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High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

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Major accidents and natural disasters risk screening (MA-001-000)

July 2017

ES 3.5.0.14

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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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A report prepared for High Speed Two (HS2) Limited:

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1 Introduction

1.1.1 This Appendix sets out the results of the review process undertaken for major accidents and natural disasters, described in the Scope and Methodology Report[1] (SMR) and SMR Addendum[2], to arrive at the 19 risk events set out in the Environmental Statement (ES), Volume 3, Section 11. It covers High Speed Rail (West Midlands - Crewe) which will pass through the following community areas (CA):

- CA1: Fradley to Colton;
- CA2: Colwich to Yarlet;
- CA3: Stone and Swynnerton;
- CA4: Whitmore Heath to Madeley; and
- CA5: South Cheshire.

1.1.1 A screening exercise of all identified project risks from the source documents listed in Section 1.2.2 was first undertaken to determine if they had the potential to cause a major impact to an environmental receptor, including members of the public. The risks that remained in scope were then grouped into high level 'Risk Events' which have the same potential consequence. For example, all hazard sources and pathways that could lead to a train derailment are combined into a single row, since it is the derailment of the train that has the potential to cause harm to an environmental receptor, regardless of the cause.

1.1.2 Table 1 sets out these grouped risk events, with the identified hazard sources and pathways, and the source document for these, it then describes the reasonable worst consequence if the event did occur and the environmental receptor category which could potentially be impacted.

1.1.3 Table 1 also defines whether the risk event could comprise a major accident or natural disaster in accordance with the definitions presented in the SMR Addendum. These are presented in Volume 3.

1.1.4 Finally, Table 1 summarises the mitigation which is currently embedded within the Proposed Scheme, through legislation, standards, policy and other measures, as defined more fully in Volume 3, and concludes on whether each risk can be considered to be managed 'as low as reasonably practicable' (ALARP).

1.2 Identification of project risks

1.2.1 The assessment has been undertaken in accordance with the methodology described in the SMR and the major accidents and natural disasters Technical Note, found in the SMR Addendum.

1.2.2 The following sources of information, current at the time of producing this appendix, have therefore been reviewed:

[1] *Environmental Impact Assessment Scope and Methodology Report*, Volume 5: Appendix CT-001-001
[2] *Environmental Impact Assessment Scope and Methodology Report Addendum*, Volume 5: Appendix CT-001-002

- Phase 2a Construction, Design and Management (CDM) risk registers[3,4] (live working documents); and
- HS2 Ltd's System Safety Hazard Record[5], (live working document).

1.2.3 The Rail Safety and Standards Board's (RSSB) Safety Risk Model (SRM) v8.1[6] has also been referred to.

1.3 Review of risks

1.3.1 The objective of this risk review is to determine whether additional mitigation measures may be required to manage the identified risks to the environment to be ALARP. This was done in consultation with the ES topic teams for each type of receptor.

[3] Arup CDM register dated 09 December 2016
[4] Parsons Brinckerhoff CDM register dated 23 January 2017
[5] HS2 Ltd's System Safety Hazard Record dated 27 May 2015
[6] Rail Safety and Standards Board (2014), *Safety Risk Model, version 8.1*, RSSB, London, https://www.rssb.co.uk/safety-risk-model/safety-risk-model/Documents/RPBv8-v1.1.pdf

Table 1: Environmental risk record

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
Construction phase									
C1	Tunnel collapse	Tunnelling (bored tunnels)	Phase 2a CDM risk registers	Ground settlement reaches surface resulting in subsidence and structural damage to buildings immediately above	• Agriculture, forestry and soils; • Community; • Cultural heritage; • Health; and • Landscape and visual.	Managed via CDM: tunnel design and construction methods includes risk assessment for overlying structures and monitoring or mitigation if required. Stakeholder engagement/community consultation will elaborate where works are occurring and what stakeholders can do if they have a grievance. A mechanism is in place to address any grievances raised.	No	Yes	The main concern related to this risk is harm to construction workers, which is managed elsewhere. The worst consequence of this risk to in scope receptors does not comprise a major accident as no catastrophic collapse.

[7] In accordance with the definitions in the SMR Addendum (Volume 5: Appendix CT-001-002)

