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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix CT-001-00001_Part 3

Cross-topic

Environmental Impact Assessment Scope and Methodology Report - Part 3 of 3

M95

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Department for Transport

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Contents

1 Introduction

1.1 Scope and Methodology Report Part 3

1.1.1 This is Part 3 of the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR). It contains the following annexes:

- Annex H – Historic environment technical notes;
- Annex I – Land quality technical notes;
- Annex J – Landscape and visual technical notes;
- Annex K – Socio-economics technical note;
- Annex L – Waste and material resources technical notes; and
- Annex M – Water resources and flood risk technical notes.

Annex H – Technical notes: Historic environment

The following technical notes are contained in this annex:

- Historic environment – Assessment of historic landscape character;
- Historic environment – Risk based approach to prioritising archaeological surveys; and
- Historic environment – Assessment of settings of heritage assets.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Historic environment – Assessment of historic landscape character

Contents

1 Introduction

1.1 Scope and purpose

1.1.1 This technical note provides a methodology for identifying baseline conditions and undertaking the assessment of effects of the Proposed Scheme on the historic landscape using extant historic landscape assessments data; National and local Historic Landscape Character (HLC) project data in England and Historic Land-use Assessment data in Scotland, including the Geographical Information System (GIS) dataset itself and any supporting or embedded non-GIS files such as databases, reports and user guides.

1.1.2 The historic environment includes archaeological and palaeoenvironmental remains, historic buildings and historic landscapes. A heritage asset comprises any building, monument, site, place, area or landscape identified as having a degree of heritage value meriting consideration in planning decisions as a result of its heritage interest.

1.1.3 Historic landscape assessments undertaken since the 1990s have enabled a deeper understanding that landscape has a historic dimension but, aside from in Wales, there are, as yet, few areas in the UK that are formally identified and treated as heritage assets on historic landscape grounds. In the context of managing change in the historic environment, historic landscape mapping is often used to identify areas with coherent or distinctive historic landscape characteristics, referred to as Historic Landscape Character Areas (HLCAs). For the purposes of impact assessment HLCAs are equated with heritage assets and assessed as receptors using the same criteria as used for other heritage assets. Well preserved and/or distinctive historic landscapes can have significant heritage value in their own right. Analysis of HLC mapping can also help to describe the value of other categories of heritage asset, including any contribution made by their settings, by allowing an understanding and articulation of the landscape context for those assets.

1.1.4 The Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR) identifies that baseline sources will include historic landscape mapping, and that the Environmental Statement (ES) will assess the potential effects of the Proposed Scheme on HLCAs formed from critical evaluation of historic landscape mapping.

2 Background

2.1 Historic Landscape Assessment

Historic Landscape Characterisation in England

2.1.1 HLC in England comprised a national programme, sponsored by Historic England and its predecessor body English Heritage, and carried out in partnership with local government archaeological services at county, unitary authority and National Park level. The fundamental aims of HLC were to map the historic dimension of the present day landscape in a comprehensive, not selective manner (i.e. no blank spaces) and to view the historic landscape in terms of areas, as opposed to individual sites.

2.1.2 The key principles of HLC are:

- projects comprise desk-based studies using Geographical Information Systems (GIS) and historic maps;
- the landscape is assessed by looking at all its major component features (e.g. fields, woodland, parklands, industrial and urban areas) and determining their origin and development through morphological analysis supported by documentary evidence, aerial photographs, historical mapping and chronological editions of Ordnance Survey maps; and
- information gathered is mapped as HLC 'types' and recorded in a GIS format. This results in the production of multifaceted maps enabling sophisticated analysis and interpretation of the predominant historic character.

2.1.3 The majority of England is now covered by HLC data prepared at local authority level. The projects were undertaken over a long timeframe (c.1994 - 2016) and most used bespoke methodologies which evolved significantly over that time. Further background on the evolution and early use of HLC is available in two reports published by English Heritage (Aldred & Fairclough 2003[1]; Clark, Darlington & Fairclough 2004[2]). The methodological evolution allowed projects to incorporate innovations or lessons from previous HLC projects and/or greater focus on aspects of the historic landscape of particular interest to that project area. It had the side-effect of meaning that adjoining HLCs, if done at differing times, could deploy quite different methods and typologies to describe fundamentally similar historic landscape types (HLTs)[3] (e.g. extensive areas of planned enclosure, such as that deriving

[1] Aldred, O. & Fairclough, G. (2003), *Historic Landscape Characterisation: Taking Stock of the Method.* (London: English Heritage/Somerset County Council).

[2] Clark, J., Darlington, J. & Fairclough, G. (2004), *Using Historic Landscape Characterisation, London: English Heritage / Lancashire County Council.*

[3] The term "historic landscape types" is applicable to types as identified in English local authority HLC and NHLC outputs and in the Scottish HLA.

from the process of parliamentary enclosure) and informed by other sources (see paragraph 3.2.6).

2.1.4 The Proposed Scheme traverses two regional archaeological advisory areas, both of which possess HLCs (date of HLC completion/publication in brackets where available):

- Cheshire (2007); and
- Greater Manchester (2012).

2.1.5 Both were executed to differing methodologies, as methodologies were developed over time and bespoke to the area being assessed. The HLCs are a valuable body of work for the interpretation and understanding of the historic environment, but, owing to their method of execution, the ability to use them in projects which cross boundaries between HLCs is hampered.

2.1.6 The Proposed Scheme has used local authority HLC data for Phase One and Phase 2a. A key lesson learned from these phases was that local authority HLC data required a significant rationalisation, both to remove issues within the GIS data (i.e. overlaps and gaps within HLCs, edge-matching between HLCs) and in terms of the consistency of terminology between datasets, to allow meaningful assessment and reporting.

2.1.7 In 2017, the National Historic Landscape Characterisation (NHLC) project was initiated by Natural England to develop a single, consistent, baseline historic landscape characterisation dataset for England. Historic England were a key part of the project's steering group. The object of this project was to develop a single, consistent, baseline HLC dataset for England from the extant local authority HLC datasets.

2.1.8 The dataset resulting from the NHLC project is intended to be used strategically in land management, forward planning and the assessment/monitoring of change, as well as for other curatorial and academic purposes. The dataset is gridded and presented at two scales; one a grid of 500m squares and the other a grid of 250m squares. It records information primarily at the level of the dominant current historic landscape type recorded within that grid square within the source local authority HLCs. The NHLC records some information on the non-dominant current HLTs and any past HLTs recorded as occurring in the grid square – again derived from the source local authority HLCs.

2.1.9 The NHLC dataset is an appropriate source of historic landscape information when used alongside other baseline sources. As such, HLC mapping derived from it will be used in the assessment.

Historic Landscape Characterisation in Scotland

2.1.10 Mapping historic landscapes has been addressed in a similar way in Scotland in the form of the Historic Land-use Assessment (HLA) project[4]. This began as a partnership project between Historic Scotland and the Royal Commission on the Ancient and Historical Monuments of Scotland undertaken by a dedicated project team[5]. Mapping for the project was undertaken between 1996 and 2015 and, although digital outputs (emerging GIS coverage and project area reports) have been available online since 2004, the completed project been recently launched formally by Historic Environment Scotland accompanied by a series of synthetic reports on Scotland's historic landscapes[6]. Whilst HLA adheres to the same principles as HLC it was, importantly, designed and executed at a national level from inception so provides a complete and coherent coverage for the whole country, which uses a consistent terminology.

2.1.11 The HLA dataset is an appropriate source of historic landscape information when used alongside other baseline sources. As such, it will be used in the assessment.

2.2 Historic Landscapes and the European Landscape Convention

2.2.1 The historic landscape assessment approach accords with the tenets of the European Landscape Convention (hereafter 'the Convention'). This defines landscape as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors'[7]. The Convention (Article 2 – Scope) covers natural, rural, urban and peri-urban areas. It includes land, inland water and marine areas. It concerns landscapes that might be considered outstanding as well as common or degraded landscapes.

2.2.2 The historic landscape is defined both by people's perceptions of the evidence of past human activities in the present landscape and the places where those activities can be understood in the landscape today. This definition highlights the role of perception and emphasises the rich cultural dimension implanted in landscape character by several millennia of human actions. The Convention's aspirations are to help create high quality landscapes for the future; their historic character will be an important part of that quality.

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[4] Project webpage. Available online at: https://hlamap.org.uk/

[5] Both bodies merged to become Historic Environment Scotland in 2017.

[6] Historic Environment Scotland (2018), *Historic Land-use Assessment of Scotland, 1996-2015.* Available online at: https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=29bf6011-b650-40d6-9cd2-aa2a00b5d26b.

[7] Council of Europe (2000), European Landscape Convention, Florence, CETS No.: 176. Available online at: http://conventions.coe.int/Treaty/EN/Treaties/Html/176.htm.

2.3 Historic Landscapes and Landscape Visual Impact Assessment

2.3.1 Historic landscape assessment has a direct relevance to Landscape and Visual Impact Assessment (LVIA).The latest LVIA guidelines[8], issued by the Landscape Institute, have specifically stressed the importance of historic landscape mapping contributing towards the baseline of landscape character assessment, the need for collaboration with historic environment specialists to fully understand how the past has contributed to the character of today's landscape and for it to be represented in the Landscape Character Areas (LCAs) which result from this process. In response, the landscape and visual assessment for the Proposed Scheme has adopted an interdisciplinary approach to developing LCAs with a number of topics contributing to the understanding of landscape character, e.g.: topography, geology/soils, natural environment, land use, soundscape studies as well as the historic environment.

