.</p> <p>(4c) Creation of green/land bridges to enhance landscape connectivity.</p> <p>(4d) Traceability studies will be carried out to minimise risk of spreading diseases and encourage good practice when planting.</p>	<p>(4) Drier/drought conditions - drought tolerant trees may become more prevalent (therefore, also changing landscape character).</p>	<p>undertaking post-construction monitoring and choosing species for replacement planting lost during construction to align with soil profiles, therefore, increasing ecological resilience of species.</p> <p>(4a,b,c) Likely / High consequence. Drier/drought conditions could increase loss of vegetation and defoliation. Existing mitigation measures will aim to minimise impacts of drought on native tree species. They include undertaking post-construction monitoring and choosing species for replacement planting lost during construction to align with soil profiles, therefore, increasing</p>	<p>profile so they could be more moisture retentive. In both cases, higher organic matter content (in the topsoil) would make them more resilient. There is also the possibility of mixing soil textures to make coarse-textured soils less droughty and fine-textured soils less prone to wetness and therefore provide greater flexibility for plant and trees species to be more resilient to drought.</p> <p>(4a,b,c) Where practicable, any surpluses or permanently displaced soils will be used to reinstate soils with profiles thicker than the originals. In these situations, 'wet' soils could be better drained and so more resilient to intense rainfall; and 'dry' soils are generally shallow and do not retain water in the profile so they could be more moisture retentive. In both cases, higher organic matter content (in the topsoil) would make them more resilient. There is also the possibility of mixing soil textures to make coarse-textured soils</p>	<p>documents.</p> <p>Operational monitoring to take place in the form of cross-checking works undertaken with contractor specification documents.</p>	

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				ecological resilience of species.	less droughty and fine-textured soils less prone to wetness and, therefore, provide greater flexibility for plant and trees species to be more resilient to drought.		
			(4) Drier/drought conditions - wetlands may disappear (also dependent on elevation) and certain soil types may be less readily available.	(4a,b,c) Likely / High consequence. Drier/drought conditions could encourage the drying out of wetlands. There are ecological mitigation measures in place to protect wetland ecosystems from drought by maintaining and enhancing ecological conditions.	(4a,b,c) Where practicable, any surpluses or permanently displaced soils will be used to reinstate soils with profiles thicker than the originals. In these situations, 'wet' soils could be better drained and so more resilient to intense rainfall; and 'dry' soils are generally shallow and do not retain water in the profile so they could be more moisture retentive. In both cases, higher organic matter content (in the topsoil) would make them more resilient. There is also the possibility of mixing soil textures to make coarse-textured soils less droughty and fine-textured soils less prone to wetness and, therefore, provide greater flexibility for plant and trees species to be more resilient to drought.	Operational monitoring to take place in the form of cross-checking works undertaken with contractor specification documents.	

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			(4) Increase in frequency and intensity of heavy rainfall events/flooding - loss of species in certain areas, because soils become water-saturated and can no longer support existing species.	(4a,b,c) Likely / Low consequence. Flood risk is likely to increase, however, the consequence is low because existing mitigation measures and early detailed design during construction works will minimise this increased flood risk.	No additional mitigation measures required because assets will be designed with embedded climate change allowances.	No specific monitoring requirements during operation of the Proposed Scheme.	
			(4) Hotter and wetter conditions - could lead to an increase in pests and diseases, leading to loss of vegetation and defoliation making species more susceptible to external stress.	(4a,b,c) Likely / Low consequence. Warmer and wetter conditions are more likely. However, the increased risk of pests and disease to species is low because existing ecological mitigation measures include the management of trees during construction works i.e. removing trees that pose a threat/are diseased.	No additional measures required as there are sufficient mitigation measures in place.	Management / monitoring of newly planted trees during aftercare period (typically 12-24 months) will help to identify diseased or pest infested trees.	

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			(4) Hotter and wetter conditions - leads to a longer growing season and an increased rate of growth of vegetation.	(4a,b,c) Likely / Low consequence. Increased growing season has both positive and negative effects for example, vegetation will be in leaf for longer reducing adverse views, but plant/tree species structure and adaptability may change. These negative impacts will be minimised by selecting trees from a range of latitudes/climate zones therefore increasing species resilience against disease and pests.	No additional measures required as there are sufficient mitigation measures in place.	Monitoring of the plant/tree species to be undertaken to identify changes in growth patterns.	
			(4) Increased wind speed – loss of valued landscape, opening up new views that were previously shielded, potential for damage to trees from construction	(4a,b,c) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. The loss of valued landscapes and tree damage is	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during operation of the Proposed Scheme.	

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			making them more vulnerable to high winds.	considered unlikely because advance planting will minimise adverse visual impacts on the landscape and construction techniques will limit damage to trees through use of tree protection fencing calculated in accordance with Tree Root Protection Areas (RPA).			

Major accidents and natural disasters

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Members of the public and local communities	<p>Construction -</p> <p>(1) Tunnel collapse due to tunnelling during construction.</p> <p>(2) Ground collapse due to presence of salt/coal along route which is susceptible to subsidence.</p> <p>(3) Train derailment or collision due to construction activities on or adjacent to existing railway.</p> <p>(4) Major road traffic accident due to construction work.</p> <p>(5) Physical damage or contamination of the aquifer or borehole causing loss of drinking water supply.</p> <p>(6) Spillage or longer term seepage of pollutants into water course, potential to affect drinking water.</p> <p>(7) Fire and/or explosion or</p>	<p>(1a,2a,3a,4a,5a,6a,7a,8a,9a, 10a, 11a) Risks identified and managed via Construction (Design and Management) (CDM) 2015 Regulations.</p> <p>(3b,4b,7b,8b,9b) Risks identified and managed via CoCP¹.</p> <p>(1b,2b, 3c,10b) Stakeholder engagement/community consultation and grievance mechanism during the construction phase.</p> <p>(3d) Consultation with Network Rail and rail service providers.</p> <p>(4c) Consultation with Highways England through design and in construction method</p>	<p>(6) Increase in frequency and intensity of heavy rainfall events / flooding - exacerbate the risk of spreading pollutants to water courses.</p> <p>(10) Increase wind speed - may cause increased loads on structures leading to collapse.</p>	<p>(6a,b) Unlikely / Low consequence. Given the embedded mitigation (see column 3) and the climate change mitigation measures that have been embedded into the design, the risks of this effect are still considered ALARP (as low as reasonably practicable).</p> <p>(10a,b,c) Unlikely / Low consequence. Climate change may increase wind speeds, however, there is high uncertainty in projections and changes are not considered to be significant by the '2020s'. Therefore, additional resilience measures are not required during the construction phase.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>No additional monitoring or measures are required during construction of the Proposed Scheme.</p> <p>(1) Tunnel design and construction methods includes risk assessment for overlying structures and monitoring or mitigation if subsequently required.</p>	<p>3 - Few potential in-combination climate change impacts with low consequence.</p>

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	<p>release of harmful gas</p> <p>(8) Release of asbestos during demolition of buildings and structures.</p> <p>(9) Extreme weather events (e.g. flood event leads to release of material).</p> <p>(10) Collapse of or damage to existing structures.</p> <p>(11) Member of public using temporary access route at Crewe Station exposed to additional safety hazards.</p>	<p>statements.</p> <p>(4d) Construction workforce travel plan further mitigation measures and details are provided by the Traffic and Transport topic (Volumes 2 and 3 Section 14).</p> <p>(5b) Liaison with Infrastructure Providers to minimise risk to supply.</p> <p>(5c) Any drainage feature within Source Protection Zone 1 would be lined.</p> <p>(6b) Risks of leaks and spills addressed in Water resources and flood risk chapter of the ES (HAWRAT assessment - highways and route-wide operational risk assessment for accidental spillages from trains). No significant</p>					

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
		<p>inventory of hazardous substances (e.g. fuel) to be used or stored at construction sites.</p> <p>(7c) Good permanent works design to control long term ground related risks like ground gases.</p> <p>(9c) Long term stockpiles to be vegetated.</p> <p>(10c) Construction sequencing e.g. build culverts prior to embankment.</p> <p>(11b) Dedicated Network Rail interface.</p>					
	<p>Operation -</p> <p>(12) Train derailment or collision (HS2) causing severe disruption to rail transportation, major accident causing harm to staff/passenger/adjacent</p>	<p>(12-26) Measures include those to remove or reduce the likelihood of each of the effects/risks identified and mitigate the severity. Please see Table 9 in Volume 3 Section 11.</p>	<p>(12, 13, 14) Increase in frequency and intensity of heavy rainfall events / flooding - could increase the likelihood of a</p>	<p>(12, 13, 14) Unlikely / Low consequence. Given the embedded mitigation (see column 3) and the climate change mitigation measures that have been embedded into the design.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>No additional monitoring or measures are required during construction.</p> <p>Real time monitoring and integrated</p>	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	<p>receptors.</p> <p>(13) Train derailment or collision (maintenance trains) - no passengers but potentially carrying flammable fuel. Could cause a diesel spillage.</p> <p>(14) Train derailment or collision (WCML) causing severe disruption to rail transportation or spillage of pollutants.</p> <p>(15) Major road traffic accident - resulting in death or permanent injury, severe congestion and delays, spillage of pollutants.</p> <p>(16) Collapse of structures leading to non-train incident - death or injury to members of public, road traffic accident.</p> <p>(17) Collapse of embankments.</p>		<p>train derailment.</p> <p>(12, 13, 14) Increased wind speed - could increase the likelihood of a train derailment.</p>	<p>Mitigation measures include rail infrastructure designed to accommodate 1 in 100 (1%) annual probability flood event plus climate change, accommodate 1 in 100 (1%) annual peak rainfall event plus climate change and remain safe during a 1 in 1000 (0.1%) annual probability flood.</p> <p>(12, 13, 14) Unlikely / Low consequence. It is considered that the risk of this impact is mitigated to be ALARP. Climate change may increase wind speeds, however, there is high uncertainty in projections. This risk will be considered during future design stages with potential mitigation through design change or operational</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>communication for rolling stock will be used.</p>	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	<p>(18) Fire and/or explosion, either direct or indirect harm.</p> <p>(19) Extreme weather (floods - the Proposed Scheme leads to alteration of flood patterns).</p> <p>(20) Accidental drowning due to presence of balancing and attenuation ponds and unauthorised 3rd party access.</p> <p>(21) Non-motorist falling/jumping from bridges, viaducts, cuttings etc.</p> <p>(22) Vehicle falling from overbridge or adjacent road.</p> <p>(23) Traffic incident involving non-motorists.</p> <p>(24) Injury to member of public using level crossing on West Coast Main Line (WCML).</p> <p>(25) Emergency response activities impacts on environmental receptors</p> <p>(26) Electric shock due to</p>		<p>(16) Increase wind speed - could cause increased loads on structures leading to collapse.</p>	<p>management.</p> <p>(16) Unlikely / Low consequence. It is considered that the risk of this impact is mitigated to be ALARP. Climate change may increase wind speeds, however, there is high uncertainty in projections. This risk will be considered during future design stages with potential mitigation through design change or operational management.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>		