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C2	Ground collapse	Presence of salt / coal along route which is susceptible to subsidence	Phase 2a CDM risk registers	Localised collapse and subsidence of ground at surface	• Agriculture, forestry and soils; • Community; • Ecology; • Health; and • Landscape and visual.	Managed via CDM: geotechnical investigations will inform infrastructure design and construction methods; risks to adjacent properties assessed as part of further investigation and design. Community engagement and grievance mechanism during the construction phase.	No	Yes	The impact on in scope receptors does not constitute a major accident (loss of life). The risk needs to be considered in comparison to the benchmark without the Proposed Scheme in place (the legacy risk of salt and coal mines still exists). During construction, no major accident arising from this hazard.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C3	Offline train derailment / collision on West Coast Main Line (WCML)	Working on or adjacent to existing railway causes a train derailment Falling objects cause train accident or derailment	Phase 2a CDM risk registers	Network Rail (NR) train derails off-track and outside the boundary	• Agriculture, forestry and soils; • Community; • Cultural heritage; • Ecology; • Health; and • Socio-economics.	Risks managed via CDM: risks assessed and managed as part of construction planning; risk management options may include speed restrictions in work areas, lifting plans etc. Consultation with NR and rail service providers. Draft Code of Construction Practice (CoCP)[8] states that emergency procedures for works on the existing railway network will be produced in accordance with established industry procedures.	Yes	Yes	Rules for working adjacent to existing railway are very strict. Possessions or speed restrictions will be required. Properties adjacent to WCML have a benchmark risk level. Risks to construction workers are not in scope. Work will be occurring to NR lines in CA5. Part of the WCML will be realigned (freight and local train lines) as they approach Crewe. Residential and farm properties are located alongside the northern construction boundary for these works (although realignment work is being undertaken to the south).

[8] *Draft Code of Construction Practice*, Volume 5: Appendix CT-003-000

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C4	Major road traffic accident	Working over or adjacent to existing highways (including M6) Realignment of existing roads and bridges during construction Movement of construction vehicles along public roads and adjacent to public rights of way Debris striking traffic / member of public	Phase 2a CDM risk registers	Death and/or injury to a member of the public Delays and congestion in surrounding area	• Community; • Health; • Socio-economics; and • Traffic and transport.	Risks identified and managed via CDM, construction planning, draft CoCP and method statements etc. Road realignments designed in accordance with design codes and in consultation with Highways England (HE) and local authorities etc. Risk to public road users addressed via consultation on design with HE, through design and in construction method statements etc. Risks to public road users assessed and managed in the ES and then as part of construction planning. Overarching controls addressed via draft CoCP and implemented through method statements, traffic management plan etc. There will be a construction workforce travel plan. Example construction controls may include speed restrictions and diversions etc.	Yes	Yes	Traffic and transport sections of the ES in Volume 3 and 5 evaluates and mitigates risks to all public road users associated with the construction works (including road works and use of public roads by heavy goods vehicles (HGVs)). No increased risk above the benchmark accident levels has been identified. Principle of mitigation is to not increase the baseline accident risk to the public using existing roads. Mitigation is reflected in the design of road realignments, construction planning and in the draft CoCP. Principles behind selection of traffic routes are as far as possible, to avoid use of local road network.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
						Whenever reasonably practicable priority will be given to the use of the main road network and on site haul to minimise the impact on local road network and local communities. Geometric constraints on construction routes have been identified and mitigation measures will be implemented including localised widening and junction improvements etc. All new infrastructure designed would be subject to detailed design and safety audit processes to seek to minimise the risk of accidents. Further detail is provided in the Traffic and Transport sections of the ES, available in Volumes 3 and 5.			

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C5	Physical damage or contamination of the aquifer or borehole	Construction through existing contaminated sites and presence of water abstraction boreholes along route	Phase 2a CDM risk registers	Loss of drinking water supply	• Health; • Socio-economics; and • Water resources and flood risk.	Risks managed via CDM: risks assessed and managed as part of construction site selection and construction planning. Construction planning for activities in/through contaminated sites will be informed by site investigation (to understand contamination risks) and risk assessment. Mitigation also includes liaison with Infrastructure Providers (Severn Trent) to minimise risk to supply. Within Source Protection Zone 1 the track design aligns for track bed ceiling, an impermeable membrane, preventing any form of infiltration which would then be captured in the track drainage system to nearest outfall, into a balancing pond. Any drainage feature within Source Protection Zone 1 would be lined.	No	Yes	Risks are assessed and addressed in the land quality and water resources and flood risk sections of the ES, Volumes 3 and 5. Minor leaks and spills are specifically addressed in water resources and flood risk. No major accident scenario associated with this risk.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C6	Spillage or longer term seepage of pollutants into watercourse	Working over or adjacent to water courses	Phase 2a CDM risk registers	Damage to natural habitat or sensitive water course Groundwater - then to drinking water	• Health; • Ecology; • Land quality; • Socio-economics; and • Water resources and flood risk.	Risks of leaks and spills addressed in water resources and flood risk sections of the ES, Volume 3 and 5. (Highways Agency Water Risk Assessment Tool [HAWRAT] assessment[9] undertaken - 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. Risks managed via draft CoCP and Local Environmental Management Plans.	No	Yes	No major accident associated with this risk, mainly because volumes of pollutants are small. Mitigation is in place.