2.3.2 Historic landscape mapping contributes one component or piece of evidence for landscape character assessment, it does not 'double count' or duplicate the historic environment assessment within the ES.

2.3.3 In addition, the holistic approach used in landscape character assessment may result in defining LCAs that are spatially different to HLCAs. There may be circumstances where boundaries do align, such as the extent of a historic park and garden.

[8] Landscape Institute and Institute of Environmental Management and Assessment (2013), *Guidelines for Landscape and Visual Impact Assessment,* Third Edition. p. 76 paras 5.9-5.10.

3 Methodology for understanding historic landscape within the ES

3.1 Introduction

3.1.1 The approach uses a character-based method. HLC mapping derived from NHLC data will be used to determine HLCAs in England and HLA data will be used to form HLCAs in Scotland. HLCAs are areas of coherent or distinctive historic landscape characteristics. They will enable consideration of attributed value, and assessment of impact, to determine the significance of effect of the Proposed Scheme in accordance with the EIA SMR.

3.2 Defining Historic Landscape Character Areas (HLCAs)

3.2.1 HLCAs are distinct from archaeological remains and historic buildings in that they are concerned with history and character on a broad landscape scale. HLCAs provide a focus in regard to managing change to historic landscape character, ensuring effects to this aspect of the historic environment can be assessed as part of the EIA process and factored into an iterative design process to enable schemes to integrate with and, if possible, enhance the local HLC.

Key considerations

3.2.2 HLCAs will be determined where the historic landscape has broadly distinct areas of homogeneity and/or distinctiveness. In some cases, this distinctiveness may derive from an area of land being very varied so that it stands in stark contrast to other, more coherent landscapes.

3.2.3 Baseline data for gathering historic landscape datasets is inclusive of a 2km study area either side of the land required for the construction of the Proposed Scheme, as set out in the EIA SMR However, no fixed study area is prescribed in which to identify HLCAs. This is to allow for the definition of appropriately scaled HLCAs and recognises that areas of distinct historic landscape will vary in extent along the route. That notwithstanding, HLCAs will be created in a way that is meaningful, i.e. that captures those areas which may experience effects due to the proposed development and coheres with the approach to study areas given in the EIA SMR. The boundaries of HLCAs will be determined by consideration of the nature and patterning of HLTs.

3.2.4 In some cases, HLCAs may be influenced by factors such as topography and geology as these physical factors influence agriculture, industry and settlement. In these instances, HLCAs may align closely with the LCAs prepared by the landscape and visual assessment team. There may be some areas defined as HLCAs that, owing to the nature of recent land-use, have limited or no heritage value. In such cases, the reasons for this this is to be clearly explained in accompanying reporting and any decision to exclude such HLCAs from further consideration is to be fully and robustly justified.

3.2.5 The process of analysing HLC data and forming HLCAs will contribute to the historical dimension of a LCA. This will include collaboration with the landscape and visual assessment team so that a common understanding is developed of how historic processes have shaped the landscape and are expressed within it. This collaboration will aid the landscape team in gaining an understanding of the historic features within the landscape.

Defining HLCA polygons

3.2.6 An understanding of a unique HLCA is drawn primarily from:

- historic landscape mapping;
- historic mapping, including tithe maps, estate maps and first edition Ordnance Survey;
- Historic Environment Record (HER) data;
- aerial photography;
- project specific data drawn from historic air photographs, LiDAR and site visits; and
- a review of existing LCA boundaries/typologies.

3.2.7 From the sources above, the author will identify the boundaries and characteristics of the HCLA based on an analysis of overall historic development trends and the following factors:

- patterning (homogeneity or variance) of HLTs in terms of type, relationships[9] and date;
- variation in apparent survival level[10] of historic landscape features; and
- professional judgement.

3.3 Baseline reporting

3.3.1 Baseline reporting will comprise a text-based narrative within a pro-forma table - this allows for the evaluation of key characteristics for a number of categories in order to provide a broad characterisation of the historic landscape. This should include data for any landscape designations and available historic landscape data, along with an initial assessment of the value of the HLCA concerned. These will be reported in an HLCA map sheet, which will be included within the technical appendices to the ES (Volume 5).

[9] i.e. the presence of types that are inherently related to on another such as assart fields and ancient woodland.

[10] This aspect can be initially evaluated from comparing recorded HLT with aerial photography. Examples can include whether vegetation, particularly hedges, look to be denuded (survive poorly) or relatively intact (survive well), or ridge and furrow is extant and visible as earthworks (survive well) or are ploughed out (survive poorly).

3.4 Assessing impact and effect on HLCAs

Assigning value

3.4.1 The heritage value of the HLCA will be described in line with the EIA SMR and professional judgement. Key attributes that contribute to this value are defined through Conservation Principles, Policies and Guidance published by English Heritage (now Historic England) in 2008[11] as follows:

- Historic and communal value – illustrative value (illustrating past events, places or people), communal value (commemorative or symbolic), and associative value (association with a notable person, event or movement);
- Evidential value - archaeological interest or research value;
- Artistic value - Architectural and artistic interest, contemporary appreciation of the asset's aesthetics;
- Historical and cultural associations (links to historic interest) – this relates to the value of a place's association with important historical events and themes, eras, patterns of use and development or individual people. It incorporates the history of aesthetics, artistic and literary, architecture, archaeology, science and society, so it overlaps (or underlies) the other categories of heritage value; and
- Research potential (links to archaeological interest) – this relates to the technical achievements associated with a place, or to its educational potential. It also encompasses places important to furthering the understanding of the natural and altered environment, and the embodiment of heritage research.

3.4.2 Each of these attributes will be graded as high, moderate, low, or not significant and will contribute to defining the overall value of the HLCA as shown on the HLCA map sheet.

3.4.3 Whilst Scotland does not currently employ a system directly analogous to Conservation Principles, its historic environment protection regime developed from the same shared legislation and underpinning principles, including guidance for listing and scheduling, as that of England and likewise focuses on understanding the value of heritage assets to enable their sustainable management in the context of informed change. As such, a method based on the language of Conservation Principles is appropriate for articulation of the value of any HLCAs lying within Scotland that may be affected by the Proposed Scheme.

3.4.4 There is no formally adopted methodology for assessing the value of an HLCA. The methodology utilised here is informed by guidance issued by the International Council on Monuments and Sites (ICOMOS) guidance on Heritage Impact Assessments for Cultural

[11] Historic England (2008), *Conservation Principles – Policies and Guidance for the Sustainable Management of the Historic Environment.* English Heritage, Waterhouse, London.

World Heritage Properties[12], Conservation Principles, and Highways Agency (now Highways England) and Historic England[13] guidance on assessing the effects of road schemes on historic landscapes. This guidance has been withdrawn and is no longer formally promoted by Historic England. However it does not conflict with any current guidance, and in the absence of revised historic landscape specific guidance, this remains an appropriate basis for defining the criteria for evaluating HLCAs as presented in Table 1.

Table 1: General value rating table for historic landscape - adapted from 'Assessing the effect of Road Schemes on Historic Landscape Character'

Value	Typical Heritage landscape values- historic, archaeological, architectural/ artistic, historic and cultural associations, research potential	Typical design considerations – rarity of historic elements, age/period coherence, legibility of historic landscape, capacity to absorb change
High	Designated or non-designated historic landscapes of outstanding interest Non-designated landscapes of high quality and importance, and of demonstrable national importance Well preserved historic landscapes, exhibiting considerable coherence, time depth or other critical factor(s)	Less static areas of landscape which are capable, in principle, of absorbing some well-managed changes Sensitive to the cumulative impact of small-scale changes Presumption against development that significantly alters the character and fabric of the historic landscape May need to provide some heritage improvements/dividends
Moderate	Designated special historic landscapes Non-designated historic landscapes that would justify special historic landscape designation landscapes of regional importance Averagely well-preserved historic landscapes with reasonable coherence, time-depth or other critical factor(s)	Dynamic landscape in which a mixture of modern and historic elements pre-supposes a capacity, in principle, to absorb most types/scales of essential, well-managed change Desirable that development enhances the residual character and fabric of historic landscape where possible
Low	Non-designated historic landscapes of local importance Historic landscapes with specific and substantial importance to local interest groups, but within limited wider importance Historic landscapes whose importance is limited by poor preservation and/or poor survival of contextual associations Historic landscapes where further investigation would add no significant additional information	High potential to absorb essential change based on former trends towards removal of the historic dimension Considerable scope for historic landscape enhancement, especially where it is possible to draw on the qualities of adjacent historic landscape character
Not Significant	Landscapes with little or no significant historic character or sensitivity	Very little scope for historic environment enhancement

[12] ICOMOS (2011), *Heritage Impact Assessments for Cultural World Heritage Properties*. ICOMOS. 49-51 rue de la Fédération 75015 Paris, France.

[13] Highways Agency and Historic England (2007), *Assessing the Effect of Road Schemes on Historic Landscape Character.*

Magnitude of impact of the Proposed Scheme

3.4.5 Reporting of the magnitude of impact on the HLCA should include a discussion of the elements of the Proposed Scheme which will extend into the HLCA, and how these will physically alter identified key elements of the HLCA which have been identified as contributing to its value. A judgement of the capacity of the HLCA to accommodate change as a result of the Proposed Scheme could also be considered and presented where relevant. An HLCA characterised by linear industrial features, such as major roads and canals, is likely to have a greater capacity to absorb an additional linear development without experiencing a significant change to its heritage value. Further guidance is provided in Table 1of this technical note and in Section 13 of the EIA SMR. Assessment should also take into account the duration and reversibility of the impact.