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	exposure to live conductor/arcng etc.						
Members of the public and local communities			(17) Increase in frequency and intensity of heavy rainfall events / flooding - could cause collapse of embankments.	(17) Unlikely / Low consequence. It is considered that the risk of this impact is mitigated to be ALARP. Mitigation measures include rail infrastructure designed to accommodate 1 in 100 (1%) annual probability flood plus climate change and remain safe during a 1 in 1000 (0.1%) annual probability flood. Risk of earthworks failure is mitigated by using robust slope design parameters to allow for future changes in soil moisture content and groundwater pressures as well as using appropriate earthworks materials in embankment.	No additional measures required as there are sufficient mitigation measures in place.	No additional monitoring or measures are required during construction of the Proposed Scheme. Real time monitoring and integrated communication for rolling stock will be used.	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
			(26) Increase wind speed - could cause overhead line collapse.	(26) Unlikely / Low consequence. It is considered that the risk of this impact is mitigated to be ALARP. Climate change may increase wind speeds, however, there is high uncertainty in projections. This risk will be considered during future design stages with potential mitigation through design change or operational management.	No additional measures required as there are sufficient mitigation measures in place.		
Infrastructure and the built environment	<p>Construction -</p> <p>(27) Tunnel Collapse due to tunnelling during construction.</p> <p>(28) Fire and/or explosion or release of harmful gas.</p> <p>(29) Collapse of or damage to existing structures.</p>	<p>(27a, 28a, 29a) Risks identified and managed via CDM.</p> <p>(28b) Risks identified and managed via CoCP¹.</p> <p>(27b,29b) Stakeholder engagement/community consultation and grievance mechanism during the construction</p>	(29) Increase wind speed - could cause increased loads on structures leading to collapse.	(29a,b,c) Unlikely / Low consequence. Climate change may increase wind speeds, however, there is high uncertainty in projections and changes are not considered to be significant by the '2020s'. Therefore, additional resilience measures are not required during the	No additional measures required as there are sufficient mitigation measures in place.	No additional monitoring or measures are required during construction of the Proposed Scheme.	(27) Tunnel design and construction methods

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
		<p>phase.</p> <p>(28c) Good permanent works design to control long term ground related risks like ground gases.</p> <p>(29c) Construction sequencing e.g. build culverts prior to embankment.</p>		construction phase.		includes risk assessment for overlying structures and monitoring or mitigation if required.	
	<p>Operation -</p> <p>(30) Train derailment or collision (HS2) causing major accident causing harm to adjacent receptors.</p> <p>(31) Collapse of structures leading to non-train incident.</p> <p>(32) Fire and/or explosion, either direct or indirect harm.</p> <p>(33) Extreme weather (floods - the Proposed Scheme leads to alteration of flood patterns).</p>	(30-33) Measures include those to remove or reduce the likelihood of each of the effects/risks identified and mitigate the severity. Please see Table 9 in Volume 3 Section 11.	(30) Increase in frequency and intensity of heavy rainfall events / flooding - could increase the likelihood of a train derailment.	<p>(30) Unlikely / Low consequence. Given the embedded mitigation (see column 3) and the climate change mitigation measures that have been embedded into the design, the risks of this effect are still considered ALARP.</p> <p>Mitigation measures include rail infrastructure designed to accommodate 1 in 100 (1%) annual probability flood event plus climate change, accommodate 1</p>	No additional measures required as there are sufficient mitigation measures in place.	No additional monitoring or measures are required during construction of the Proposed Scheme.	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				in 100 (1%) annual peak rainfall event plus climate change and remain safe during a 1 in 1000 (0.1%) annual probability flood.			
			(30) Increase wind speed - could increase the likelihood of a train derailment.	(30) Unlikely / Low consequence. The risk of this impact is mitigated to be ALARP. Climate change may increase wind speeds, however, there is high uncertainty in projections. Risk will be considered during future design stages with potential mitigation through design change or operational management.	No additional measures required as there are sufficient mitigation measures in place.		
			(31) Increase wind speed - could cause increased loads on structures leading to collapse.	(31) Unlikely / Low consequence. The risk of this impact is mitigated to be ALARP. Climate change may increase wind speeds, however, there is high uncertainty in projections. Risk will be	No additional measures required as there are sufficient mitigation measures in place.		

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				considered during future design stages with potential mitigation through design change or operational management.			
Natural environment (including ecosystems, land and soil quality, air quality, surface and groundwater resources and landscape)	<p>Construction -</p> <p>(34) Tunnel collapse due to tunnelling during construction.</p> <p>(35) Ground collapse due to presence of salt/coal along route which is susceptible to subsidence.</p> <p>(36) Train derailment or collision due to construction activities on or adjacent to existing railway.</p> <p>(37) Physical damage or contamination of the aquifer or borehole.</p> <p>(38) Spillage or longer term seepage of pollutants into water course, potential to</p>	<p>(34a, 35a, 36a, 37a, 38a, 39a, 40a, 41a) Risks identified and managed via CDM.</p> <p>(36b, 39b, 40b) Risks identified and managed via CoCP¹.</p> <p>(34b, 35b, 36c, 41b) Stakeholder engagement/community consultation and grievance mechanism during the construction phase.</p> <p>(36d) Consultation with Network Rail and rail service providers.</p> <p>(37b) Liaison with infrastructure providers</p>	<p>(38) Increase in frequency and intensity of heavy rainfall events / flooding - exacerbate the risk of spreading pollutants to water courses.</p> <p>(41) Increase wind speed - could cause increased loads on structures leading to collapse.</p>	<p>(38a, b) Unlikely / Low consequence. Climate change mitigation measures have been embedded into the design. Given the embedded mitigation (see column 3) it is considered that the risks of this effect are ALARP.</p> <p>(41a,b,c) Unlikely / Low consequence. Climate change may increase wind speeds, however, there is high uncertainty in projections and changes are not considered to be</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>No additional monitoring or measures are required during construction</p> <p>(34) Tunnel design and construction methods includes risk assessment for overlying structures and monitoring or mitigation if required.</p>	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	<p>affect drinking water.</p> <p>(39) Fire and/or explosion or release of harmful gas.</p> <p>(40) Extreme weather events (e.g. flood event leads to release of material).</p> <p>(41) Collapse of or damage to existing structures</p>	<p>to minimise risk to supply.</p> <p>(37c) Any drainage feature within Source Protection Zone 1 would be lined.</p> <p>(38b) Risks of leaks and spills addressed in Water resources and flood risk chapter of the ES (HAWRAT assessment - highways and route wide operational risk assessment for accidental spillages from trains). No significant inventory of hazardous substances (e.g. fuel) to be used or stored at construction sites.</p> <p>(39c) Good permanent works design to control long term ground related risks like ground gases.</p> <p>(40c) Long term stockpiles to be</p>		<p>significant by the '2020s'. Therefore, additional resilience measures are not required during the construction phase.</p>			

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
		<p>vegetated.</p> <p>(41c) Construction sequencing e.g. build culverts prior to embankment.</p>					
	<p>Operation -</p> <p>(42) Train derailment or collision (HS2) causing major accident causing harm to adjacent receptors.</p> <p>(43) Train derailment or collision (maintenance trains) - could cause a diesel spillage.</p> <p>(44) Train derailment or collision (WCML) causing spillage of pollutants.</p> <p>(45) Major road traffic accident resulting in spillage of pollutants.</p> <p>(46) Collapse of embankments.</p> <p>(47) Fire and/or explosion,</p>	<p>Measures include those to remove or reduce the likelihood of each of the effects/risks identified and mitigate the severity. Please see Table 9 in Volume 3 Section 11.</p>	<p>(42, 43, 44) Increase in frequency and intensity of heavy rainfall events / flooding - could increase the likelihood of a train derailment.</p>	<p>(42, 43, 44) Unlikely / Low consequence. Given the embedded mitigation (see column 3) and the climate change mitigation measures that have been embedded into the design, the risks of this effect are still considered ALARP.</p> <p>Mitigation measures include rail infrastructure designed to accommodate 1 in 100 (1%) annual probability flood event plus climate change, accommodate 1 in 100 (1%) annual peak rainfall event plus climate change and remain safe during a 1 in 1000 (0.1%)</p>	<p>There are sufficient mitigation measures in place, no additional mitigation measures required.</p>	<p>No additional monitoring or measures are required during construction.</p> <p>(42, 43, 44) Real time monitoring and integrated communication for rolling stock will be used.</p>	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	<p>either direct or indirect harm.</p> <p>(48) Extreme weather (floods - the Proposed Scheme leads to alteration of flood patterns).</p> <p>(49) Emergency response activities impacts on environmental receptors.</p>		<p>(42, 43, 44) Increase wind speed - could increase the likelihood of a train derailment.</p> <p>(46) Increase in frequency and intensity of heavy rainfall events / flooding - could cause collapse of embankments.</p>	<p>annual probability flood.</p> <p>(42, 43, 44) Unlikely / Low consequence. It is considered that the risk of this impact is mitigated to be ALARP. Climate change may increase wind speeds, however, there is high uncertainty in projections. This risk will be considered during future design stages with potential mitigation through design change or operational management.</p> <p>(46) Unlikely / Low consequence. It is considered that the risk of this impact is mitigated to be ALARP. Climate change mitigation measures include rail infrastructure designed to accommodate 1 in 100</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p> <p>No additional mitigation measures required because assets will be designed with embedded climate change allowances.</p>		