[9] Highways Agency (2009), *Highways Agency Water Risk Assessment Tool v1-0*, www.haddms.com

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C7	Fire and/or Explosion or release of harmful gas	Presence of former landfill sites along route Presence of coal bed methane or other ground gas along route Presence of unexploded ordnance Presence of natural gas transmission pipelines along route (route crossings) Fuel storage at construction sites Wildfire	Phase 2a CDM risk registers	Fire and/or explosion affects neighbouring property and/or members of the public	• Agriculture, forestry and soils; • Air quality; • Community; • Ecology; • Health; • Land quality; • Landscape and visual; and • Water resources and flood risk.	Risks managed via CDM (e.g. site searches, geotech investigations, consultation with utility providers, construction planning, construction siting) and via draft CoCP. Good permanent works design to control long term ground related risks like ground gases. Environmental Management Plans which guide and govern maintenance and management of risks.	Yes	Yes	Greatest risk is to construction workforce. Appropriate measures must be in place (emergency response plans etc.). Wildfire does not present an increase of risk compared to the baseline, as there are no significant volumes of flammable materials and these will be appropriately managed.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C8	Release of asbestos during demolition of buildings and structures	Presence of asbestos in buildings to be demolished	Phase 2a CDM risk registers	Accident during demolition results in uncontrolled release of asbestos containing material and exposure of public to asbestos containing material	• Health	Risks managed via legislation governing the handling and disposal of asbestos containing materials, CDM and resulting construction planning associated with demolition of properties with potential asbestos containing materials, and draft CoCP which specifies: - measures to control risks associated with asbestos dust; and - pre-demolition asbestos surveys- asbestos containing materials to be removed by suitability licensed contractors and in accordance with relevant statutory controls governing its disposal).	No	Yes	The greatest risk is to construction workers (not in scope). Planned demolition works and management of asbestos waste addressed in waste section of the ES, Volume 3. Risk of asbestosis derives from longer term exposure to asbestos dust. If accident occurred, quantity of asbestos and period of exposure to members of public would not be great enough to constitute a major accident.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C9	Extreme weather (flood)	Presence of construction materials, equipment and potential contaminants	Phase 2a CDM risk registers	Loss of equipment and release of contaminants onto land outside construction site Loss of topsoil stockpiles (for restoration of temporary use agricultural land)	• Agriculture, forestry and soils; • Ecology; • Land quality; • Socio-economics; and • Water resources and flood risk.	Draft CoCP (Section 16) includes measures for contractors to manage risks of pollution due to severe weather events, to inform themselves of the potential for severe weather and put in place contingency plans to ensure the resilience of other mitigation required in draft CoCP in the event of severe weather. Draft CoCP advises on location of stockpiles considering predominant wind direction relative to sensitive receptors, away from flood zones and sensitive watercourses where practicable, and covered where necessary. Long term stockpiles to be vegetated.	Yes	Yes	Concern was raised about loss of stockpiles due to extreme weather event impacting on restoration, the draft CoCP deals with stockpile management and weather adequately. Loss of a short term stockpile is not within the scope of a major accident. It does however, need to be appropriately managed.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C10	Collapse / damage to structures	Earthquake Construction activities adjacent to existing structures (piling, construction vehicle impact) Tunnelling	Phase 2a CDM risk registers	Falling debris or collapse of infrastructure affecting a public right of way / public area (e.g. M6 overbridge) Collapse of structure leads to harm to members of public Implications for flood risk, for example, collapsed culvert and the Proposed Scheme embankment starts to impound water and subsequently breached in an uncontrolled manner	• Community; • Health; • Landscape and visual; • Socio-economics; • Traffic and transport; and • Water resources and flood risk.	Construction works adjacent / over public rights of way or to public property are managed via CDM and construction planning. Tunnel design and construction methods includes risk assessment for overlying structures and monitoring or mitigation if required. Construction sequencing - build culverts prior to embankment. Stakeholder engagement/community consultation will elaborate where works are occurring and what stakeholders can do if they have a grievance. A mechanism is in place to address any grievances raised.	Yes	Yes	Seismic design basis will be produced for the Proposed Scheme. No new risk to existing infrastructure arising.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
C11	Member of public using temporary access route at Crewe Station	Fire Fall from height Explosion Mismanagement of passenger flow Inadequate/poor design for passenger flow Emergency conditions	HS2 Ltd's System Safety Hazard Record Phase 2a CDM risk registers	Injury or fatality to member of public	• Community; and • Health.	Clear signage and routing. Station evacuation strategy. Station fire strategy to identify rendezvous points and through routes. From HS2 Ltd's Supply Chain Health and Safety Standard[10]: 'The Network Rail Interface Team provides details of Network Rail's requirements for accessing their infrastructure or assets and the contact details for arranging access. Contractors, suppliers and manufacturers shall comply with all Network Rail requirements when on Network Rail railway infrastructure or in the manufacture and supply of components that could have an impact on their kinetic envelope and/or general operations'.	Yes	Yes	Slips trips and falls are not major accidents so this is not within the scope of this assessment. HS2 passengers are also not within scope of the assessment. This risk relates to existing passengers at Crewe Station who are part of the impacted community and hence a receptor. Ensure that the need for station evacuation and fire strategy at Crewe Station to reflect this change is communicated.