Significance of effect

3.4.6 The significance of effect will be reported in accordance with Section 13 of the EIA SMR. Any predicted effect as a result of the Proposed Scheme on the historic landscape greater than minor is considered to be a significant effect.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Historic environment – Risk based approach to prioritising archaeological surveys

Contents

1 Introduction

1.1 Introduction

1.1.1 This technical note sets out a priority-based methodology for the identification of areas for non-intrusive archaeological survey. It considers the extent to which the potential for encountering previously unknown archaeological remains during construction presents a risk to the Proposed Scheme. As a result, areas within the land required for the construction and operation of Proposed Scheme with varying degrees of potential for the presence of previously unknown archaeological remains are assigned a 'risk ranking'.

1.1.2 The methodology presented has been developed in consultation with Historic England (HE), and Local Planning Authority (LPA) archaeological officers. The approach is based on that developed and implemented for HS2 Phase 2a[1], which itself was based on a technical note developed for HS2 Phase One.

1.1.3 The approach to determining priority areas for survey presented in this technical note seeks to assess the archaeological potential of the landscape as a whole and recognises the possibility that there may be land access issues that limit areas available for non-intrusive survey work.

1.1.4 Areas prioritised for survey, for the purposes of this methodology, are defined as areas within the land required for the construction and operation of the Proposed Scheme where additional knowledge regarding the potential presence or character of buried archaeology will assist in more fully understanding the value of the heritage assets and the level of harm to that value which might be anticipated.

1.1.5 The methodology comprises an approach to the landscape that defines distinct areas of archaeological character; initially as broad Archaeological Character Areas (ACAs), and then more narrowly as Archaeological Sub-zones (ASZs). The latter are then used to define areas of priority for non-intrusive survey.

1.1.6 Prioritising areas for survey uses a risk-based approach (the 'risk model'), and can be broken down into two distinct phases, which are subject to ongoing review, as understanding of the heritage resource increases:

i) development of a spatial model; and

ii) assignment of risk rankings to each ASZ.

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[1] High Speed Two Ltd (2016), High Speed Rail (West Midlands – Crewe), *Environmental Statement. Environmental Impact Assessment Scope and Methodology Report, Technical Note: Risk Based Approach to Prioritising Archaeological Surveys: Technical Note.* Available online at: https://www.gov.uk/government/publications/scope-and-methodology-report-for-hs2-phase-2a.

1.2 Predictive modelling

1.2.1 Data bias is an inherent problem in the production of archaeological predictive models. Detailed knowledge of known heritage assets is often informed by developer-funded archaeological fieldwork. As a result, information concerning the historic environment, as presented in LPA Historic Environment Records (HERs), can result in a bias in relation to those areas that have been subject to investigation. Fieldwork undertaken in association with large-scale infrastructure projects has, in many areas thought to be devoid of buried archaeology, identified multi-period archaeological evidence[2].

1.2.2 Development-focused fieldwork, particularly on linear projects traversing areas of varying landscape characteristics, provides an opportunity to enhance data held by the HERs. Further detail on archaeological predicative modelling can be found in Kamermans *et. al.* (2009)[3] and Verhagen and Whitley (2012)[4].

1.2.3 The process of defining ACAs and ASZs requires the analysis of baseline data relating to individual heritage assets, combined with a broad understanding of local landscape history and the physical environment in order to construct an overall appreciation of the historical character of the landscape (see Technical Note: Historic Landscape Character). This approach is facilitated by the collation of a range of sources collated during the Environmental Impact Assessment (EIA).

[2] Examples of this include A421 Great Barford Bypass (Brown et al 2007) and A428 Caxton common to Hardwick (Abrahms and Ingham 2008) where areas of clay lands not thought suitable for agriculture have identified evidence of activity from the Neolithic to medieval periods.

[3] Kamermans, H, van Leusen, M, and Verhagen, P (2009), *Archaeological Prediction and Risk Management Alternatives to Current Practice.* Archaeological Studies Leiden University 17.

[4] Verhagen, P. and Whitley, T. G. (2011), I*ntegrating Archaeological Theory and Predictive Modelling: a Live Report from the Scene,* Journal of Archaeological Method and Theory (2012) 19: 49. doi:10.1007/s10816-011-9102-7. Available online at: http://link.springer.com/article/10.1007/s10816-011-9102-7

2 Methodology

2.1 Baseline data collection

2.1.1 Baseline data sources are set out in full in the EIA Scope and Methodology Report (SMR).

2.1.2 Archaeological Character Areas and ASZs should be defined based on data gathered as part of the EIA process. No additional data gathering will be required to inform initial ASZ risk rankings.

2.1.3 Defined ACAs and ASZs should be developed in draft form and will be reported in Volume 5 of the Environmental Statement (ES).

2.2 Defining Archaeological Character Areas

Purpose

2.2.1 Archaeological Character Areas are intended to provide a high-level geographically based contextual framework for the analysis of known buried archaeological remains. ACAs will provide an understanding of the archaeological character of the historic environment in a broad landscape unit, facilitating the identification and sub-division of the landscape into ASZs.

Guidance on defining ACAs

2.2.2 Archaeological Character Areas will be defined for the entire length of the Proposed Scheme, using professional judgement, and broadly within the study areas set out in the EIA SMR, which comprise:

- 500m from the boundary of land required for the construction and operation of the Proposed Scheme (in rural areas);
- 250m (in urban areas); and
- 100m from the centreline of mined or bored tunnels.

2.2.3 Archaeological Character Areas are intended to define areas of consistent archaeological character, such as prehistoric activity in river valleys or areas of dispersed medieval settlement. As a result, ACAs should be broadly defined. The archaeological understanding required for broad definition should include a consideration of the different periods and types of remains present in each ACA and how particular qualities of the ACA combine to create a distinctive archaeological character.

2.2.4 The definition of ACAs should be informed by a consideration of the geology, topography and geography of an area supported by the results of relevant or notable fieldwork. Both solid and drift geology, and overlying soils should be considered.

2.2.5 The Proposed Scheme traverses regions of contrasting landscape character, geology and topography and there will be a number of ACAs identified across the route. It is unlikely that ACAs will correspond with community area boundaries. Terminology must be consistent between community areas.

2.2.6 The definition of each ACA should not be presented as an exhaustive list of archaeological interventions, but as an overarching review of those archaeological investigations in the ACA that particularly characterise the ACA and make it distinct. It should include an analysis of how land use, geology, topography and geography have influenced the type, visibility and survival of archaeological remains within the ACA.

2.2.7 Current land use may inform the archaeological understanding of the ACA, but will not be sufficient to define the ACA. Not all archaeological sites are influenced by land use. For example, the location of prehistoric funerary monuments may not have been confined to upland arable, but current land use determines where they may be most visible during survey. Discussion of current land use should be considered in terms of how it can provide information regarding the archaeological potential of the ACA.

2.3 Defining Archaeological Sub-zones

Purpose

2.3.1 Archaeological Sub-zones will provide more detailed analysis of the known and potential archaeology in the area, as a basis for the 'risk ranking' (see Table 1) used to prioritise areas where non-intrusive field surveys should be focused. A range of survey techniques appropriate for field investigation should be considered for each ASZ and recommendations made for those that are most appropriate, based on the suitability of the techniques, to further define the potential archaeological resource.

Guidance on defining Archaeological Sub-zones

2.3.2 Archaeological Sub-zones should be defined for the entire length of the Proposed Scheme. In order to accommodate design changes, individual ASZs should extend to cover the full extent of land required for the Proposed Scheme. Revisions to risk rankings may be necessary before publication of the ES to ensure that all areas subject to design changes are incorporated into an ASZ.

2.3.3 Defined ACAs will contribute to the general discussion regarding the potential for archaeological remains within an ASZ. Definitions of ASZs should refer as relevant to the baseline description for the Proposed Scheme.

2.3.4 A flexible approach to the definition of ASZs may mean that, for areas of limited archaeological visibility or where the terrain is relatively homogenous, archaeological potential is best understood through a larger ASZ. Alternatively, the crossing of a Roman road with potential roadside settlement may require a more tightly defined ASZ, possibly only tens of metres across. Discrete archaeological sites, archaeological interventions or areas previously investigated should, in most cases, be defined as individual ASZs.

2.3.5 The archaeological potential of an ASZ should be considered in regard to:

- geological and geomorphological factors as summarised in baseline descriptions;
- geographical factors, including geology, soils, topography and hydrology indicators, deep deposits, areas with potential for palaeoenvironmental and/or waterlogged survival, as well as, for example, hilltop defensive locations and routeways. Watercourses should be discussed where relevant;
- areas where there is a lack of archaeological knowledge resulting from an absence of previous archaeological investigations. If no previous archaeological work has been undertaken, this should be clearly stated;
- the location of previous archaeological investigations in the surrounding locality where the presence of a specific monument and/or type of evidence is suggested – known patterns of discovery;
- the context of these investigations; i.e. where the investigated locations themselves may have been affected by misconceptions regarding potential landscape models; and
- land use; e.g. quarrying, urban expansion, agricultural regime and its influence on the survival of heritage assets.

3 Assigning risk ranking and determining requirements for non-intrusive survey

3.1 Assignment of risk rankings

3.1.1 Table 1 presents criteria to define the risk ranking for individual ASZs in terms of the presence or potential for buried archaeology. The purpose of the risk ranking is to identify areas where non-intrusive survey should be prioritised to more fully inform the assessment of the value of heritage assets and to inform the EIA.