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				(1%) annual probability flood plus climate change and remain safe during a 1 in 1000 (0.1%) annual probability flood. Risk of earthworks failure is mitigated by using robust slope design parameters to allow for future changes in soil moisture content, and groundwater pressures as well as using appropriate earthworks materials in embankment.			
Historic environment (including archaeology and built heritage)	Construction - (50) Tunnel collapse due to tunnelling during construction. (51) Train derailment or collision due to construction activities on or adjacent to existing railway. (52) Collapse of or damage to existing structures.	(50a,51a,52a) Risks identified and managed via CDM. (51b) Risks identified and managed via CoCP ¹ . (50b,51c,52b) Stakeholder engagement/community consultation and grievance mechanism during the construction	(52) Increase wind speed - could cause increased loads on structures leading to collapse.	(52a,b,c) Unlikely / Low consequence. Climate change may increase wind speeds, however, there is high uncertainty in projections and changes are not considered to be significant by the '2020s'. Therefore, additional resilience measures are not required during the	No additional measures required as there are sufficient mitigation measures in place.	No additional monitoring or measures are required during construction (50) Tunnel design and construction methods includes risk assessment for overlying	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
		<p>phase.</p> <p>(51d) Consultation with Network Rail and rail service providers.</p> <p>(52c) Construction sequencing e.g. build culverts prior to embankment.</p>		construction phase.		structures and monitoring or mitigation if required.	
	<p>Operation -</p> <p>(53) Collapse of structures leading to non-train incident.</p> <p>(54) Fire and/or explosion, either direct or indirect harm.</p> <p>(55) Extreme weather (floods - the Proposed Scheme leads to alteration of flood patterns).</p>	<p>Measures include those to remove or reduce the likelihood of each of the effects/risks identified and mitigate the severity. Please see Table 9 in Volume 3 Section 11.</p>	(53) Increase wind speed - could cause increased loads on structures leading to collapse.	(53) Unlikely / Low consequence. It is considered that the risk of this impact is mitigated to be ALARP. Climate change may increase wind speeds, however, there is high uncertainty in projections. This risk will be considered during future design stages with potential mitigation through design change or operational management.	No additional measures required as there are sufficient mitigation measures in place.	No additional monitoring or measures are required during construction.	

Socio-economics

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Businesses and community organisations	<p>Construction –</p> <p>(1) Business relocation during construction.</p> <p>(2) Location of construction compounds for the proposed scheme, creating many construction employment opportunities.</p> <p>(3) Job loss and job creation during construction and operation, direct and indirectly.</p> <p>(4) Socio-economic resources affected by isolation from customers/users during construction and operation.</p> <p>(5) In-combination effects – a number of businesses may experience significant in-combination effects (visual, HGV, air quality, noise, vibration) during</p>	<p>Construction –</p> <p>(1a) Businesses displaced by the Proposed Scheme will be compensated in accordance with the Compensation Code.</p> <p>(2a, 3a) Work to create skilled work force</p> <p>(1b, 2b, 3b, 4a, 5a) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p>	(5) Hotter and wetter conditions - leads to a longer growing season and increased rate of growth of vegetation.	(5a) Likely / Low consequence. Increased growing season has both positive and negative effects, for example, vegetation will be in leaf for longer reducing adverse visual impacts, but plant/tree species structure and adaptability may change. Sufficient mitigation measures in place, see Landscape and visual topic assessment (Volume 2 Section 11, Volume 3 Section 10) for further details.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	3 - Few potential in-combination climate change impacts with low consequences.
			(5) Increased wind speed – impact on landscape through potential tree losses.	(5a) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. Sufficient mitigation measures in place, see Landscape and visual topic assessment (Volume 2 Section 11, Volume 3 Section 10) for further details.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
			(5) Drier/drought conditions - drought tolerant	(5) Likely / Low consequence. Drier/drought conditions could increase loss of vegetation and	No additional measures required as there are sufficient	No specific monitoring requirements	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	construction.		trees may become more prevalent (therefore also changing landscape character).	defoliation however there are sufficient mitigation measures in place, see Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10) assessment for further details.	mitigation measures in place.	during construction of the Proposed Scheme.	
			(5) Drier/drought conditions – could lead to loss of vegetation and defoliation.	(5) Likely / Low consequence. Drier/drought conditions could increase loss of vegetation and defoliation, however, there are sufficient mitigation measures in place, see Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10) assessment for further details.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	
	<p>Operation –</p> <p>(6) Job creation during operation, direct and indirectly.</p> <p>(7) In-combination effects – a number of businesses may experience significant in-combination effects (visual, HGV, air quality, noise, vibration) during</p>	<p>Operation –</p> <p>(6a) No mitigation measures required - positive effect.</p> <p>(7a) Compensation will be provided where necessary</p>	(7) Hotter and wetter conditions - leads to a longer growing season – increased rate of growth of vegetation	(7a) Likely / Low consequence. Increased growing season has both positive and negative effects, for example, vegetation will be in leaf for longer reducing adverse views, but plant/tree species structure and adaptability may change. Sufficient mitigation measures in place, see Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10) assessment for	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during operation of the Proposed Scheme.	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	operation.	for significant residual effects which cannot be avoided or mitigated.		further details.			
			(7) Increased wind speed – impact on landscape through potential tree losses	(7a) Unlikely / Low consequence. There is considerable uncertainty in projections for changes in wind speed and wind direction, and studies show statistically insignificant variation in wind speed. Sufficient mitigation measures in place, see Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10) assessment for further details.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during operation of the Proposed Scheme.	
			(7) Drier/drought conditions - drought tolerant trees may become more prevalent (therefore also changing landscape character)	(7a) Likely / Low consequence. Drier/drought conditions could increase loss of vegetation and defoliation however there are sufficient mitigation measures in place, see Landscape and visual topic (Volume 2 Section 11, Volume 3 Section 10) assessment for further details.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during operation of the Proposed Scheme.	
			(7) Drier/drought conditions – could lead to loss of vegetation and defoliation	(7a) Likely / Low consequence. Drier/drought conditions could increase loss of vegetation and defoliation, however, there are sufficient mitigation measures in place, see Landscape and visual	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during operation of the Proposed	

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
				topic (Volume 2 Section 11, Volume 3 Section 10) assessment for further details.		Scheme.	

Sound and noise vibration

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Residential properties and community facilities	<p>Construction –</p> <p>(1) Airborne noise during construction operations.</p> <p>(2) Ground borne vibration.</p> <p>(3) Impact on vegetation.</p>	<p>Construction –</p> <p>(1a, 2a, 3a) Compliance with CoCP¹, CoPA² and Environmental Protection Act (1990)³.</p> <p>(1b, 2b, 3b) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p>	(1, 2, 3) Changes in humidity and increase in temperature - greater number of people sleeping with windows open, may alter propagation characteristics of sound through air.	<p>(1a,b, 2a,b, 3a,b) Unlikely / Low consequence. No anticipated effect on propagation of sound being affected by temperature or humidity.</p> <p>(3a) Unlikely / Low consequence. No anticipated effect on change in density of vegetation during the Proposed Scheme.</p>	No additional mitigation measures required as there is no in-combination impact.	No specific monitoring requirements during construction of the Proposed Scheme.	4 - No potential in-combination climate change impacts.
	<p>Operation –</p> <p>(4) Ground borne vibration for small number of properties very close to alignment and tunnels.</p> <p>(5) Noise due to operation of train post-construction.</p>	<p>Operation –</p> <p>(4a, 5a) Development of the Proposed Scheme has sought to keep alignment as low as reasonably practicable and away from main communities. These avoidance measures have protected many</p>	(5) Changes in humidity and increase in temperature - greater number of people sleeping with windows open, may alter propagation characteristics of sound through air.	(5a,b,c) Unlikely / Low consequence. No anticipated effect of noise and vibrations from open windows as the night-time assessment already assumes that windows are open.	No additional mitigation measures required as there is no in-combination impact.	No specific monitoring requirements during operation of the Proposed Scheme.	

² Control of Pollution Act (1974)

³ Environmental Protection Act (1990)

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	All noise effects decrease significantly with distance from track.	<p>communities from likely significant noise or vibration.</p> <p>(5b) Train designs expected to be quieter than current European specifications on noise.</p> <p>(5c) The Proposed Scheme will incorporate noise barriers in the form of landscape earthworks and/or noise fence barriers to avoid or reduce significant airborne noise effects.</p> <p>(4b) Significant ground-borne noise or vibration effects will be avoided or reduced through the design of the track and track-bed.</p>					

Traffic and transport

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources/ receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
All forms of motorised traffic and transport	<p>Construction –</p> <p>(1) Existing rail network to be used for construction (rail possession at night).</p> <p>(2) Roads: temporary diversions, closures, alternative routes.</p>	<p>(1a, 2a) Compliance with Section 14 of CoCP¹.</p> <p>(2b) Realignment of roads during construction and for permanent use after.</p> <p>(2c) Creation of haul route running parallel to alignment.</p> <p>(2d) Restricting road closures to overnights and weekends.</p> <p>(2e) Provision of worker accommodation to reduce daily travel by site workers.</p> <p>(1b) Railway possession measures to be short term and designed for minimum intrusion on regular operations.</p> <p>(2f) The use of borrow pits to reduce construction traffic on highway</p>	(2) Hotter and drier/drought conditions – variation to public transport methods and time spent outdoors.	(2a,d,e) Likely / Low consequence. It is likely that drier/drought conditions will increase the time the public spend outdoors, however, dust suppression measures and compliance with the CoCP ¹ will limit the impact to human receptors during construction works.	No additional measures required as there are sufficient mitigation measures in place.	No specific monitoring requirements during construction of the Proposed Scheme.	3 - Few potential in-combination climate change impacts with low consequences