[10] HS2 Ltd (2014), *Supply chain health and safety standard*, https://www.gov.uk/government/publications/hs2-supplier-guide

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
Operation and maintenance phase									
OM1 A	Train derailment or collision (HS2)	Interface with existing railway Object on the line (unauthorised 3rd party access, animals, vehicle incursion, falling trees, failure to provide a secure boundary, landslide material, overbridge or other structure damage due to earthquake or bridge strike) Vandalism and terrorism Failure of safety critical functions and systems (control systems etc.), including cyber terrorism, leading to train failure, signal failure, runaway train, failure in	HS2 Ltd's System Safety Hazard Record Phase 2a CDM risk registers	Off-track and outside boundary derailment Severe disruption to rail transportation, major accident causing harm to staff, passengers and adjacent receptors	• Agriculture, forestry and soils; • Community; • Ecology; • Health; • Socio-economics; and • Traffic and transport.	See text in ES about the measures in place, required by legislation, to manage all train accident risks, in accordance with the Common Safety Method - Risk Assessment (CSM-RA)[11]. Measures have to be accepted by the regulator to manage risks to be ALARP in order for licence to be granted. Comply with standards and where necessary demonstrate other means of mitigating risk from hazard. Good asset information practice. Training to be provided, sufficient resources to be in place. Operation and maintenance (O&M) manuals to be communicated early, robust, maintained, complete etc.	Yes	Yes	System is designed both to reduce the likelihood of a derailment, and manage the impact. The risk to any in scope receptors will be lower than the risk to train passengers and staff, and this latter risk has to be ALARP. If risks to passengers and staff related to train accidents are managed to be ALARP, there is no plausible major accident scenario that can only affect the in scope environmental receptors. Disruption, due for example to emergency response to an unexpected event, does not constitute a major accident. Wilful trespassers (including suicide) have been excluded as

[11] Office of Rail Regulation (2015), *Common Safety Method for risk evaluation and assessment - Guidance on the application of Commission Regulation (EU) 402/2013,* Crown copyright, London, http://www.orr.gov.uk/

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
		controlling the train service, high winds Human factors including driver error leading to train travelling at wrong speed, signal error, error in controlling the train service, bright lights from vehicles on access track leads to unsafe decision, points wrongly set Rolling stock failure Electrical infrastructure failure (including due to lightning or high winds) Structural movement of underbridge or viaduct leads to track problems (due to poor quality of				Safe system of working. Design to appropriate environmental parameters (wind, water etc.), including designed in consideration of climate change. Appropriate human factors considerations. Appropriate back up procedures. Interface with classic network must be timely and of high integrity, the interface is defined and all issues should be addressed. Design of line side features (bridge supports, etc.) in line with code of practice. Use of derailment containment measures where reasonably practicable. High integrity of safety critical functions required in reference and detailed design. High integrity of configuration control, data links and protocols. Limit track gradients in accordance with Technical			receptors, however, the measures in place to provide a secure boundary will mitigate the indirect risk of a train incident related to trespass or suicide. There is a secondary risk that the incident/emergency management plans in place to mitigate these risks ALARP have a temporary or local impact on communities or other receptors. This is covered separately in OM17.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
		materials, scour, poor design/construction, third party bridge strike, earthquake) Ground collapse and/or settlement leads to track problems Track defects (including due to vandalism or inadequate drainage) Insufficient adherence (or other poor wheel rail interface) Points freezing				Specifications for interoperability (TSI)[12], manage vegetation in accordance with TSI maintenance requirements. O&M manual and safe system of working to consider cyber-crime and viruses. Rolling stock design standards, resilient to object incursion at HS2 speeds. Real time monitoring and integrated communication for rolling stock. Minimise use of switches and crossings. Use of single, unified and modern signalling system on HS2 network. Suite of design considerations related to monitoring and control of electrical infrastructure. Adequate braking specifications as requirement/design consideration.			

[12] Commission regulation (EU) 1299/2014 of 18 November 2014 on the *technical specifications for interoperability relating to the 'infrastructure' subsystem of the rail system in the European Union 2014*,Official Journal of the European Union

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
						Include requirement for provision of adequate barriers/protection of overbridges and parallel roads; requirement for design to be adequate to protect railway from incursion by objects or vehicles. Provision of a secure boundary (see Risk OM8 for full list of measures). Design for clearance, signage, bollards to mitigate bridge strike. Ensure integrity of safety related power systems Any safety critical system must have a Safety-Integrity-Level. Real time monitoring and integrated communication takes account of speed, headway conditions and performance and safety requirements. Ensure integrity of monitoring systems. Monitor electrical infrastructure and manage asset information. Models and simulations in design. Integrity of communications and processes.			