Table 1: Risk ranking

Risk ranking	Risk	Criteria
1	High	An area where there are no or only limited site specific data available to characterise the archaeological resource, but data from other sources, for example remote sensing, boreholes and historic landscape analysis, indicate the potential for significant remains to be present.
2	Medium	An area where there are no site-specific data available to define the archaeological resource and no available data from other sources.
3	Low	An area where archaeological character is very well understood and sufficient data is available to inform EIA.
4	None	An area where the potential for archaeological remains is known to have been removed by past activity and the potential for the presence of archaeological remains to be present is reduced to essentially nil.

3.2 Non-intrusive survey requirements

3.2.1 Where an area has been identified as a priority for non-intrusive survey, recommendations will be made for appropriate survey techniques.

3.2.2 The purpose of non-intrusive survey is to:

- confirm the presence/absence of heritage assets;
- establish the value of heritage assets, where confirmed, through understanding of their date range, extent and character;
- inform the understanding of the potential for harm to the value of heritage assets resulting from the Proposed Scheme;
- contribute to the reduction of the risk of unexpected discoveries during construction of the Proposed Scheme as far as is practicable; and
- inform the overall design of the Proposed Scheme, any potential mitigation for and/or investigation and recording of heritage assets.

3.2.3 Although not an exhaustive list, the following comprises potentially suitable non-intrusive survey techniques:

- surface artefact collection;
- geophysical survey; and
- metal detecting (to determine artefact distribution only).

3.2.4 Where access for survey is not possible, the assessment will be undertaken on a reasonable worst-case basis, using professional judgement and available information.

3.3 Ongoing development of the risk-based approach

3.3.1 Reporting for the risk-based approach should be continually updated as non-intrusive surveys are completed and as further information becomes available. As a minimum the risk-based approach should be reviewed when a first draft of the baseline data is completed and again when the final design for the Proposed Scheme is issued. This will allow the identification of risk areas to be reviewed and revised as the extent of heritage assets contributing to the ASZs becomes better understood.

3.3.2 The results of non-intrusive survey should be combined with baseline datasets derived from desk-based work to inform the development of research questions. These research questions will be presented in the ES. Following the enactment of the Bill into law a Historic Environment Research and Delivery Strategy (HERDS) will be developed.

3.4 Engagement

3.4.1 As part of an ongoing programme of engagement with historic environment stakeholders, meetings will be held, as necessary, with HE, Historic Environment Scotland (HES) and the relevant LPA Archaeologists to discuss the development and application of the ACAs and ASZs.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Historic environment – Assessment of settings of heritage assets

Contents

1 Introduction

1.1.1 This technical note is intended to be read in conjunction with the following standards, guidance and methodology:

- Historic England (HE) and Historic Environment Scotland (HES) guidance on the Setting of Heritage Assets[1,2];
- Guidelines for Landscape and Visual Impact Assessment[3];
- Standard and guidance for archaeological desk-based assessment (CIfA)[4]; and
- Managing Significance in Decision-Taking for the Historic Environment[5].

1.1.2 The above documents present some fundamentals for the understanding of setting within a historic environment context and for undertaking historic environment setting assessments within the environmental impact assessment (EIA) process established for the Proposed Scheme in the EIA Scope and Methodology Report (SMR).

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[1] Historic England (2017), *Historic Environment Good Practice Advice Note 3*, 2nd Edition: The Setting of Heritage Assets. English Heritage, Waterhouse, London.

[2] Historic Environment Scotland (2020), *Managing Change in the Historic Environment: Setting*. Available online at: https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=80b7c0a0-584b-4625-b1fd-a60b009c2549.

[3] Landscape Institute, Institute of Environmental Management Assessment (2013), *Guidelines for Landscape and Visual Impact Assessment,* Third Edition.

[4]Chartered Institute for Archaeologists (2020), *Standard and guidance for historic environment desk-based assessment*. Available online at: https://www.archaeologists.net/sites/default/files/CIfAS%26GDBA_4.pdf.

[5] Historic England (2015), *Managing Significance in Decision-Taking in the Historic Environment*. Historic Environment Good Practice Advice in Planning: 2. Available online at: https://historicengland.org.uk/images-books/publications/gpa2-managing-significance-in-decision-taking/.

2 Understanding setting

2.1.1 The importance of setting lies in what it contributes to the value of a heritage asset. For the purposes of the EIA for the Proposed Scheme, as detailed in the EIA SMR, the term 'value' is used in place of 'significance' to avoid confusion with the term 'significance of effect'. Setting is not considered a separate asset; it is always considered in association with an asset.

2.1.2 The National Policy Planning Framework (NPPF)[6] defines setting, as it relates to the historic environment, as follows:

"The surroundings in which a heritage asset is experienced. Its extent is not fixed and may change as the asset and its surroundings evolve. Elements of a setting may make a positive or negative contribution to the significance of an asset, may affect the ability to appreciate that significance or may be neutral". National Planning Policy Framework (NPPF, Annex 2: Glossary, 2019)

2.1.3 Historic Environment Scotland (in Managing in Managing Change in the Historic Environment: Setting, HES 2020) setting is further described as:

"Setting often extends beyond the property boundary or 'curtilage' of an individual historic asset into a broader landscape context. Both tangible and less tangible elements can be important in understanding the setting. Less tangible elements may include function, sensory perceptions or the historical, artistic, literary and scenic associations of places or landscapes."

2.1.4 Historic England similarly describes setting in their setting guidance (HE, 2017) as follows:

"Setting is the surroundings in which an asset is experienced, and may therefore be more extensive than its curtilage. All heritage assets have a setting, irrespective of the form in which they survive and whether they are designated or not."

2.1.5 Development within the setting of a heritage asset can affect the value of the asset or our ability to appreciate that value. National and local planning policies identify the need to protect the value of designated and non-designated heritage assets and to mitigate predicted impacts and effects on them. The way in which the contribution made by setting to

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[6] At the time of assessment, the relevant version of the NPPF was Department for Communities and Local Government (2019), *National Planning Policy Framework*. Available online at: https://www.gov.uk/government/collections/revised-national-planning-policy-framework.

In July 2021, an updated version of the NPPF was published: Ministry of Housing, Communities and Local Government (2021). National Planning Policy Framework. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf.

The key principles of sustainable development set out in NPPF 2019 have been retained in NPPF 2021 and therefore it is considered the NPPF 2019 remains an appropriate basis to influence the assessment and design of the Proposed Scheme for the ES. Where reference is made to NPPF in this SMR or the ES, it refers to the NPPF 2019.

the value of an asset is changed by a development will be clearly presented in any assessment of impacts/effects on that asset.

2.1.6 All heritage assets have a setting. For some archaeological remains and historic buildings setting makes a greater contribution to the value of a given heritage asset than for others. The value of a defined historic landscape area is understood comprise elements within its extent; therefore changes to the setting of historic landscape types is, typically, not undertaken as part of assessment. There are exceptions; usually for designated historic landscapes that are designed, as these are considered to have a setting.

2.1.7 Historic Environment Scotland has produced a series of guidance notes "Managing Change in the Historic Environment". Included in this series is Managing Change in the Historic Environment: Setting (HES, 2020), which includes guidance on assessing effects on historic assets arising from development within their setting. This is broadly similar to Historic England Good Practice Advice note 3 (GPA3), the setting of heritage assets (HE, 2017).

2.1.8 Historic England and HES guidance provide a staged process for the assessment of impacts on heritage assets resulting from changes to setting. This staged process will be followed when undertaking an EIA, and can be summarised as follows:

- **Stage 1**: The identification of heritage assets where the potential exists for their setting to be changed as a result of the construction or operation of the Proposed Scheme:
  - heritage assets to be assessed will be identified based on the study area/s and in relation to the Zone of Theoretical Visibility (ZTV). The database used to record heritage assets will include the reasons why certain heritage assets have been screened or scoped out of further assessment and this database will have a filter function.
- **Stage 2**: An assessment of how and to what degree setting makes a contribution to the value of an asset:
  - for those heritage assets where setting makes a significant contribution to value, key attributes will be identified and recorded in the gazetteer (Section 3.3). Historic England and HES guidance provide checklists of potential attributes of setting for heritage assets. These will be utilised during assessment.
- **Stage 3:** Assessment of impact to heritage assets. Historic England and HES guidance provide lists of key considerations for EIA in relation to setting. These will be utilised and include:
  - the consideration of impacts to heritage assets arising from changes to visual aspects of a heritage asset and/or changes to its noise environment that change its setting;
  - a development being visible or audible from a heritage asset does not automatically imply that an impact will result. The degree to which particular views or the existing noise environment contributes to the value of an asset, and the degree to which this would be changed, will be considered in collaboration with other relevant specialist disciplines;

  - the consideration of impacts resulting from changes to setting arising from noise requires collaboration with the Sound, noise and vibration topic; especially with regard to the perceptibility of changes to the existing noise environment;
  - assessments referring to changes in the noise environment that are predicted to result in a change to setting will be cross-referenced to the appropriate source;
  - the consideration of impacts resulting from direct changes to setting as a result of the construction and operation of the Proposed Scheme;
  - these are direct, physical impacts, i.e. they result directly from the development and not through a secondary pathway. Both adverse and beneficial changes to setting will be considered and the potential for impacts arising assessed;
  - the use of photomontages, wireframes or views sheds to support assessment of impact in regard to views to and from heritage assets; and
  - collaboration with the Landscape and visual impact topic will be undertaken to obtain relevant data, while noting that significant lead-time may be required for the production of visualisation outputs.
- **Stage 4:** Determination of appropriate mitigation:
  - changes to setting predicted to result in impacts on heritage assets may be mitigated through recording, landscape screening, noise screening, or offset by enhancement measures such as interpretation. Landscape and noise screening may themselves result in changes to setting. Discussion with other environmental topics is essential to ensure that mitigation proposals are feasible and effective. Proposed landscape screening will be communicated to, and agreed with the landscape and project management teams. This will facilitate realistic design proposals while allowing for non-heritage impacts resulting from proposed screening to be considered.