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources/ receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
		<p>network.</p> <p>(2g) Use of railway to reduce impact on highway network.</p> <p>(1c, 2h) Measures in place to manage/reduce impact on work trips on the highway network during construction</p> <p>(1d, 2i) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p>	<p>(1, 2) Increase in frequency and intensity of heavy rainfall events/flooding - programme delays/ reduced productivity due to poor weather.</p>	<p>(1a,c,d, 2a,c,j) Likely / Low consequence. Whilst the potential for rainfall events and flooding is likely to increase, it is unlikely that increased rainfall events or flooding will cause programme delays or reduce productivity because the construction programme has allocated additional time to account for increased rainfall and saturated material. The rates of excavation during the four month winter period is 50% of the normal rate of 2,000 cubic metres, therefore, minimising the impact of increased rainfall events.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Transport monitoring will include information on how construction traffic will use highway network.</p>	
			<p>(1, 2) Hotter and drier/drought conditions – potential productivity impacts resulting in programme delays.</p>	<p>(1a,c,d, 2a,c,j) Likely / Low consequence. Hotter and drier conditions are likely during construction works. However, there are sufficient measures in place for site workers to cope with warmer conditions during working hours.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>No specific monitoring requirements during construction of the Proposed Scheme.</p>	
<p>Operation –</p> <p>(3) Roads:</p>	<p>Operation –</p> <p>(3a) Reinstatement of</p>		<p>(3, 4) Hotter and drier/drought conditions –</p>	<p>(3a, 4) Likely / Low consequence. Impact could be</p>	<p>No additional measures required as there are sufficient</p>	<p>No specific monitoring requirements</p>	

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	<p>permanent diversions, closures, alternative routes.</p> <p>(4) Reduction of strain on existing rail networks.</p>	<p>most roads on or close to their original alignments.</p> <p>(3b, 4a) Information provided on sustainable modes of transport.</p>	<p>variation to public transport methods and time spent outdoors.</p>	<p>positive or negative.</p>	<p>mitigation measures in place.</p>	<p>during operation of the Proposed Scheme.</p>	
<p>Pedestrian routes</p>	<p>Construction–</p> <p>(5) Footpaths: diversions, closures, alternative routes – temporary and permanent.</p>	<p>Construction –</p> <p>(5a) Compliance with Section 14 of CoCP¹.</p> <p>(5b) Realignment of footpaths during construction and for permanent use after</p> <p>(5c) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p>	<p>(5) Increase in frequency and intensity of heavy rainfall events/flooding - increased flood risk.</p>	<p>(5a,b,c) Likely / Low consequence. PROW are generally described as less vulnerable receptors to flood risk (when compared with property). While increases in rainfall events / flooding is likely, the risk of flooding to PROW is considered to be low. Flood risk analysis has identified a couple of PROW areas (near a section of the River Trent and Filly Brook), however, the modelling does not account for floodplain</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Climate change including flood risk has been embedded into design based on the assessments carried out by the Water Resources and Flood Risk team, therefore, no future measures or monitoring are required.</p>	

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				compensation and mitigation measures. It is believed that with this mitigation the risk of flooding of PROW along the route is negligible.			
	Operation – (6) Footpaths: diversions, closures, alternative routes – temporary and permanent.	Operation – (6a) Replacement or realignment of footpaths and bridleway.	(6) Increase in frequency and intensity of heavy rainfall - increased flood risk.	(6a) Likely / Low consequence. PROW are generally described as less vulnerable receptors to flood risk (when compared with property). While increases in rainfall events / flooding is likely, the risk of flooding to PROW is considered to be low. Flood risk analysis has identified a couple of PROW areas (near a section of the River Trent and Filly Brook), however, the modelling does not account for floodplain compensation and mitigation measures. It is believed that with this mitigation the risk of flooding of PROW along the route is negligible.	No additional measures required as there are sufficient mitigation measures in place.	Climate change including flood risk has been embedded into design based on the assessments carried out by the Water Resources and Flood Risk team, therefore, no future measures or monitoring are required.	

Waste and material resources

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Non-hazardous waste landfill	<p>Construction –</p> <p>(1) Excavated material - approximately 0 tonnes of chemically unacceptable Class U1B material to require off-site disposal to non-hazardous landfill.</p>	<p>(1a, 2a, 3a) It is considered that there will be sufficient non-hazardous waste landfill capacity available to accept the forecast quantity of non-hazardous waste.</p>	<p>(1, 2, 3) Hotter and drier/drought conditions – waste will desiccate instead of decompose.</p>	<p>(1a,b,c,d, 2a,b,c,d, 3a,b,c,d) Unlikely / Low consequence. This is not considered an in-combination impact. Whilst waste will be generated which needs to be disposed of in landfill, no additional waste sites will be needed.</p>	<p>No additional mitigation measures required as there is no in-combination impact.</p>	<p>Monitoring of waste management activities will be undertaken by lead contractors in accordance with Section 15.3 of the draft CoCP¹.</p>	<p>3 - Few potential in-combination climate change impacts with low consequences</p>
	<p>(2) Demolition material and waste – forecast that quantity of demolition waste for off-site disposal would be 7,781 tonnes.</p> <p>(3) Construction waste – approximate quantity of waste that would require off-site disposal to landfill during the overall construction period of 2020 to 2026 would be 43,380</p>	<p>(1b,2b,3b) Management of Construction, demolition and excavation waste (CDEW) and worker accommodation site waste (no worker accommodation sites are currently shown in the design) generated by the Proposed Scheme will be subject to the Environmental Minimum Requirements (EMR) discussed within Volume 1.</p>	<p>(1, 2, 3) Hotter and drier/drought conditions may increase consumption of beverages, increased frequency of waste collection required.</p>	<p>(1a,b,c,d, 2a,b,c,d, 3a,b,c,d) Unlikely / Low consequence. Whilst hotter and drier conditions are likely, there are sufficient mitigation measures in place, including compliance with the EMR requirements. This additional quantity of waste will also be insignificant compared to other waste generated.</p>	<p>No additional measures required as there are sufficient mitigation measures in place.</p>	<p>Monitoring of waste management activities will be undertaken by lead contractors in accordance with Section 15.3 of the draft CoCP¹.</p>	

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	<p>tonnes.</p> <p>(4) Worker accommodation sites - approximately 544 tonnes of waste will require off-site disposal to landfill</p>	(1d,2d,3d) Compliance with the CoCP ¹ .	(1, 2, 3) Hotter wetter conditions - could affect decomposition and odour production (anaerobic more quickly).	(1a,b,c,d, 2a,b,c,d, 3a,b,c,d) Unlikely / Low consequence. This is not considered a significant in-combination impact. Whilst waste will be generated which needs to be disposed of in landfill, the additional odour from this waste will be insignificant.	No additional mitigation measures required as there is no in-combination impact.	Monitoring of waste management activities will be undertaken by lead contractors in accordance with Section 15.3 of the draft CoCP ¹ .	
			(1, 2, 3) Increase in frequency of extreme weather events (e.g. drought, flooding, heat waves) - loss and reduction in quality of available waste and material resources.	(1a,b,c,d, 2a,b,c,d, 3a,b,c,d) Unlikely / Low consequence. This is not considered a significant in-combination impact. Whilst some waste will be suitable for energy recovery, most waste will be sent to landfill and therefore this loss and reduction in quality of available waste and resources is not affected by the	No additional mitigation measures required as there is no in-combination impact.	Monitoring of waste management activities will be undertaken by lead contractors in accordance with Section 15.3 of the draft CoCP ¹ .	

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				Proposed Scheme.			
			(1, 2, 3) Increase in intensity and frequency of heavy rainfall events/flooding – impact excavated soils, turn valuable stock pile into waste through contamination.	(1a,b,c,d, 2a,b,c,d, 3a,b,c,d) Unlikely / Low consequence. It is unlikely that increased frequency of heavy rainfall or flooding will reduce the value of excavated soils during construction because works will comply with the CoCP ¹ .	No additional measures required as there are sufficient mitigation measures in place.	Monitoring of waste management activities will be undertaken by lead contractors in accordance with Section 15.3 of the draft CoCP ¹ .	
	Operation – (4) Railway station and train waste – no stations along Proposed Scheme therefore no waste of this type. (5) Rolling stock maintenance waste – no depot along the line of the Proposed Scheme so no waste	Operation – (6, 7) it is considered that there will be sufficient non-hazardous waste landfill capacity available in the aggregated two regions to accept the forecast quantity of non-hazardous operational waste for off-site disposal to landfill. (6, 7) Some of the non-hazardous waste generated during the operation of the Proposed Scheme will also be suitable for	(6, 7) Hotter and drier/drought conditions - could affect decomposition and odour production.	(6a,b, 7a,b) Unlikely / Low consequence. This is not considered a significant in-combination impact. Whilst waste will be generated which needs to be disposed of in landfill, the additional odour from this waste will be insignificant.	No additional mitigation measures required as there is no in-combination impact.	Monitoring of waste management activities will be undertaken by train operating companies in accordance with statutory requirements.	