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
						Earthing and bonding at sub-stations and other at risk locations (lightning risk assessment).			
OM1 B	Train derailment or collision (maintenance trains)	Interface with existing railway Runaway vehicles and trains (maintenance) Presence of diesel fuel on maintenance trains	As above	Off-track and outside boundary derailment involving single train travelling at low speed, but potentially carrying flammable fuel. No passengers. Diesel spillage contamination	• Health; • Socio-economics; and • Water resources and flood risk.	Mitigation measures listed for risk OM1A are relevant here. Additionally and specifically: • buffer stop risk assessment; • engineering trains require visual inspection before release on to main line; • training to be provided, sufficient resources to be in place; • O&M manuals to be communicated early, robust, maintained, complete etc.; • safe system of working • appropriate human factors considerations; and • limit track gradients in accordance with TSI12, manage vegetation in accordance with TSI maintenance requirements.	No	Yes	The potential for a maintenance train to cause an impact on an environmental receptor is limited to fire which is covered under a separate item. Maintenance trains and passenger trains do not use the line at the same time.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
OM2	Train derailment or collision (WCML)	Interface with existing railway Unauthorised 3rd party access to rail line (including animal) Signal error or failure Vandalism and terrorism Earthquake Flooding Ground collapse Settlement HS2 trains using conventional network not compatible Driver error in transition from HS2 to conventional rail	HS2 Ltd's System Safety Hazard Record Phase 2a CDM risk registers	Off-track and outside boundary derailment Severe disruption to rail transportation Spillage of pollutants	• Agriculture, forestry and soils; • Community; • Ecology; • Health; • Socio-economics; • Traffic and transport; and • Water resources and flood risk.	Overall management of derailment and collision risk to be ALARP is defined for risk OM1A. Interface with the existing railway is included in the CSM-RA. See text in ES about the measures in place, required by legislation, to manage all train accident risks, in accordance with the CSM-RA. Measures have to be accepted by the regulator to manage risks to be ALARP in order for licence to be granted. Must comply with Railway Group Standards to be allowed on the conventional network specify appropriate characteristics on conventional network and check for compatibility. Human factors studies checks and processes to prevent driver error Co-ordination between HS2 and the conventional network must be timely and have high integrity.	Yes	Yes	This risk relates to the interface with the conventional railway, and HS2 trains using NR tracks, joining tracks etc. The risks and mitigations are similar to risk OM1, but merit separate documentation as the interface and the use of infrastructure owned and maintained by others presents a different risk. In terms of impact on environmental receptors, this is not different.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
OM3	Major road traffic accident	Presence of new infrastructure (e.g. new junctions, alignments, cuttings etc.)	Phase 2a CDM risk registers	Major road traffic accident resulting in death or permanent injury to members of public Severe congestion and delays Spillage of pollutants	• Health; • Socio-economics; • Traffic and transport; and • Water resources and flood risk.	The traffic and transport sections in the ES, Volumes 3 and 5, describe the baseline assessment. Traffic surveys are undertaken for all roads with the potential to be affected by the Proposed Scheme supplemented by other available data. The transport assessment (Volume 5: Appendix TR-000-001) also considers public transport (buses) and non-motorised users on public rights of way and cycle paths. Accident clusters are identified, and there are no locations during operation where there are existing safety issues. Road realignments designed in accordance with design codes and in consultation with HE and local authorities etc. Risk to public road users addressed via consultation on design with HE, through design and in construction method statements etc. All new infrastructure designed would be subject to detailed design and	Yes	Yes	No new risk to road traffic compared to baseline assuming bridge and road are designed to standards. No stations in Phase 2a, so operational traffic minimal. Access to infrastructure maintenance base (IMB-R).

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
						safety audit processes to seek to minimise the risk of accidents. An operational work force travel plan will be implemented to manage travel demand. Further detail is provided in traffic and transport section of the ES, Volumes 3 and 5.			