3 Presentation of setting assessment

3.1 Assessment

3.1.1 The results of the assessment of setting are presented within Volume 2 and Volume 5 of the Environmental Statement (ES).

3.2 Baseline reporting

3.2.1 Baseline reporting identifies the way in which setting contributes to value of a heritage asset where this has been identified. The character of the setting of an asset will be described, along with its extent and key elements (including any significant views).

3.3 Gazetteer

3.3.1 Where setting makes a positive contribution to the value of an asset, a description of the character, extent and key elements (including any significant views) of the setting will be presented. This will include where setting has been defined through field visit (walkover survey and/or setting assessment).

3.4 Impact assessment tables

3.4.1 The impact assessment tables describe the way in which setting is changed by the Proposed Scheme and if/how this results in an impact on the value of an asset. The nature of any change to setting and the way in which the overall value of an asset is affected will be presented with reference to the methodology set out in the EIA SMR.

4 Interdisciplinary work

4.1 Sharing predicted impacts

4.1.1 During assessment, the assessor will ensure that the database used to record setting assessments can be filtered to highlight those assets where a change to setting is predicted. This filtered database can then be shared with other environmental topics in order to identify potential cross-topic impacts/effects that could contribute to identified impacts on the historic environment.

4.1.2 Key environmental topics with which predicted impacts will be discussed include:

- Landscape and visual;
- Sound, noise and vibration; and
- Ecology and biodiversity.

4.1.3 Impacts identified by other environmental topics will be considered during assessment, recorded in the impact assessment table and cross-referenced to the relevant ES section. Guidance produced by other environmental topics, such as landscape and visual, presented in Annex J, will be consulted in support of the assessment.

4.2 Considering visualisation

4.2.1 The assessor will illustrate the assessment of potential changes to setting, where practicable and relevant, through the recommendation of specific heritage assets or groups of heritage assets to the landscape and visual impacts topic, enabling cross referencing to visualisations produced by this topic; including photomontages, wireframes and view sheds.

4.3 Summary

4.3.1 In summary, the assessor will ask:

- From what does the asset derive its value?;
- How is the setting of the asset characterised and how (if at all) does this contribute to the value of the asset under consideration?;
- How is the setting changed as a result of the construction/operation of the Proposed Scheme?;
- Does the assessed change in setting result in an impact/effect on the asset under consideration?;
- Do these impacts/effects detract from the overall value of the asset?; and
- How (if at all) can the impacts/effects be mitigated?

Annex I – Technical notes: Land quality

The following technical notes are contained in this annex:

- Land quality – Introduction to land quality;
- Land quality – Detailed methodology for contaminated land assessment;
- Land quality – Operational effects;
- Land quality – Potential mitigation measures; and
- Land quality – Mineral and geological resources.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Land quality – Introduction to land quality

Contents

1 Introduction

1.1.1 This technical note presents the introduction to the Land quality assessment for the Proposed Scheme and should be read in conjunction with the associated Land quality technical notes. It is based on the methodology used on HS2 Phase 2a[1] and as described in the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR).

1.1.2 The land quality assessment considers the quality of the land that the Proposed Scheme will pass over or through, and the resources that the soil or rocks contain. It is predominantly a desk based assessment which considers the following principal issues:

- the presence of existing land contamination along or close to the Proposed Scheme that may be disturbed by the construction or operation of the Proposed Scheme;
- the presence of land contamination or potential pathways for contaminant migration due to mining related activities that may have an impact along or close to the Proposed Scheme during construction or operation;
- the presence of mineral resources that may be sterilised or otherwise adversely affected during construction or operation of the Proposed Scheme; and
- the presence of geo-conservation resources that may be destroyed or their integrity otherwise affected during construction or operation of the Proposed Scheme.

1.1.3 In addition, the construction and operation of the Proposed Scheme may give rise to potential contaminative effects. For example, from activities at construction sites during the construction of the Proposed Scheme and track and train maintenance work at the main depot sites during the operational period.

1.1.4 The land quality assessment identifies those areas or sites along or near to the Proposed Scheme that may have existing contamination present on them. It assesses the potential significance of the contamination, with respect to construction of the Proposed Scheme and indicates whether specific mitigation may be required during the construction period to contain or remediate the contamination to allow safe construction, and to bring operational risks to an acceptable level. It outlines the types of remedial works that may be necessary at certain locations.

1.1.5 The assessment also identifies the scale of any impacts on identified geological, geomorphological and mineral resources. It estimates the significance of the effects that the construction and operation of the Proposed Scheme may have on these resources and areas in the future.

[1] High Speed Two Ltd (2017), High Speed Rail (West Midlands – Crewe), *Environmental Impact Assessment Scope and Methodology Report*, Volume 5: Appendix CT-001-002. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627189/E24-B_CT-001-002_Part_B_WEB.pdf.

1.1.6 Finally, it identifies the potential for contamination arising from the construction and operation of the Proposed Scheme and sets out the operational mitigation measures that will be undertaken to minimise this risk.

2 National policy and guidance

2.1 National EIA guidance on land quality issues

2.1.1 There is no national legislation or policy specifically for the assessment of land quality within an EIA. However, within the UK, the assessment of land or groundwater in general is underpinned by Part IIA of the Environmental Protection Act and subsequent Statutory Guidance[2,3] that has been issued to support the Act.

2.1.2 There are a number of national policy and guidance documents on EIA which refer to land quality issues, such as:

- Environmental Impact Assessment - A handbook for scoping projects[4];
- LA104 Environmental assessment and monitoring. Highways England Design Manual for Roads and Bridges[5]; and
- LA109 Geology and Soils. Highways England Design Manual for Roads and Bridges[6].

2.2 Contaminated land

Planning guidance

2.2.1 The principal guidance document relating to contaminated land is the National Planning Policy Framework (NPPF)[7]. The NPPF core planning principles encourages the effective use of

[2] *Environmental Protection Act 1990.* London, Her Majesty's Stationery Office. Available online at: https://www.legislation.gov.uk/ukpga/1990/43/contents.

[3] Department for Environment, Food and Rural Affairs (2012), *Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance (Section 4.3).* Her Majesty's Stationery Office, London.

[4] Environment Agency (2012), *Environmental Impact Assessment; A handbook for scoping projects*.

[5] Highways Agency (2020), *Design Manual for Roads and Bridges (DMRB), Sustainability and Environmental Appraisal, LA104, Environmental assessment and monitoring.* Highways Agency, London. Available online at: https://www.standardsforhighways.co.uk/dmrb/.

[6] Highways Agency (2019), *Design Manual for Roads and Bridges (DMRB), Sustainability and Environmental Appraisal, LA109, Geology and soils.* Highways Agency, London. Available online at: https://www.standardsforhighways.co.uk/dmrb/.

[7] At the time of assessment, the relevant version of the NPPF was Department for Communities and Local Government (2019). National Planning Policy Framework. Available online at: https://www.gov.uk/government/collections/revised-national-planning-policy-framework

In July 2021, an updated version of the NPPF was published: Ministry of Housing, Communities and Local Government (2021). National Planning Policy Framework. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf

The key principles of sustainable development set out in NPPF 2019 have been retained in NPPF 2021 and therefore it is considered the NPPF 2019 remains an appropriate basis to influence the assessment and design of the Proposed Scheme for the ES. Where reference is made to NPPF in this SMR or the ES, it refers to the NPPF 2019.

land by promoting reuse of previously developed (brownfield) land, provided that it is not of high environmental value. The NPPF envisages that the planning system should contribute to conserving and enhancing the natural environment by remediating and mitigating despoiled, degraded, derelict, contaminated and unstable ground where appropriate. However, to prevent unacceptable risks to human health and the environment, a new development should be appropriate for its location and, after treatment where necessary, suitable for its new use. After remediation, land should not be capable of being determined as 'contaminated land' under Part IIA of the Environmental Protection Act (1990).

2.2.2 In order to assess risks from contamination, site investigation data needs to be presented during the planning stage. These data should as a minimum contain desk study information and a site reconnaissance. This procedure will be followed as far as possible in this assessment.

Contamination Risk Assessment guidance

2.2.3 There are two complementary systems in the UK for dealing with issues of land contamination. Part IIA of the Environmental Protection Act of 1990 set up a system of control by regulators (either the local authority in the case of human health risks and/or the Environment Agency, which deals separately with controlled water risks). The local authorities deal with issues of ongoing contamination of sites within their boundaries by determining land as 'contaminated land' and, if necessary, by issuing a 'remediation notice' to the responsible person (usually the owner or occupier of the site in the absence of the original polluter) to enforce investigation and remediation. In 2012, Defra published guidance documents concerning the identification and determination of 'contaminated land'[8].