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	<p>of this type will arise.</p> <p>(6) Track maintenance waste – all waste will be diverted from landfill via reuse, recycling and recovery therefore 0 tonnes of waste will be sent to landfill.</p> <p>(7) Ancillary infrastructure waste - The quantity of ancillary infrastructure waste that will require off-site disposal to landfill in 2027 will be approximately 37 tonnes.</p>	<p>energy recovery (i.e. incineration). This will reduce reliance on non-hazardous waste landfill capacity.</p> <p>(6) Track maintenance waste - ballast will be recycled off-site.</p>	<p>(7) Hotter and drier/drought conditions - increased frequency of waste collection required, increased consumption of beverages.</p> <p>(6, 7) Increase in frequency of extreme weather events (e.g. drought, flooding, heat waves) - loss and reduction in quality of available waste and material resources.</p>	<p>(7a,b) Unlikely / Low consequence. Given there are no stations along the route of the Proposed Scheme and significantly reduced works on site during operation this is not considered to be a significant in-combination impact.</p> <p>(6a,b, 7a,b) Unlikely / Low consequence. This is not considered a significant in-combination impact. While waste will be generated and resources needed, the quantities are small during operation.</p>	<p>No additional mitigation measures required as there is no in-combination impact.</p> <p>No additional mitigation measures required as there is no in-combination impact.</p>	<p>Monitoring of waste management activities will be undertaken by train operating companies in accordance with statutory requirements.</p> <p>Monitoring of waste management activities will be undertaken by train operating companies in accordance with statutory requirements.</p>	
Hazardous waste landfill	Construction – (8) Excavated material - approximately 6,306 tonnes will require	According to the significance criteria applicable to hazardous waste landfill capacity, the likely significant environmental effects associated with the off-site disposal to landfill of hazardous	(8, g) Increase in frequency of extreme weather events (e.g. drought, flooding, heat	(8a,b) Unlikely / Low consequence. The likely significant environmental effects associated with the disposal of	No additional mitigation measures required as there is no in-combination impact.	Monitoring of waste management activities will be undertaken by lead contractors	

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	<p>off-site disposal to landfill.</p> <p>(g) Demolition material and waste – forecast that quantity of demolition waste for off-site disposal would be 5,187 tonnes.</p>	<p>surplus excavated material, construction and demolition waste generated by the Proposed Scheme would be minor adverse.</p> <p>(8,9a) Detailed chemical sampling and laboratory analysis, as part of future ground investigation works, may allow the hazardous waste to be reclassified as non-hazardous waste. This would reduce reliance on hazardous waste landfill capacity.</p> <p>(8,9b) It is likely that a large proportion of the hazardous demolition waste would comprise asbestos containing materials. This material could be disposed of at non-hazardous landfill sites within a separate cell for Stable Non-Reactive Hazardous Waste (SNRHW) providing it meets SNRHW waste acceptance criteria in accordance with the Landfill Directive⁴ and</p>	<p>waves) - loss and reduction in quality of available waste and material resources.</p> <p>(8, g) Increase in frequency and intensity of heavy rainfall events/flooding – impact excavated soils.</p>	<p>hazardous surplus waste has been considered a minor adverse and, therefore, it is not considered that there is a significant in-combination impact.</p> <p>(8a,b) Unlikely / Low consequence. The likely significant environmental effects associated with the disposal of hazardous surplus waste has been considered a minor adverse and, therefore, it is not considered that there is a significant in-combination impact.</p>	<p>No additional mitigation measures required as there is no in-combination impact.</p>	<p>in accordance with Section 15.3 of the draft CoCP¹.</p> <p>Monitoring of waste management activities will be undertaken by lead contractors in accordance with Section 15.3 of the draft CoCP¹.</p>	

⁴ Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999L0031:EN:NOT>

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		the Proposal for a Council Decision Establishing Criteria and Procedures for the Acceptance of Waste at Landfills. This would reduce reliance on hazardous waste landfill capacity.					
	Operation – Assume no effect post-construction.	No mitigation measures required.	n/a	n/a	n/a	n/a	
Inert Waste	Construction – (10) Excavated material - approximately 674,179 tonnes will require off-site disposal to landfill.	Construction – (10a) There are measures in place for managing soils and subsoils. (10b) In accordance with the significance criteria, the likely significant environmental effects associated with the off-site disposal to landfill of inert surplus excavated material generated by construction of the Proposed Scheme will be minor adverse.	(10) Increase in frequency of extreme weather events (e.g. drought, flooding, heat waves) - loss and reduction in quality of available waste and material resources.	(10a,b) Unlikely / Low consequence. The likely significant environmental effects associated with the disposal of inert surplus waste has been considered a minor adverse and, therefore, it is not considered that there is a significant in-combination impact.	No additional mitigation measures required as there is no in-combination impact.	Monitoring of waste management activities will be undertaken by lead contractors in accordance with Section 15.3 of the draft CoCP ¹ .	
			(10) Increase in frequency and intensity of heavy rainfall events /	(10a,b) Unlikely / Low consequence. The likely significant environmental	No additional mitigation measures required as there is no in-combination	Monitoring of waste management activities will be	

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			flooding – impact excavated soils.	effects associated with the disposal of inert surplus waste has been considered a minor adverse and, therefore, it is not considered that there is a significant in-combination impact.	impact.	undertaken by lead contractors in accordance with Section 15.3 of the draft CoCP ¹ .	
	Operation – Assume no effect post-construction.	No mitigation measures required.	n/a	n/a	n/a	n/a	

Water resources and flood risk

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
Surface water resources	<p>Temporary and permanent effects from construction -</p> <p>(1) Pollution to water courses and associated water bodies.</p> <p>(2) Impact on water resources due to channel realignments.</p> <p>(3) Temporary and permanent channel diversions.</p>	<p>Temporary and permanent effects from construction -</p> <p>(1a, 2a, 3a) Compliance with Section 16 of CoCP¹.</p> <p>(1b, 2b) Comply with the Water Framework Directive⁵ (WFD) compliance strategy to limit effects on surface water resources by avoiding sensitive receptors (i.e. floodplain areas, surface water abstractions) wherever reasonably practical.</p> <p>(2c, 3b) Permanent effect only: where permanent water course diversions or re-alignments are proposed the aim will be to design these with equivalent</p>	(1, 2, 3) Drier/drought conditions – lower flows in water courses, low river flows.	(1a, 2a, 3a) Unlikely / Low consequence. Whilst the risk of drought occurring in the future is likely to increase as a result of climate change, leading to lower than normal river flows, the Proposed Scheme incorporates sustainable drainage systems (SuDS) measures, which will aim to encourage infiltration of storm runoff promoting groundwater re-charge at source wherever this is reasonably practicable.	No additional mitigation measures required because climate change has already been embedded into existing mitigation measures.	No specific monitoring requirements during construction of the Proposed Scheme.	3 - Few potential in-combination climate change impacts with low consequences
			(1, 2, 3) Increase in frequency and intensity of heavy rainfall events/flooding – increased flood risk, increased discharge volume, increased surface water runoff.	(1a, 2a, 3a) Unlikely / Low consequence. Increased frequency and intensity of heavy rainfall events/flooding will not increase flood risk, discharge volumes and surface water runoff because climate change allowances have been incorporated into the design of the Proposed Scheme, in line with the latest guidance from the Environment Agency (EA) (see ES	No additional mitigation measures required because climate change has already been embedded into existing mitigation measures.	No specific monitoring requirements during construction of the Proposed Scheme.	

⁵ The Water Framework Directive, http://ec.europa.eu/environment/water/water-framework/index_en.html

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		<p>hydraulic capacity to the existing channels.</p> <p>(1c, 2d, 3c) Where water courses are natural channels, the design will aim to incorporate appropriate features to retain and where reasonably practicable enhance their hydro-morphological status.</p> <p>(1d) Comply with relevant, pollution prevention guidelines and CIRIA publications as far as reasonably practicable (see Water and flood risk section of Volumes 2 and 3 for further details).</p> <p>(2e, 3d) Where water courses are permanently culverted under the route or beneath proposed highway realignments/diversion or to allow maintenance features (i.e. balancing</p>		Volume 3, Section 16).			

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		<p>ponds) temporary channel realignments may be required to allow new culverts to be constructed in dry conditions.</p> <p>(1e, 2f, 3e) Monitoring will be undertaken in consultation with the Environment Agency prior to, during and after construction to establish baseline conditions for surface water and confirm effectiveness of agreed construction impact mitigation measures.</p> <p>(2g, 3f) Compliance with the extreme weather events clause (5.14) in the CoCP¹.</p> <p>(1f, 2h, 3g) Completion of a Flood Risk Assessment for temporary works.</p>					

1. Resources / receptors potentially impacted by the Proposed Scheme by environmental topic	2. Effects of Proposed Scheme on receptors / resources identified by environmental topic	3. Existing / embedded mitigation measures	4. Potential climate change impacts on resources / receptors	5. Likelihood and consequence of in-combination climate change impacts and effects given existing / embedded mitigation measures	6. Additional mitigation measures to address adverse effects on the ability of resources and receptors to adapt to climate change	7. Allowances for future measures and monitoring	8. Categorisation of topic based on number and consequence of in-combination climate change impacts
	<p>Permanent effects during operation.</p> <p>(4) Potential for accidental spillages that release contaminants into the water environment.</p>	<p>Permanent effects during operation -</p> <p>(4a) Considered in route-wide assessment in Volume 3 (see ES Volume 3, Section 16).</p> <p>(4b) A draft operation and maintenance plan for Water resources and flood risk is provided in Volume 5 (see ES Volume 5, Appendix WR-005-000).</p>	<p>(4) Drier/drought conditions – lower flows in water courses, low river flows.</p> <p>(4) Increase in frequency and intensity of heavy rainfall events/flooding – increased flood risk, increased run-off, increased discharge volume, increased surface water run-off.</p>	<p>(4a, d) Unlikely / Low consequence. Whilst the risk of drought occurring in the future is likely to increase as a result of climate change, leading to lower than normal river flows, the Proposed Scheme incorporates sustainable drainage systems (SuDS) measures, which will aim to encourage infiltration of storm runoff promoting groundwater re-charge at source wherever this is reasonably practicable.</p> <p>(4a,b,c, e) Unlikely / Low consequence. Increased frequency and intensity of heavy rainfall events/flooding will not increase flood risk, discharge volumes and surface water runoff because climate change allowances have been incorporated into the design of the Proposed Scheme, in line with the latest guidance from the EA (see ES Volume 3, Section 16).</p>	<p>No additional mitigation measures required because climate change has already been embedded into existing mitigation measures.</p> <p>No additional mitigation measures required because climate change has already been embedded into existing mitigation measures.</p>	<p>No specific monitoring requirements during operation of the Proposed Scheme.</p> <p>No specific monitoring requirements during operation of the Proposed Scheme.</p>	
Ground water resources	Temporary and permanent effects from construction -	Temporary and permanent effects from construction –	(5, 6, 7) Drier/drought conditions – lower flows in water	(5a,b,c,d,e 6a,b,c,d,e 7a,b,c,d,e) Unlikely / Low consequence. There are no potential climate change impacts on ground water	No additional mitigation measures required because climate change has	No specific monitoring requirements during	