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
OM4	Collapse of structures leading to non-train incident	Bridge strike by train Bridge strike by road traffic Vandalism and terrorism Earthquake Inadequate design of new structures Poor quality of materials (lack of maintenance) Scour failure caused by high winds	Phase 2a CDM risk registers HS2 Ltd's System Safety Hazard Record	Death or injury to members of public (pedestrians, cyclists or road users etc.) Road traffic accident	• Community; • Health; • Landscape and visual; • Socio-economics; and • Traffic and transport.	Design for clearance, signage, bollards to mitigate bridge strike. Structures designed and maintained in accordance with standards. Seismic basis of design will be in place for the Proposed Scheme materials and design to be of sufficient quality for HS2 operating conditions (including monitoring and maintenance) Ensure structures are designed in consideration of environmental conditions including climate change Incident response for bridge strike.	Yes	Yes	New structures will be designed for impact and operational responses to bridge strike will be in place. Note that collapse of structures leading to train incident is covered in risk item OM1.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
OM5	Collapse of embankments	Extreme weather (rain/flood) Blockage of siphons or culverts	Phase 2a CDM risk registers HS2 Ltd's System Safety Hazard Record	Breach of embankment and rapid inundation of land on other side of railway	• Agriculture, forestry and soils; • Ecology; • Health; • Landscape and visual; • Socio-economics; and • Water resources and flood risk.	Rail infrastructure designed to accommodate 1 in 100 (1%) annual probability flood plus climate change and remain safe during a 1:1000 (0.1%) annual probability flood. New road alignments etc. designed in accordance with design manual for highways and streets and local authority requirements. Drainage design including track drainage to comply with standards which includes climate change. Draft water resources and flood risk operation and maintenance plan for water / drainage infrastructure includes provision for blockage removal and maintenance.	No	Yes	This event leading to a train derailment is covered by risk OM1, this risk refers to other impacts of an embankment failure, i.e. failed material impacting on adjacent land; these would not constitute a major accident. Embankment design will include an allowance for extreme weather and climate change.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
OM6	Fire and/or explosion, either direct or indirect harm	Overheating of tunnels Maintenance activities Depot activities Wildfire Electrical fault on train Unexploded ordnance (UXO) adjacent to route Transformer explosion explosive gases within drainage system Fire causes degradation to track/ infrastructure - secondary effect	HS2 Ltd's System Safety Hazard Record	Contamination of aquifer / drinking water supply resulting from run off of fire water Drift of fire from HS2 facility (e.g. depot) into public property (e.g. properties or arable land) with resulting damage to property and/or loss of crops.	• Agriculture, forestry and soils; • Air Quality; • Ecology; • Health; • Land quality; • Landscape and visual; • Socio-economics; and • Water resources and flood risk.	A fire risk assessment must be carried out under legislation, to ensure the safety of the occupants of the tunnel and those in the immediate vicinity who are at risk. A fire management strategy will be drawn up in line with the Technical Specifications for Interoperability - Safety in Railway Tunnels (TSI - SRT)[13]. The fire safety objectives of the project include the protection of the environment. Any drainage contaminated by firefighting operations will be discharged into an attenuation pond and discharged safely in agreement with the Environment Agency. The point of discharge for the attenuation ponds into the wider water environment would be agreed with the	Yes	Yes	Air quality impacts would be temporary and localised. Mitigation of likelihood of fire in place. Impacts associated with fire water runoff is localised and there is no potential to trigger significant effects on receptors. Reference to Fire Strategies for tunnels which describes the processes for management. Contaminants in firewater are unlikely to cause a major accident. Incident response plans to include consideration of local community and receptors, see Risk OM17.

[13] Commission regulation (EU) No 1303/2014 of 18 November 2014 *concerning the technical specification for interoperability relating to 'safety in railway tunnels' of the rail system of the European Union 2014*, Official Journal of the European Union

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						Environment Agency, local water company and local authority and any other relevant stakeholder. Fire policy – tunnels. Electric trains (except maintenance). Fire water should go into drainage and attenuation ponds, no direct pathway for it to reach sensitive receptors. Ensure processes are in place through reference and detailed design. Maintenance trains are diesel, but do not carry flammable materials. Low speed and do not share track with the passenger trains at the same time. The CSM-RA will demonstrate adequate mitigation of the risk of fire to be ALARP No significant quantities of fuel etc. stored in maintenance depots. Fire and emergency response equipment and systems.			

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						Design consideration to include detection and inspection for degradation. Ensure HS2 Ltd is a statutory consultee on neighbouring activities. Comply with standards where applicable. Assess need for firefighting provision and provide facilities on-site if necessary (emergency procedures). IMB-R design to ensure access for emergency services. Safe system of working to cover adequate isolation of power. Assessment of heating/cooling requirements in tunnels as requirement/design consideration. The railway shall not carry hazardous (combustible/explosive) freight.			