2.2.4 Secondly, for those sites that enter the planning and redevelopment process, whether via the Town and Country Planning Act or a hybrid Bill, the developer is required to undertake sufficient assessment of the site to show whether the site is contaminated or not, and if so, to design, undertake and verify adequate remediation as part of the development. Each stage of the process needs to be agreed with the regulator(s). The introduction of the Brownfield Register[8] and associated Permission in Principle order[9] in 2017 has revised the requirements for planning permission for housing on brownfield sites.

2.2.5 With respect to the identification, assessment and remediation of contaminated land and groundwater there is a considerable body of knowledge that has been built up over the last 30 or so years, principally by the Environment Agency, the Department for Environment, Food and Rural Affairs (Defra), Construction Industry Research and Information Association (CIRIA) and Contaminated Land: Applications in Real Environment (CL:AIRE), together with

[8] *Town and Country Planning (Brownfield Land Register) Regulations* 2017/403. Her Majesty's Stationary Office, London.

[9] *Town and Country Planning (Permission in Principle) Order* 2017/402. Her Majesty's Stationary Office, London.

other organisations. The most relevant documentation to support the assessment and management of contaminated land is the Land Contamination Risk Management (LCRM) framework[10], replacing CLR11 Model Procedures for the Management of Contaminated Land[11] which sets out the procedures to be undertaken at various stages of a project on land affected by contamination. A key activity is the development of an initial conceptual model identifying plausible contaminant linkages between potential sources and receptors.

2.2.6 Detailed guidance is given within various Environment Agency, Defra documents and other guidance documents, which deal with the detailed risk assessment of sites once direct intrusive ground investigation has been undertaken and the detailed scope and nature of contaminants and the immediate environment is understood. For the Proposed Scheme, direct intrusive ground investigation will be completed in the post EIA phase.

2.2.7 The primary method by which contaminants in soil are assessed in relation to human health is the Contaminated Land Exposure Assessment (CLEA) methodology[12]. This methodology has been prepared by the Environment Agency and sets out the science and assumptions by which critical criteria for contaminants can be estimated for different end-use scenarios and in different soils. A set of criteria, using the most onerous assumptions, are encapsulated within the Soil Guideline Values[13] (SGVs) by the Environment Agency. This was followed in 2014 by the publication of the Category 4 Screening Levels (C4SLs) policy companion document[14], which presents a set of criteria generally based upon less onerous assumptions. In 2015, Suitable 4 Use Levels (S4ULs)[15] were developed and represent minimal or tolerable levels of risks to health ensuring that the resulting assessment criteria are 'suitable for use' under planning. For contaminants for which no authoritative criteria have been published, the CLEA methodology provides a framework for the derivation of assessment criteria.

2.2.8 The primary method by which contaminants in controlled waters are assessed is the methodology published within the Environment Agency document Remedial Targets Methodology 2006[16].

2.2.9 The primary method of assessing the risks to designated ecological receptors from contaminants is based upon LCRM. It sets out a three-tiered risk assessment process that is

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[10] Environment Agency (2021), *Land contamination risk management (LCRM)*. Available online at: https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm.

[11] Environment Agency (2004), *CLR11 Model Procedures for the Management of Land Contamination.* Available online at: http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/scho0804bibr-e-e.pdf.

[12] Environment Agency (2008), *Science Report – SC050021/SR3 - Updated Technical Background to the CLEA Model*, Environment Agency.

[13] Environment Agency (2009), *Using Soil Guideline Values.* Science Report SC050021/SGV Introduction.

[14] Department for Environment, Food and Rural Affairs (2014), *SP1010: Development of Category 4 Screening Levels for Assessment of Land affected by Contamination – Policy Companion Document.*

[15] LQM/CIEH (2015), *Suitable 4 Use Screening Levels for Human Health Risk Assessment*.

[16] Environment Agency (2006), *Remedial Targets Methodology.*

designed to establish whether contaminant linkages between contamination and ecological receptors exist, and to gather sufficient information for making decisions on whether harm to those receptors could occur.

2.2.10 Where more complex/sensitive ecological contaminant linkages are identified, the LCRM qualitative risk assessment processes can be augmented by utilising the 'Ecological risk assessment framework for contaminants in soil (2008)[17]' guidance document as published by the Environment Agency. Quantitative risk assessment of ecological impacts is outside the scope of the land quality assessment.

2.2.11 The primary method by which ground gases are assessed is the CIRIA report C665[18] and BS8485:2015 Code of practice for the characterisation and remediation from ground gas of affected developments[19], which assess risks posed by hazardous ground gases to buildings. The methodology includes information on how best to monitor ground gases over an interval of time, how to interpret the results and design mitigation measures to prevent ground gases entering buildings.

2.2.12 Below ground concrete (e.g. building foundations) is at risk from various chemical species within the ground, primarily types of sulphates. The sulphates are often naturally occurring but can also be present as a result of pollution. The assessment and mitigation of this risk is considered as part of the geotechnical engineering assessment of the Proposed Scheme and will not be considered within the Environmental Statement (ES).

2.2.13 Whilst the above approach is conventionally used in the assessment of risk posed by existing contamination, the principles involved are also consistent with assessment of risks posed by potential contamination. This framework will therefore also be used in the assessment of potential contamination during both construction and operational phases.

2.2.14 Applying a risk based approach will identify relevant contaminant linkages within the study area and whether they pose a significant risk to receptors as a result of the construction of the Proposed Scheme. Rational decisions can then be made on the detailed extent and type of mitigation and/or remediation methods that could be applied, as identified within the Technical Note: Land quality – Potential mitigation measures.

2.2.15 In choosing particular remediation methods, a number of factors are relevant including:

- the type or types of contamination;
- their extent;
- the types of soils or groundwater they are contained within;

[17] Environment Agency (2008), *An ecological risk assessment framework for contaminants in soil'.* Science Report SC07009/SR1.

[18] Construction Industry Research and Information Association (2007), *Assessing risks posed by hazardous gases to buildings*. Report C665.

[19] British Standards Institution (2015), *BS8485 Code of practice for the characterisation and remediation from ground gas affected developments*.

- the time period for remediation;
- the site size and other logistical constraints; and
- the sustainability of the various remedial options.

2.2.16 An options appraisal in line with LCRM and Sustainable Remediation Forum (SURF-UK)[20] is usually undertaken as part of the pre-construction works to identify and evaluate the option or options that would be most appropriate. This appraisal process would include, but is not limited to, assessment of ground investigation data to facilitate the development of a remedial strategy for the site.

2.3 Mineral and geological resources

2.3.1 Guidance on the approach to be adopted in the land quality section of the ES for minerals and geological resources is set out in Sections 15 and 17 of the NPPF[7], 'Conserving and enhancing the natural environment' and 'Facilitating the sustainable use of minerals', and in Technical Note: Land quality – Mineral and Geological Resources.

[20] Sustainable Remediation Forum UK. Available online at: https://www.claire.co.uk/projects-and-initiatives/surf-uk.

3 Assessment methodology

3.1 Introduction

3.1.1 The land quality topic contains several differing strands of assessment. There is not a single assessment methodology that can be used for the various sub-topics. Therefore, detailed methodologies have been developed for each sub-topic, based on current best practice and guidance. A summary of these assessment methodologies is set out in this section. They are given in detail in Technical Note: Land quality – Detailed methodology for land contamination assessment, Technical Note: Land quality – Mineral and Geological Resources and Technical Note: Land quality – Operational effects.

3.1.2 Technical Note: Land quality – Detailed methodology for land contamination assessment is based on the source-pathway-receptor (contaminant linkage) concept whereby, in order to have an environmental effect, there needs to be:

- a source (e.g. of contamination) that can impact a receptor;
- a contaminant pathway (between the source and receptor);
- a receptor or receptors (that may have varying sensitivity to the impacts from the source); and
- the contaminant linkage, as a minimum, must be likely to cause a significant possibility of significant harm or pollution.

3.1.3 Technical Note: Land quality – Mineral and Geological Resources considers the sensitivity or value of the resource and the magnitude of the impact on the resource from the construction and operation of the Proposed Scheme. These two elements are then combined in a matrix to provide an estimate of the significance of the effects on the resource.

3.1.4 Technical Note: Land quality – Operational effects describes operational effects in how potential contamination could arise from activities at the proposed stations and depot sites and how this would be controlled and mitigated.

3.2 Scope

3.2.1 The study area used in the assessment of land quality is the area of land required to construct the Proposed Scheme together with a buffer extending out for a minimum of 250m, but in the case of groundwater abstraction data up to 1km. Areas of land required for the construction of the Proposed Scheme which only entail minimal ground disturbance (e.g. utility diversions within highways and existing remote train stabling areas) will not be assessed.

3.2.2 The impact of existing and known land contamination during the construction stage will be considered. Any significant existing contamination intercepted by the Proposed Scheme will be remediated during the construction process; therefore it is not considered further during assessment of the operational stage of the project.

3.3 Sources of information

3.3.1 Sources of information for contamination issues, mineral resource and geological conservation issues are shown in the tables below.

Table 1: Sources of information for contamination issues

Source of information	Type of information
Envirocheck / Groundsure Report	Historical mapping, landfill and other waste management activities, surface and groundwater data, pollution control data, Radioactive Substance Act data, previous and current industrial land uses, and hazardous substances planning data.
Local authorities	Supplementary information on landfills and other waste management activities, underground petrol tanks and petroleum records, previous ground investigation data, potential and/or determined (Part 2A) contaminated land sites.
Environment Agency	Supplementary information on landfills, and surface water/groundwater, gas and leachate monitoring data.
Animal and Plant Health Agency (APHA)	Animal burial sites.
British Geological Survey (BGS)	Basic geological mapping (1:10,000 and 1:50,000), specialist mapping, memoirs, borehole logs from BGS borehole database.
Network Rail	Previous ground investigation data.
Ministry of Defence (MoD)	Information on current and former Ministry of Defence land.
Other archive resources	For example, available third party data including open source data, in house investigation data, information from waste disposal companies.
Current/historical aerial photography	Where required, to supplement historical mapping.