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	<p>(5) Groundwater resources impacted by the construction of tunnels.</p> <p>(6) Pollution to groundwater resources.</p> <p>(7) Loss of features (i.e. springs) due to the construction of culverts etc.</p>	<p>(5a, 6a, 7a) Compliance with Section 16 of draft CoCP¹.</p> <p>(5b, 7b) Comply with the WFD⁵ compliance assessment to limit effects on surface water resources by avoiding sensitive receptors (i.e. Groundwater dependent terrestrial ecosystems (GWDTEs) including natural springs, major public water supplies, ground water abstractions) wherever reasonably practical.</p> <p>(6b, 7c) Existing groundwater abstraction boreholes will be protected from physical damage and for those that need to be decommissioned contractors will adopt good practices.</p> <p>(5c, 6c) Measures introduced to mitigate</p>	<p>courses, reduction in groundwater levels, low river flows and reduced groundwater recharge and levels.</p>	<p>resources during construction works because of the existing water resources and flood risk mitigation measures.</p>	<p>already been embedded into existing mitigation measures.</p>	<p>construction of the Proposed Scheme.</p>	

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		<p>temporary and permanent effects on groundwater flows and water quality during excavation and construction of foundations and cuttings ALARP (see Volume 2, Community Area 1, Section 15 for the types of measures to be adopted).</p> <p>(5d, 6d, 7d) Monitoring will be undertaken in consultation with the Environment Agency prior to, during and after construction to establish baseline conditions for groundwater and confirm effectiveness of agreed construction impact mitigation measures.</p> <p>(5e, 6e, 7e) Completion of a FRA for temporary works.</p>					

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	<p>Permanent effects during operation -</p> <p>(8) Potential for accidental spillages that release contaminants into the water environment.</p>	<p>Permanent effects during operation –</p> <p>(8a) Considered in route wide assessment in Volume 3. Spillage risk is considered very low. Specific measures will be incorporated with regard to incident response, communication with the emergency services and EA and to help contain any spillages that do occur within the drainage systems – with shut-off valves on balancing ponds.</p> <p>(8b) Mitigation measures will include the maintenance of water course crossings and drainage infrastructure.</p>	<p>(8) Drier/drought conditions – lower flows in water courses, reduction in groundwater levels, low river flows and reduced groundwater recharge and levels.</p>	<p>(8a,b) Unlikely / Low consequence. Whilst the risk of drought occurring in the future is likely to increase as a result of climate change, leading to lower than normal river flows, the Proposed Scheme incorporates sustainable drainage systems (SuDS) measures, which will aim to encourage infiltration of storm runoff promoting groundwater re-charge at source wherever this is reasonably practicable.</p>	<p>No additional mitigation measures required because climate change has already been embedded into existing mitigation measures.</p>	<p>No specific monitoring requirements during operation of the Proposed Scheme.</p>	
<p>Flood risk and land drainage</p>	<p>Temporary and permanent effects from construction -</p> <p>(9) Field subsurface drainage systems.</p>	<p>Temporary and permanent effects from construction -</p> <p>(9a, 10a) Ensure these systems can be adapted</p>	<p>(9, 10) Increase in frequency and intensity of heavy rainfall events/flooding – increased flood risk,</p>	<p>(9, 10) Unlikely / Low consequence. Increased frequency and intensity of heavy rainfall events/flooding will not increase flood risk, discharge volumes and surface water runoff</p>	<p>No additional mitigation measures required because climate change has already been embedded into</p>	<p>No specific monitoring requirements during construction of the Proposed</p>	

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	(10) Flooding and impact on floodplains.	<p>to discharge into the new channel.</p> <p>(9b) Temporary provision would be made to manage impacts on existing land drainage systems during construction.</p> <p>(9c, 10b) Compliance with the CoCP¹.</p> <p>(9d) Monitoring undertaken to ensure temporary structures are installed, maintained and removed in accordance with relevant environmental permits whilst minimising impacts on existing land drainage systems.</p> <p>(10c) The impacts of the Proposed Scheme will be considered for a range of design floods up to and including the 1% (1 in 100) annual probability event, including addition</p>	increased run-off, increased discharge volume, increased surface water run-off.	because climate change allowances have been incorporated into the design of the Proposed Scheme, in line with the latest guidance from the EA (see ES Volume 3, Section 16).	existing mitigation measures.	Scheme.	

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		<p>of the relevant climate change allowance.</p> <p>(10d) Proposed Scheme assets critical to operation should all be 1m above, or protected to, the 1 in 1,000 year event.</p> <p>Balancing ponds, drainage designed to encourage water to soak back into the ground and introduce measures to reduce potential significant effects on groundwater flood risk.</p> <p>(9e) Sustainable drainage systems used to remove any suspended material from runoff within the proposed scheme.</p>					
	<p>Permanent effects during operation -</p> <p>(11) Potential for accidental spillages that release</p>	<p>Permanent effects during operation -</p> <p>(11a) Considered in route-wide assessment</p>	<p>(11) Increase in frequency and intensity of heavy rainfall events/flooding –</p>	<p>(11a,b,c, e) Unlikely / Low consequence. Increased frequency and intensity of heavy rainfall events/flooding will not increase flood risk, discharge</p>	<p>No additional mitigation measures required because climate change has already been</p>	<p>No specific monitoring requirements during operation of</p>	

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	contaminants into the water environment.	<p>in Volume 3.</p> <p>(11b) A draft operation and maintenance plan for Water resources and flood risk is provided in Volume 5 (see ES Volume 5, Appendix WR-005-000).</p> <p>(11c) Adherence to NPPF⁶ policies to ensure the Proposed Scheme is safe from flooding. The Proposed Scheme aligns with the Sequential Test and Exception Test policies in NPPF. It will be safe from flooding over its lifetime, without increasing flood risk to vulnerable receptors elsewhere.</p> <p>(11d) SuDS features will store water, promote infiltration at source and re-charge of aquifers wherever reasonably practicable. All ponds lost as a result of the</p>	increased flood risk, increased run-off, increased discharge volume, increased surface water run-off.	volumes and surface water runoff because climate change allowances have been incorporated into the design of the Proposed Scheme, in line with the latest guidance from the EA (see ES Volume 3, Section 16).	embedded into existing mitigation measures.	the Proposed Scheme.	

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		<p>Proposed Scheme will be replaced.</p> <p>(11e) Structures and drainage measures are to be designed to accommodate a 1% (1 in 100) annual probability event including climate change allowances in line with the latest EA guidance (see ES Volume 3, Section 16).</p>					

3 Climate change resilience assessment results

- 3.1.1 The technical scope of the climate change resilience assessment incorporated an initial climate change resilience assessment of all potential climate hazards for all Hs2 Phase 2a infrastructure and assets to the end of their design life; and a further climate change resilience assessment of potentially significant climate hazards for relevant infrastructure and assets associated with the Proposed Scheme to the end of their design life.
- 3.1.2 The spatial scope of the assessment comprised all five of the community areas within Phase 2a. The temporal scope of the assessment included consideration of climate change risks relevant to the design and construction stages (the '2020s') and operation (the '2080s') of the Proposed Scheme.
- 3.1.3 The risk assessment was based on the likelihood of a hazard having an impact on the Proposed Scheme and the consequence of the impact. The definitions of these terms can be summarised as follows:
- likelihood of a hazard is the probability of a hazard occurring and having an impact on the Proposed Scheme, taking into account existing and embedded mitigation measures;
 - consequence of the impact refers to the magnitude of the impact on the Proposed Scheme once the hazard occurs; and
 - risk is the likelihood of a hazard occurring multiplied by the consequence of the impact of the hazard.
- 3.1.4 The risk assessment considered the likelihood of a hazard occurring that could result in an impact on HS2 Phase 2a infrastructure and assets. The risk to the Proposed Scheme is dependent on the magnitude of the consequence of the impact.
- 3.1.5 The potential likelihood and consequence of impacts to infrastructure and assets were scored using a qualitative five point scale. Likelihood levels are summarised in Table 2 and Table 3 and are a combination of the climate hazard level and the impact level. Consequence of impact levels are summarised in Table 4 and were assessed against safety, cost, journey times and public perception criteria. The resulting risk level was then assessed and scored as either 'very high', 'high', 'medium', 'low' or 'very low' using the assessment matrix in Table 5.
- 3.1.6 The assessment of likelihood of impact considered existing or embedded resilience measures already in place or in development for infrastructure and assets. Risks assessed as scoring 'high' or 'very high' would have been considered significant climate change resilience effects and therefore subject to additional resilience measures to protect against the effects of climate change. However, no risks were scored 'high' or 'very high'. Therefore, no significant climate change effects were identified and no additional resilience measures are considered necessary nor are

proposed. The results of the climate change resilience assessment are presented in Table 6.