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						Heating, ventilation, and air conditioning equipment to be designed for appropriate environmental conditions. Tunnel vent to be designed for appropriate range of conditions inspection and maintenance of drainage.			
OM7	Extreme weather (flood)	Presence of embankments leads to alteration of flood patterns Extreme weather Flooding of underpasses or subways	Technical discussion and water resource and flood risk sections of the ES	Extension/change of flood risk profile impacts property/land Flooding of underpasses or subways	• Agriculture, forestry and soils; • Community; • Cultural heritage; • Ecology; • Health; • Landscape and visual; • Socio-economics; • Traffic and transport; and • Water resources and flood risk.	Rivers and watercourse crossings i.e. viaducts, bridges and culverts are designed to accommodate 1 in 100 (1%) annual probability flood plus climate change to post 2080. For a flood with an annual probability in excess of 1 in 100 (1%) plus climate change allowance, modelling work indicates that the Proposed Scheme will result in only minor localised alterations in the distribution of floodwaters relative to the baseline. The track is designed to remain safe during a 1 in 1,000 (0.1%) annual probability flood. The drainage infrastructure is designed to ensure that no increases in surface water runoff occur from the footprint of the Proposed Scheme,	The impacts do not meet the criteria, but an extreme flood event in itself does	Yes	The difference between 1:100 year plus climate change (where flood events will be mitigated) will not be significant. Important to consider this compared to the baseline without the Proposed Scheme, which would have the potential to be classified as a national emergency anyway. The presence of the railway and the requirement for it to remain safe is a potential benefit, as much of the transport system would not perform as well. While this does not constitute a major

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						including an allowance for increases in peak rainfall intensity predicted to occur due to climate change post 2080. All river, watercourse crossings and drainage infrastructure will be operated and maintained in accordance with the procedures outlined in the draft water resources and flood risk operation and maintenance plan (Volume 5: Appendix WR-005-000). This manual includes provision for debris clearance and blockage removal.			accident, a 1 in 1000 year flood could potentially be a natural disaster over a wider area, therefore important to understand the management and mitigation of this related to the Proposed Scheme. Flooding of underpass or subway not a major accident in itself.
OM8	Accidental drowning	Presence of balancing and attenuation ponds Unauthorised 3rd party access to ponds (trespass, vandalism) Failure to provide a secure boundary	Phase 2a CDM risk registers HS2 Ltd's System Safety Hazard Record	Member of public accidentally falls into attenuation pond and drowns	• Community; and • Health.	Addressed under other legislation: inclusion, design and monitoring of fences/barriers and signage around ponds to prevent access. To provide a secure boundary, HS2 Ltd will put in place the following mitigation measures: • secure fences in place; • risk assessment by location; • tunnelling where appropriate; • passive protection (line	Yes	Yes	Wilful trespassers are outside scope, therefore with signage, fences, monitoring etc. the risk of accidental access is managed to be ALARP.

ID	Risk	Hazard sources and/or pathways	Source document	Reasonable worst consequence if event did occur	Topic	Embedded mitigation	Could this constitute a major accident or natural disaster[7]?	Is this ALARP with existing mitigation?	Clarification
						side security); • identify and remove the desire to cross the railway; • defensive planting; • active protection; • awareness education; • proactive security where appropriate; and • active monitoring (CCTV, electrified fencing).			
OM9	Pedestrians/ equestrians falling/jumping from overbridges	Falling from height due to presence of bridges, viaducts, cuttings etc. Electric shock Overhead line equipment (OHLE) Failure to provide a secure boundary	HS2 Ltd's System Safety Hazard Record	Injury or fatality of member of public	• Community; and • Health.	Addressed under other legislation: • design of bridges (including fencing and barriers) will meet regulatory requirements for safety of pedestrians; • crossings must be compliant with standards; and • provide appropriate and easy to use crossings.	Yes	Yes	Wilful trespassers are outside scope.

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OM10	Vehicle falling from overbridge or adjacent road	Presence of overbridges Steep gradient downhill on approach to HS2 in cutting (only maintenance vehicles using this) Combined HS2 access with public rights of way	Phase 2a CDM risk registers HS2 Ltd's System Safety Hazard Record	Injury or fatality to pedestrians/ cyclists or motorists	• Health; • Socio-economics; and • Traffic and transport.	Crossings must be designed and built to be fit for purpose and compliant with standards. Sufficient barrier/protection proportional to the risk. Allowance has been made for vehicle restraint system (VRS) between track and access roads where roads are adjacent. Spatial provision in other areas of the site left for VRS protection. Provide VRS at the bottom of slopes. Only trained rail staff will be using the access. Slow speed access roads. Provide adequate VRS.	Yes	Yes	Vehicle incursion as a cause of train derailment is covered in risk OM1. This risk deals with harm to motorists. The access road risk relates mainly to maintenance workers which is out of scope.

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OM11	Traffic incident involving pedestrians/ cyclists/ equestrian	Changes to public rights of way, including shared use Combined HS2 access and accommodation access with public rights of way Pedestrian and maintenance vehicle proximity Inappropriate exposure of members of public to depot activities	Phase 2a CDM risk registers HS2 Ltd's System Safety Hazard Record	Injury or fatality to pedestrians/cyclists/horse riders and motorists	• Community; • Health; and • Traffic and transport.	New crossings and road layout to be designed and built to be fit for purpose and compliant with standards. Drivers using road vehicles for maintenance activities. Travel time and distance to be limited, training, procedures and licencing to be in place. Design depot to ensure segregation is appropriate crossings under the railway to be shown designed and built to be fit for purpose and shown to be compliant with standards.	Yes	Yes	This risk relates to the potential for shared access between HS2 maintenance vehicles and members of public using existing rights of way, particularly around the IMB-R. Mitigation relies on appropriate design and construction, and driver training and protocols.