Table 2: Typical sources of information for mineral resource issues

Source of Information	Type of Information
Coal Authority	Details of previous, current and potential future opencast and underground coal mining and associated activities.
Local mineral authorities	Planning designations regarding mineral extraction.
British Geological Survey	Geological and mineral resources information
Mineral extraction companies	Supplementary information.
Oil and Gas Authority	Location and allocation of areas identified/licenced for exploration or extraction of hydrocarbons
UK Petroleum Exploration and Development Licence	Potential Licence for a range of oil and gas exploration activities
Natural England	Historic information relating to mining heritage sites

Table 3: Sources of information for geological conservation issues

Source of Information	Type of Information
Natural England	Data on geological or geomorphological Sites of Special Scientific Interest (SSSI).
Local authorities	Data on Local Geological Sites or other local geological conservation sites.
Geo-Conservation UK	Data on Local Geological Sites or other local geological conservation sites.

3.4 Site inspections

3.4.1 In addition to 'familiarisation visits', following collection of data, site visits will be required to confirm some of the data collected (particularly from key sites). Such visits may require:

- access to private land for which access permission will be required; and/or
- access to public land (e.g. highways, public footpaths, amenity land etc.).

3.4.2 Because access to private land requires permission, which may not always be granted, access to certain areas may not be available during the preparation of the ES.

3.5 Existing land contamination

3.5.1 The methodology for assessing potential land contamination is set out in Technical Note: Land quality –Detailed Methodology for contaminated land assessment. Part of HS2's strategy for contaminated land investigations is also encapsulated in the draft Code of Construction Practice (CoCP)[21].

3.5.2 Essentially the process consists of three stages:

- a screening process whereby all potential areas of land contamination identified from the data collected, are assessed against criteria including current and historical land use, the proximity of receptors (e.g. aquifers and watercourses), the proximity of the potential land contamination to the Proposed Scheme and the nature of construction etc. A scoring system for the screening process helps rank and prioritise those areas that potentially pose a contaminative risk for the Proposed Scheme;
- a more detailed risk assessment process involving the development of conceptual models and contaminant linkages will be undertaken for areas that have come through the screening process and are more likely to pose a contaminative risk. This allows a more detailed understanding of the nature of the contaminant linkages and the degree of risk they are likely to pose; and

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

- consideration is given to the effects that remediation or mitigation of the contamination could have on areas that potentially pose a contaminative risk, and whether this will lead to a longer term beneficial effect (because of containment or removal of contamination).

3.5.3 During the screening and the risk assessment process, where potentially contaminated sites are likely to give rise to the same types of risks, they can be grouped and considered together, where appropriate.

3.5.4 Potential mitigation measures (including contamination remediation) are described in the Technical Note: Land quality – Potential mitigation measures. It is the intention to treat and re-use as much contaminated soil as possible within the Proposed Scheme to minimise offsite disposal in line with the waste hierarchy. The potential mitigation measures for contaminated soils could include but are not limited to, the following methodologies as either a single approach or as part of a 'treatment train':

- bio-remediation: excavation and placing of contaminated soils in bio-piles or windrows, followed by aeration, and where required, addition of composting materials, nutrients and microbial inoculants[22]. This technique is useful for remediation of certain types of hydrocarbon contamination. Treatability studies are generally required and remediated soil can be usually re-used on-site following treatment;
- chemical treatment systems: controlled and in-situ injection of contaminant specific oxidising or reducing agents to destroy or immobilise contaminants, followed by confirmatory monitoring. This technique is useful for sites with limited access or groundwater hydrocarbon contaminant plumes beneath buildings etc;
- soil stabilisation: excavation and batch treatment, or in-ground mixing and treatment of soil, with additives such as lime, cement and other proprietary materials to alter the physico-chemical characteristics of the soil, to reduce the leachability of contaminants within the soil and/or reduce the permeability of the soil. Stabilisation is useful for a wide range of contaminants, both organic and inorganic but, for ex-situ treatment, significant areas may be required for stockpiling of untreated soils. Treatability studies are generally required and remediated soil can be re-used on-site following treatment. Stabilisation may be required independently for geotechnical purposes;
- soil washing: excavation and batch or continuous treatment of soils to remove contaminants (or the soil matrix that contains the contaminants). In practice the finer particles (clays and silts) with contaminants adhered to them are separated from the coarser particles (sands and gravels) which can then be re-used. Wash water can be recycled, but contaminated residues may need to be disposed of at a landfill site. It can be used on soils with a wide range of contaminants, but the soils themselves need to have a reasonably high proportion of re-usable granular materials (>70%) for the process to be economic;
- cover systems and vertical cut-offs: contaminated soils are left in the ground and the contaminant linkage is broken by placing a cover system on top of the contaminated soil

[22] A substance used/usually injected into the ground under controlled conditions.

and/or providing a cut-off around the contaminated soil. Cover systems most often comprise clay systems sometimes accompanied by geotextiles, capillary break systems etc. Alternatively, geo-synthetic clay systems are also used. Vertical cut-offs can include bentonite, concrete or sheet steel barriers. No remediation trials are generally necessary, and they can be installed quickly. However, contaminants are not removed or destroyed, and long term maintenance requirements can be associated with this type of approach, including leachate, gas (including mine gas), ground or surface water monitoring. In addition, some simple measures can be taken to manage specific contaminant linkages, such as gas barriers in the floor slab of structures. Some contaminated materials are not amenable to treatment and re-use and will need to be disposed of off-site. Such materials may include asbestos containing materials (ACM), radioactive materials and recent domestic waste;

- ground gas/mine gas control: ground gas and mine gas migration can be controlled by vertical and/or horizontal cut-offs together with controlled venting to the atmosphere. In some cases the removal of gas generating material (e.g. recent domestic waste) may also be required; and
- groundwater remediation: There are a wide number of groundwater remediation methodologies. Where groundwater receptors are not immediately at risk monitored natural attenuation (MNA) can be undertaken, whereby the contaminated groundwater is monitored on a regular basis to confirm that natural processes are acting to degrade and disperse the contaminants within the groundwater. Where receptors are at risk, such as from riverside industrial works or acid mine drainage sites, contaminants in the groundwater can be treated using a variety of methods including injection, pump and treat and vacuum extraction based techniques. On a larger scale, major outbreaks of contaminated water could require treatment through aeration ponds, settlement lagoons and reed beds.

3.6 Construction issues

3.6.1 At construction compounds, there will be a variety of materials and liquids being stored, handled and used during the construction period, as well as excavated soils being stockpiled pending re-use. Therefore, there is a risk that such materials could give rise to soil and/or surface and groundwater contamination through spillage, leakage and mobilisation of fine particles.

3.6.2 In these locations, consideration will be given to the types of construction activities that will be undertaken, the types of contaminative materials or liquids that will be used or stored (for example fuel oils), and the types of safeguards (mitigation measures) that will be required in order that such materials, liquids or soils would not give rise to significant soil or surface and groundwater contamination. This process has informed the development of environmental management protocols for construction compounds (for example, specific measures within the draft CoCP).

3.7 Operational issues

3.7.1 The main potential operational sources of contamination will be derived from maintenance works at the proposed rolling stock depot (RSD) to the north of Crewe.

3.7.2 Consideration will be given to the types of operations that will be undertaken, the types and volumes of contaminative materials or liquids that will be used or stored (for example fuel oils), and the types of safeguards (mitigation measures) that will be required in order that such materials or liquids will not give rise to significant soil or groundwater contamination.

3.7.3 A number of stations are included in the Proposed Scheme:

- at Manchester Airport; and
- at Manchester Piccadilly Station.

3.7.4 The stations will generally give rise to a much smaller range of contaminative materials than depots and given modern design standards the likelihood of significant contamination from the operation of stations is not considered significant and should be scoped out of the assessment.

Mineral and geological resources

3.7.5 Existing mining and/or mineral sites, together with the areas or sites that are likely to be considered as future mining or mineral extraction / recovery areas will be identified through review of desk study data as set out in Table 1 to Table 3. These are usually designated as mineral safeguarding areas in county council or unitary authority mineral plans and indicate that for any planning applications submitted within those areas, there is a need to consider conflicts with the mineral extraction requirements for the county.

3.7.6 The methodology for assessing the effects of the Proposed Scheme on current and future mineral resources is contained in detail in Technical Note: Land quality – Mineral and geological resources, which sets out a method to assess the value of a resource and the magnitude of impact that it will experience, to determine whether there are significant effects.

3.7.7 Where significant effects are determined, then mitigation measures may be required to reduce or offset the impacts. Such measures for mineral resources may include, for example, prior use of the resource before construction of the Proposed Scheme or, in the case of severance or isolation, providing additional or alternative accesses to working sites.

3.7.8 In areas of coal measures and coal mining, consultation with the Coal Authority will also be required to assess the potential impacts and agree appropriate mitigation. Where mitigation has a potential to affect mine structures and buildings with possible cultural heritage value, consultation with Historic England and/or the local planning authority should be undertaken.