Table 2: Likelihood levels of climate hazard occurring⁶

Level	Likelihood of the occurrence
Very likely	>90% probability
Likely	>66% probability
As likely as not	>33- 66% probability
Unlikely	<33% probability
Very unlikely	<10% probability

Table 3: Likelihood levels of an impact to HS2 Phase 2a⁷

Level	Likelihood
Very unlikely	Event only occurs in exceptional circumstances and would not be expected to occur during the 120 year lifetime of the project and/or 40 years for lifetime of rail systems and/or 10 years for construction phase
Unlikely	Given design and engineering standards and operation and maintenance plans the event is not expected to occur more than once during the 120 year lifetime of the project and/or 40 years for lifetime of rail systems and/or 10 years for construction phase
As likely as not	Event may occur at least once during the 120 year lifetime of the project and/or 40 years for lifetime of rail systems and/or 10 years for construction phase
Likely	Event expected to occur several times during the 120 lifetime of the project and/or 40 years for rail systems and/or 10 years for construction
Very likely	Event is expected to occur many times during the 120 lifetime of the project and/or 40 years for rail systems and/or 10 years for construction

Table 4: Definition of consequence of impact for different aspects of HS2 Phase 2a

Level	Safety	Cost	Journey Times	Public Perception
Very low	Minor harm or near miss	<£5m	Minor delays	Short-term adverse local stakeholder reaction
Low	Lost time injury or medical treatment required, short term impact on persons affected	£5m to £25m	Significant delays	Adverse local media reports over sustained period; localised stakeholder concern
Medium	Long-term injury or illness, prolonged hospitalisation or inability to work	£25m to £100m	Major delays and cancellations <1 day	Significant local and/or regional reports including social media; national media interest creating public concern

⁶ The values are taken directly from UKCP09. Available at: UKCP09 <http://ukclimateprojections.metoffice.gov.uk/23192>; Accessed 30 April 2017

⁷ Likelihood is the chance that something might happen. By definition, risks are not certain to occur. The likelihood of a risk occurring has been assessed qualitatively using expert opinion and engineering judgement. The likelihood of the impact occurring is evaluated against the levels described. The assessment considers the design and operational and maintenance resilience measures put in place. The definitions of likelihood used here are in combination with the likelihood of a climate hazard occurring.

High	Single fatality / multiple long-term injuries	£100m to £250m	Major cancellations 1-14 days	Extensive prolonged adverse national reporting and public disputes with key stakeholders such as Department for Transport, Network Rail, Transport for London, train operating companies, utility companies or other government agencies such as the Environment Agency.
Very high	Multiple fatalities	>£250m	Severe cancellations >2 weeks	Extensive and prolonged negative reporting nationally and or public disputes with key stakeholders.

Table 5: Risk scoring matrix summarising levels of likelihood of impact and consequence of impact⁸

Consequence	Very high					
	High					
	Medium					
	Low					
	Very low					
		Very unlikely	Unlikely	As likely as not	Likely	Very likely
		Likelihood				
	Risk level	Very low	Low	Medium	High	Very high

⁸ The levels take into account the likelihood of an impact occurring and its corresponding consequence. Risks that are (very) unlikely to occur generally are regarded as an overall low risk with an additional weighting towards the magnitude of the consequence.

Table 6: Climate change resilience assessment results

*Abbreviations for infrastructure and assets:

AD&FC – Abstraction, drainage and flood conveyance systems; **ATS** – Autotransformer stations; **ATFS** – Autotransformer feeder stations; **Buildings** – Buildings; **E&L** – Earthworks and Landscaping; **ERS** – Emergency Response Services (for staff and passengers); **F&NB** – Fencing and Noise Barriers; **FS** - Feeder Stations (National Grid responsibility); **GSP** Grid Supply Points (National Grid responsibility) e.g. Rugeley Power Station; **HS2M&AA** – HS2 maintenance and accommodation accesses (i.e. routes facilitating the movement of HS2 staff and neighbouring landowners); **HF** – Human Factors (i.e. the staff and passenger experience of the Proposed Scheme); **IMB-R** – Infrastructure Maintenance Base - Rail; **LE** – Lineside Equipment; **M&E** – Mechanical and Electrical Equipment; **O&U** – Overbridges and Underbridges; **OLE** – Overhead line equipment; **Planting** – Planting; **RS** – Rolling Stock; **S&C** – Signalling and Communications; **TW** – Track Work (Rail System and Civil Engineering); **TO** – Train Operations; **Tunnels** – Tunnels (including portals and vent shafts); **U&WS** – Utilities and Water Supply; **Viaducts** – Viaducts;

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
High precipitation	Likely increase in projected mean daily rainfall, especially in winter months	Increased risk of flooding from river, surface and groundwater sources	Flooding of track.	Operation	AD&FC; IMB-R; LE; O&U; S&C; TW; TO; Tunnels; Viaducts.	Rail line is designed to a 1 in 100 year + climate change peak river flow event. There is also an additional sensitivity test for resilience to a 1 in 1,000 year event. This will protect the railway infrastructure from floodwater ensuring that the line will remain operational or can restart without undue delay. During operation regular maintenance strategies will be undertaken to ensure continual operation of infrastructure.	Low	No additional resilience measures required.
			Flooding of access roads and/or road infrastructure linked to HS2, such as access routes for HS2 staff and neighbouring landowners.	Operation	AD&FC; ERS; HS2M&AA; HF; O&U; TO;	Access and maintenance routes are designed to a 1 in 100 year + climate change peak river flow event. Drainage is designed to a 1 in 100 year + climate change peak rainfall event.	Low	No additional resilience measures required.

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
High precipitation	See above.	See above.	Water ingress to critical equipment, including traction power distribution sites, leading to signalling or other electronic equipment failures, requiring switch off or, possibly causing damage.	Operation	ATS; ATFS; Buildings; ERS; FS; IMB-R; LE; M&E; S&C; TO; U&WS.	Automatic Transformer Feeder Stations (ATFS) and Automatic Transformer Stations (ATS) are essential in delivering traction power supply to the route. Where practical, ATFS/ATSs will be located outside of Environment Agency flood zones. Where not practical, ATFS/ATSs will be located at flood level with sufficient freeboard above design flood level.	Low	No additional resilience measures required.
			Inundation of tunnels	Operation	TW; TO; Tunnels	Tunnel portals shall be protected by measures such as flood walls and cut-off channels to prevent inundation in the 1 in 1,000 year event without the need for intervention (passive provision). Flood walls will have a freeboard of 300mm.	Low	No additional resilience measures required.
			Construction site flooding during construction phase, excavations flooded and site roads impassable. Safety risk of slips, trips and falls to construction workers	Construction	AD&FC; Buildings; E&L; ERS; HS2M&AA; HF; M&E; U&WS.	Flood risk during construction is mitigated by the draft CoCP and contractors are required to be aware of and take appropriate measures during extreme weather events. Measures on site will also be put in place to prevent flooding	Very Low	No additional resilience measures required.

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
High precipitation	See above.	See above.	Increased risk of scouring of bridge piers and abutments during periods of peak river flow.	Operation	O&U; TW; TO	Scouring risk is reduced through use of reinforced concrete to strengthen structures of abutments and piers. A residual operational risk may remain as a result of scouring of river beds during peak river flow. For new structures in locations exposed to the forces of flowing water, an assessment will be made of the risk of scour. This will consider the risk associated with natural processes (channel migration/ degradation), contraction (increases in velocity from channel narrowing) and local (piers and abutments) scour. Assessments will be based on a range of flood return periods up to 200 years, with protection measures being designed for the highest flow velocities.	Low	No additional resilience measures required.
		Increased soil moisture levels	During prolonged wet winters the combination of low soil moisture deficit and rainfall will increase risk of earthworks failure and landslides	Operation	AD&FC; Buildings; E&L; ERS; F&NB; HS2M&AA; LE; M&E; O&U; Planting; S&C; TW; TO; Tunnels.	Risk of earthworks failure is mitigated by using robust slope design to allow for future changes in soil moisture content and groundwater pressures as well as using appropriate earthworks materials in embankments. Drainage is designed to a 1 in 100 year + climate change peak rainfall event. This is coupled with appropriate slope gradient, material (non-shrinkable soil) and/or planting selection (species and	Low	No additional resilience measures required

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
						location) to ensure earthwork stability as well as continued care of embankments, drainage and (where unavoidable) vegetation management.		
Low precipitation	Very likely increase in the number of dry days per year, especially in summer	Increased risk of soil shrinkage around foundations of structures.	Movement of OHL equipment and other shallow foundations due to soil shrinkage.	Operation	E&L; LE; M&E; OLE; S&C; TO.	Risk of earthworks shrinkage is mitigated by suitable depth of founding, appropriate earthworks material and planting selection/location to ensure volumetric stability as well as continued care of embankments, drainage and (where unavoidable) vegetation management.	Low	No additional resilience measures required.
		Dry weather for extended periods of time could lead to increased desiccation of soils followed by heavy rain fall.	Increased slope stability in general. However, potential earthworks failure during or immediately after summer storm events falling on desiccation-cracked soils. Volumetric instability of track earthworks and loss of track geometry.	Operation	AD&FC; E&L; F&NB; HS2M&AA; LE; M&E; Planting; S&C; TW; TO; Tunnels.	Risk of temporarily lowered slope stability is mitigated using robust slope design parameters to allow for future changes in soil moisture content and groundwater pressures as well as using appropriate earthworks materials in embankments. Volumetric instability controlled by appropriate material and planting selection to ensure earthworks stability.	Low	No additional resilience measures required.

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
Low precipitation	See above.	Dry weather for extended periods of time could lead to increased desiccation of soils.	Earthing and thermal and electrical conductivity issues for high voltage or dynamically loaded cables. In typical ground conditions (i.e. near surface geology and subsoil), ground resistance and electrical and thermal conductivity of earthing arrays and high voltage cables are controlled by a range of factors including the presence of moisture (% water saturation) and temperature. As ground moisture decreases, conductivity also decreases and ground 'resistance' therefore increases.	Operation	E&LLE; M&E; OLE; S&C; TO.	Thermal and electrical conductivity risks mitigated by cables being located sufficiently deep to avoid desiccated soil zones.	Very Low	No additional resilience measures required.
			Impact on the effectiveness of earthing systems for traction power distribution sites, leading to possibility of dangerous Earth Potential Rise and touch voltages. Similarly on effectiveness of Overhead Contact System (OCS) foundation earthing leading to possibility of	Operation	ATFS; ATS; FS; GS	Thermal and electrical conductivity risks mitigated by cables and foundations of OCS earthing being located sufficiently deep to avoid desiccated soil zones.	Very Low	No additional resilience measures required.