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OM12	Crime / risk to personal safety of member of public	New infrastructure, e.g. bridges and underpasses Assault	HS2 Ltd's System Safety Hazard Record Phase 2a CDM risk registers	Injury to member of public	• Community; and • Health.	Minimum dimensions for public rights of way (headroom / width) will be complied with and are usually exceeded as in all cases identified at present, underpasses are combined public rights of way / accommodation access which have greater clearance requirements: • the underpasses are shown as straight with no hidden niches. (designing out hiding places); • consideration at detailed design stage of measures to avoid blind corners e.g. mirrors, orientation of wing walls etc.; • consideration at detailed design stage of reducing the length to the minimum required for track / drainage requirements; and • consider lighting where required.	No	Yes	Assault on trains or in station is not in scope of this assessment.

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OM13	Injury to member of public; pedestrians, equestrians	Changes to public rights of way, including shared use underpasses Struck by object falling from railway infrastructure or object falling off train (including during high winds)	HS2 Ltd's System Safety Hazard Record Phase 2a CDM risk registers	Injury to pedestrians/cyclists/horse riders	• Community; and • Health.	Maintain structural integrity due to fatigue, corrosion etc. Provide safe environment for passengers, staff and neighbours Stone footpath (FP33) has been realigned further due to the relocation of the IMB-R to Stone. The realigned FP33 has been located to keep the footpath separate from the high security areas of the IMB-R. Investigate requirement for overbridge or underpass crossings for primary roads. For low-speed minor and access roads provide at-grade crossing in combination with appropriate signage for further caution, sufficient lighting to be provided on roads. Design and maintenance of infrastructure and trains. Design structures for high winds.	No	Yes	Member of public access to the track is managed by provision of a secure boundary plus active and passive security measures. This risk covers pedestrians, equestrians and cyclists sharing access with other vehicles due to changes to public rights of way, or being struck by object when using crossings or underbridges, related to risks OM9 and OM11.

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OM15	Injury to member of public using level crossing	Increased train frequency at existing level crossing on WCML	Phase 2a CDM risk registers	Injury or fatality to member of public	• Community; and • Health.	Level crossing risk assessment will be undertaken at GRIP3[14,15]. This may result in the closure of the crossing or the construction of a bridge Currently the crossing is medium risk and there is no NR proposals to close or change to a bridge.	Yes	Yes	There are no level crossings on the Proposed Scheme. However, works associated with the Proposed Scheme and shared use of NR tracks may increase frequency of trains using a WCML level crossing which then requires appropriate risk assessment to manage this risk.

[14] GRIP: Governance for Railway Investment Projects: the process that Network Rail uses to manage developments to enhance or renew Britain's rail network. GRIP3 = Option selection which assesses potential options and selects the most appropriate one to deliver stakeholders' requirements

[15] Network Rail (2016), *Governance for Railway Investment Projects (GRIP)*, Policy, NR/L1/INI/PM/GRIP100 issue 4, Network Rail, London

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OM16	Emergency response impacts on environmental receptors	Incident management plans focus on the safe evacuation of passengers and staff and have the potential to have an adverse effect on local receptors	HS2 Ltd's System Safety Hazard Record	Harm to environmental receptor	• Agriculture, forestry and soils; • Community; and • Water resources and flood risk.	Robust studies carried out at an early stage to provide incident management plans. Incident management plans should be developed and communicated sufficiently early enough to influence design. Ensure plans are maintained, audited etc. Integrity of communications and processes in event of fire or other incident.	The impact in itself is not a major accident but this is an example of where a major accident has the potential to have an impact if not appropriately managed, so yes	Yes	Any impact would be local, temporary and reversible and as such is unlikely to be considered significant against the criteria used in the ES. However for good practice and a robust approach, it is recommended that incident management plans consider the local environmental receptors and are shared with the community where appropriate.

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OM17	Exposure to live conductor/ arcing etc.	Inadvertent contact with live conductor (both workers and 3rd party) OHLE collapse in extreme weather event Hazard to emergency services using water to fight fire	HS2 Ltd's System Safety Hazard Record	Injury or fatality to member of public	• Community; • Cultural heritage; and • Health.	Earthing and bonding undertaken in line with industry standards. Supervisory control and data acquisition (SCADA) system. Isolation and earthing procedures. Provision of a secure barrier. OHLE designed to appropriate parameters including climate change. OHLE to have sufficient protection from flashover.	Yes	Yes	Electric shock resulting from train derailment is part of risk OM1, member of public falls/jumps from overbridge (leading to exposure to OHLE) is risk OM12. This risk is to ensure any other potential pathways where a source of high voltage electricity could reach a member of pubic are captured.

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