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
			dangerous trackside touch voltages.					
High temperatures	Very likely increase in summer maximum temperature and number of hot days.	Increased number of extremely hot days.	Rail buckling and/or associated misalignment problems.	Operation	TW; TO.	Asset will be designed to be resilient to climate change using existing design standards. Maintenance and monitoring measures will also be put in place.	Very Low	No additional resilience measures required.
			Increased heat stress for passengers and staff on trains.	Operation	HF; RS.	Specification of rolling stock will be considered and addressed in future design stages.	Very Low	No additional resilience measures required.
			Increased heat stress for staff, particularly for outdoor maintenance workers.	Operation	Buildings; HF; IMB-R; TO.	Risk of heat stress for staff working indoors during operation is mitigated by buildings being designed to Building Research Establishment Environmental Assessment Method (BREEAM) "Excellent Rating" which includes appropriate climate change measures. Maintenance workers during operation will need to adhere to health and safety standards.	Very Low	No additional resilience measures required.
			Increased heat stress for staff, particularly outdoor construction workers.	Construction	Buildings; HF; IMB-R; TO.	Risk of heat stress to staff during construction is mitigated by contractors required to be aware of and take appropriate measures during	Very Low	No additional resilience measures

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
High temperatures	See above.	See above.				extreme weather events and adhere to health and safety standards.		required.
			Overhead line equipment (OLE) including overhead lines (OHL), traction distribution sites (ATFS, ATS) and other M&E equipment may fail to operate properly under extreme heat resulting in a reduction in electrical loading capability, fail to operate properly or be damaged.	Operation	ATS; ATFS; FS; GS; LE; M&E; OLE; S&C; TO.	Asset will be designed to be resilient to climate change using existing design standards.	Low	No additional resilience measures required.
			Increased risk of thermal expansion joints being pushed beyond their design capability, presenting a direct risk of damage to bridge structures and indirect of damage of other assets dependent upon bridge.	Operation	O&U; TW; TO	Climate change and high temperatures are incorporated into bridge design.	Low	No additional resilience measures required.
			Impact of extreme hot weather could lead to increase in number of days outside the normally acceptable conditions for cooling systems on trains	Operation	TO; RS.	Specification of rolling stock will be considered and addressed in future design stages.	Low	No additional resilience measures required.

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
High temperatures	See above.		and affect efficiency of auxiliary power supply.					
		Increased number of extremely hot days will lead to increased drying out of soils and vegetation.	Planting failures may occur due to drought.	Operation	E&L; Planting.	Planting failures can have a detrimental impact on stability of embankments. This is mitigated against in embankment design requirements. Constraints are also placed on high-water demand plants. Plant selection also takes into account climate change. Green bridges will be designed to retain the water required to support vegetation accounting for climate change.	Very Low	No additional resilience measures required.
			Extended periods of hot days may lead to a risk of grassland fires in vicinity of the route.	Operation	Planting.	Whilst the risk of grassland fires in the Midlands/North West of England is low, planting will avoid fire-prone species and vegetation will be appropriately managed and maintained.	Low	No additional resilience measures required.

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Low temperatures	Overall decrease in prevalence of cold conditions and snowfall, but cold weather events have the potential to be more extreme.	Impacts of extreme cold weather	Overhead line equipment (OLE) including overhead lines (OHL) or aerial bus bars/connections of outdoor switchgear at traction power distribution sites may fail due to snow overloading. Sensitive electronic equipment (protection, control etc.) and mechanical operating mechanisms, moving parts, motors and solenoids may fail to operate due to low temperatures or freezing.	Operation	ATS; ATFS; LE; M&E; OLE; S&C; TO.	Assets will be designed to be resilient to climate change using existing design standards.	Low	No additional resilience measures required.
			Reliability of trains may reduce at low temperatures due to: failure of train horns due to ice/snow accretion; failure of sliding doors, couplers, pneumatic devices and reduced effectiveness of brakes due to ice/snow accretion; traction motor failures due to snow and/or water ingress, and damage from snow and/or ice accretions dislodged at speed. Freight trains more susceptible.	Operation	HF; RS; TO	Specification of rolling stock will be considered and addressed in future design stages.	Low	No additional resilience measures required.

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Low temperatures	See above.	See above.	Possible negative health implications for passengers and staff, disruption to service operation.	Operation	Buildings; HF; IMB-R; TO	Cold weather risk to passengers and staff during operation will be mitigated by appropriate operational management and health and safety plans.	Very Low	No additional resilience measures required.
			Possible negative health implications for staff, disruption to construction.	Construction	Buildings; HF	Cold weather risk to staff during construction is mitigated by contractors being aware of and taking appropriate measures during extreme weather events.	Very Low	No additional resilience measures required.
		Overall decrease in prevalence of cold conditions and snowfall, but cold weather events have the potential to be more extreme.	General risk of freezing of mechanical and electrical equipment.	Operation	LE; M&E; OLE; S&C; TW; TO; U&WS.	Risk of mechanical and electrical equipment freezing is mitigated through preventative measures proposed as part of infrastructure maintenance.	Very Low	No additional resilience measures required.
			Increase risk of rail breaks due to extreme cold conditions.		ATS; ATFS; FS; HF; IMB-R; LE; M&E; OLE; RS; S&C; TW; TO.	Asset will be designed to be resilient to climate change using existing design standards. Maintenance and monitoring measures will also be put in place.	Low	No additional resilience measures required.
			Potential increase in number of days outside normally acceptable range of conditions for heating systems on trains and affect efficiency of auxiliary power supply.	Operation	ATS; ATFS; FS; HF; IMB-R; LE; M&E; OLE; RS; S&C; TW; TO.	Specification of rolling stock will be considered and addressed in future design stages.	Low	No additional resilience measures required.

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
Low temperatures	See above.	See above.	Freezing of earthwork surfaces can inhibit natural drainage and/or cause frost-wedging on rock slopes, leading to instability.	Operation	See above	Risk of earthworks failure due to freeze/thaw cycles is mitigated by using robust slope design parameters to allow for future changes in soil moisture content, as well as using appropriate earthworks materials in the embankment and maintenance measures.	Low	No additional resilience measures required.
Wind	Likely increase in the frequency and intensity of high wind events (with some uncertainty).	Risk of windborne debris due to extreme winds.	Possible blockage of railway drainage systems due to obstructions and windborne debris from domestic or third party objects, as well as potentially landing on track and causing damage to OHL.	Operation	AD&FC; OLE; Planting; TW; TO.	<p>Lineside vegetation and landscape planting areas will be managed to minimise the likelihood of windborne debris blocking water courses and drainage systems, obstructing the tracks or causing damage to OLE.</p> <p>Specific tree species will be avoided to minimise the risk associated with leaf fall.</p>	Very Low	No additional resilience measures required.
		Increased stress on trees due to extreme winds leads to risk of trees/branches falling and changes to leaf fall patterns. Exacerbated by other factors e.g. seasonal	Increased disruption from autumn leaf fall or changed temporal patterns of leaf fall.	Operation	AD&FC; Planting; TW; TO.	<p>Lineside vegetation and landscape planting areas will be managed to minimise disruption due to leaf fall.</p> <p>Specific tree species will be avoided to minimise the risk associated with leaf fall.</p>	Very Low	No additional resilience measures required.

Climate hazard	Trend and likelihood of climate hazard	Potential climate change impact	Potential climate change risk to HS2 Phase 2a	Construction or Operation Stage	Affected infrastructure and assets associated with the Proposed Scheme	Existing / embedded mitigation measures	Assessed risk level = likelihood of hazard X consequence of impact	Proposed additional resilience measures
Wind	See above.	precipitation and temperature patterns.	Wind interference with construction equipment and workers, particularly with temporary equipment.	Construction	HF.	Climate change may increase wind speeds however there is high uncertainty in projections and changes are not considered to be significant by the '2020s'. Therefore additional resilience measures are not required during the construction phase.	Very Low	No additional resilience measures required.
		Increased stress on infrastructure due to extreme winds.	Failure of or damage to parts of structure or infrastructure as a result of changes in extreme winds and gustiness. Noise barriers and fencing are likely to be most at risk.	Operation	F&NB; LE.	<p>Whilst structures in Phase 2a are generally deemed not to be sensitive to wind loading, as there are no slender/suspension bridge types, auxiliary components such as parapets may be vulnerable to wind events. These will be considered and mitigated through measures to be developed during future design stages.</p> <p>Along lengths of HS2 without clearly-defined earthworks (e.g. where landscape mitigation earthworks merge into any structural earthworks required), security fencing should preferably be located where gradient of side-slopes are less than 1 in 3. The steeper the slope, the more likely it is that the fence will start to act as a trap for fallen leaves and branches, litter and other wind borne debris.</p>	Very Low	No additional resilience measures required.

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Wind	See above.	See above.	Failure of or damage to electrical and mechanical equipment including aerial bus bars/connections of outdoor switchgear at traction power distribution sites may fail or be damaged.	Operation	ATS; ATFS; LE; M&E; OLE; S&C.	Climate change may increase wind speeds however there is high uncertainty in projections. This risk will be considered during future design stages with potential mitigation through design change or operational management.	Very Low	No additional resilience measures required.
Lightning	Increases in the number of lightning days are projected for all four seasons, with the largest projected increases occurring in summer, associated with storms.	Increased risk of lightning strikes.	Indirect damage to buildings, structures, line side equipment and equipment and cabling traction power distribution sites from lightning strikes damaging trees.	Operation	ATS; ATFS; Buildings; FS; LE; M&E; OLE; Planting; S&C.	Risk of damage to assets is partially mitigated by planted trees being positioned to ensure that if struck by lightning they would not fall into the route of train.	Low	No additional resilience measures required.
			Direct damage to buildings, structures, lineside equipment and equipment and cabling traction power distribution sites from lightning strikes.	Operation	ATS; ATFS; Buildings; FS; LE; M&E; OLE; Planting; S&C.	Direct risk of lightning strikes will be addressed during further design stages.	Low	No additional resilience measures required.
			Safety risk to construction equipment and workers.	Construction	HF.	Safety risk to construction workers due to lightning is mitigated by contractors taking appropriate measures to manage extreme weather events.	Low	No additional resilience measures required.

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