3.7.9 In areas of salt mining/extraction consultation with the operators and local authority should also consider potential subsidence effects from salt mining but, only in the context of whether this could lead to the formation of pathways for contaminant migration from nearby sources that could affect the Proposed Scheme or nearby receptors. The local planning authority should also be consulted to establish whether there any plans to utilise existing salt mining cavities for other uses (such as heritage or gas storage, for example).

3.7.10 In the case of a geo-conservation resource, mitigation will involve measures to protect or mitigate the potential impacts to the identified resource. Replacement of a feature (e.g. by making available a similar geological feature revealed in the railway construction or elsewhere) may also be an option.

3.7.11 Further details regarding mitigation measures are contained within Technical Note: Land quality – Potential mitigation measures.

3.8 Assumptions and limitations

3.8.1 The assessment will primarily be based on existing documentation (such as historical mapping, geological mapping and a variety of reports) supplemented by site visits. In some areas, previous ground investigation data may also be available to assist in the assessments. Project specific ground investigation would be undertaken after the completion of the formal ES.

3.8.2 Considerable use is made of historical Ordnance Survey mapping to identify previous uses of land. There is the possibility that short term or localised contaminative land uses may not be shown on mapping if it only occurred for a brief period between two subsequent mapping editions or was below the resolution of mapping.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Land quality – Detailed methodology for contaminated land assessment

Contents

1 Introduction

1.1 General

1.1.1 This technical note presents the detailed methodology for the assessment of existing sites that may be contaminated, along the length of Proposed Scheme. It is based on the HS2 Phase 2a methodology[1].

1.1.2 The methodology is based primarily on the assessment of potential sources of contamination identified from current and historical mapping, site inspections where these are possible and other documentary data made available. It includes:

- categorisation of sources of contamination;
- categorisation of potential receptors as defined in the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR);
- presentation/identification of contaminant linkages (whereby there could be plausible pathways linking sources to receptors);
- assessment of potential impacts on sensitive receptors;
- assessment of environmental effects; and
- identification of high risk sites in terms of construction risk and/or long term liability risk.

1.1.3 These terms are further defined in Table 1 to Table 4 and the appendices referenced herein.

1.1.4 The methodology essentially comprises two two-stage parts; an initial screening process referred to as Stages A and B; followed by a more detailed assessment for those sites which were not screened out at Stages A and B, referred to as Stages C and D.

1.1.5 This technical note deals with the assessment of existing land contamination including where land quality may affect controlled waters. It does not deal with any contamination potentially arising from the operation of the railway (see Technical note: Land quality – Operational effects), nor with other land quality issues such as geological or mineral issues (see Technical note: Land quality – Mineral and Geological Resources). It does however deal with contamination aspects of landfills.

[1] High Speed Two Ltd (2017), High Speed Rail (West Midlands – Crewe), *Environmental Statement, Volume 5:* Technical Note – Land Quality – Detailed Methodology for Contaminated Land Assessment. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627189/E24-B_CT-001-002_Part_B_WEB.pdf.

1.1.6 The process used is based on the procedures outlined in the Environment Agency's Land Contamination Risk Management (LCRM) framework[2], which has replaced CLR 11[3]. LCRM provides guidance on the risk-based approach to dealing with land contamination. It is relevant to sites being assessed under Part 2A of Environment Protection Act (EPA) 1990 as well as land affected by contamination more generally, for example when considered for redevelopment under the planning regime. It covers circumstances where land may have contamination present which may, or may not, meet the statutory definition of contaminated land.

1.2 Layout of the report

1.2.1 Section 2 of this technical note details the screening methodology proposed (Stages A and B). The screening aims to identify those sites with potential sources of contamination, which could be impacted by the construction of the Proposed Scheme, and in turn cause a significant effect on the surrounding population and environment. These sites will then be taken through to a more detailed assessment (Stages C and D), taking into account the potential for complete contaminant-pathway-receptor linkages.

1.2.2 Section 3 of this technical note describes the assessment process for sites which have come through for more detailed assessment (i.e. Stages C and D). It is essentially a preliminary risk assessment employing a conceptual site model (CM) to identify the various types of risk present at the site. The more detailed assessment will be undertaken for baseline (i.e. pre-construction), construction and post construction stages. The construction stage assessment assumes that normal construction mitigation measures have been applied during the construction work, as set out in the draft Code of Construction Practice (CoCP). This will include site investigation, risk assessment and in some cases, remediation. The post-construction assessment assumes that appropriate remedial measures have been undertaken during the construction phase. It is possible that if longer term remedial measures are required (such as ground gas or groundwater collection and/or treatment systems) these may be started in the construction phase and carry on during the post-construction phase.

1.2.3 Contamination risks at baseline and construction stages are then compared to estimate the temporary effects of dealing with land contamination during the construction stage.

1.2.4 Contamination risks at baseline and post-construction stages are also compared to estimate the long term (permanent) effects following appropriate remediation as part of the construction stage. Where significant remediation of contaminated land is required, a

[2] Environment Agency (2021), *Land contamination risk management (LCRM).* Available online at: https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm.

[3] Environment Agency (2004), *CLR11 Model Procedures for the Management of Land Contamination.* Available online at: http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/scho0804bibr-e-e.pdf.

beneficial effect may be recorded at the post-construction stage (even when risks during the construction stage may be temporarily higher).

1.3 Coverage, constraints and data limitations

1.3.1 For the purposes of undertaking the Land quality contamination assessment, information on potentially contaminated sites will be collected for a 250m wide buffer around the land required for construction of the Proposed Scheme including:

- line of route;
- road/rail and some utility alterations and realignments;
- new stations, rolling stock depots (RSDs) and stabling facilities; and
- temporary construction sites and compounds including borrow pits, where known.

1.3.2 For the purposes of considering receptors at groundwater abstraction points, the buffer shall extend to 1km where appropriate, in accordance with normal practice and professional judgement.

1.3.3 The land quality study area will therefore be defined as all land within the land required for construction of the Proposed Scheme together with the 250m buffer area, and in the case of groundwater abstraction points, the land required for construction of the Proposed Scheme and a 1km buffer.

1.3.4 The study area for each community area does not extend into the adjacent community area. Where community areas border each other, the boundary will be set between each community area.

1.3.5 Should a site be located on the boundary between two community areas, assess the site and label it in the community area where it is predominantly situated. Where a site is proportionate on either side of the boundary, report authors are to agree which community area the site is assessed in.

1.3.6 Should a community area need to refer to a site/feature or information in another community area, refer to the appropriate report (e.g. 'Effects on this site are discussed in Volume 2, Community Area report: Wimboldsley to Lostock Gralam, Section 7.') and Volume 5 Map books (e.g. 'These features are shown on Volume 5, MA02 Map Book, Map Series CT-01-73.').

1.3.7 At each relevant assessment stage, the data and information required to support the assessment process is outlined. However, it should be noted that not all the desired data will necessarily be in the possession of HS2 Ltd and may not be made available for inclusion within the relevant reporting period. In such instances, assessments will be made based on information available at the time of drafting/preparation of the assessment.

2 Screening

2.1 Stage A

2.1.1 The screening process is divided into two stages (A and B). Seven steps are involved in Stage A:

- divide the route into lengths showing similar vertical alignment (see Table A1 in Appendix A);
- divide the area either side of the route into proximity zones (see Table A2 in Appendix A);
- review mapping and other data sources and identify potentially contaminative land uses and categorisation (see Table A3 in Appendix A);
- review other sources of land use information and identify any additional potentially contaminative land uses and categorisation;
- assign a unique reference number to all sites identified;
- apply impact potential scoring (see Table A4 in Appendix A); and
- determine, from scoring, which sites to take through to Stage B.

2.1.2 Professional judgement may be required for determining proximity zones for sites identified near to side roads crossing the route, utility diversions and upgrades, compound areas and other areas of non-invasive construction activity.

2.1.3 Table A3 in Appendix A provides a list of the more common contaminative land uses but is not exhaustive. Where potentially contaminative land uses are identified but not listed, professional judgement will be used to agree the contaminative use terminology and Class, and the use recorded as "other" (with clarification or justification of what that is) in the listing.

2.1.4 Where sites present a similar contamination risk, they may be grouped and considered together. This may be the case in the more urban areas where, for example, a light industrial estate may be considered as one site, rather than a number of individual sites. Similarly, in rural areas, small historical backfilled ponds and pits might be grouped together.

2.1.5 Where a site may have more than one contaminative land use for the purposes of the screening process (for example, previously a gasworks, now a warehouse), the highest class category for type of contamination as set out in Table A3 in Appendix A will be used.

2.1.6 The scoring system set out in Table A4 assigns a score of between 0 and 5 to each site based on the type of potentially contaminative land use, the proximity of the site to the Proposed Scheme and the vertical alignment.

2.1.7 Scores of 0 to 1 require no further action. Scores of 3 and above automatically will go through to Stage B. For scores of 2, a sense check will be undertaken to decide whether further assessment is necessary. It is recommended that where a value of 2 is associated with bored tunnels, they all proceed to Stage B to establish whether they are located within a sensitive groundwater environment or a non-aquifer.

2.2 Stage B

2.2.1 There are three steps in Stage B:

- identify sensitive land use locations (receptors) in the construction footprint and 250m buffer zone (see Table A5 in Appendix A);
- identify sensitive receptors, e.g. controlled waters in the construction footprint (consolidated construction boundary) and 250m buffer zone and for groundwater abstractions up to 1km (see Table A5 in Appendix A); and
- based on impact potential scoring, apply receptor proximity assessment as shown below to determine which sites should proceed to Stage C.

2.2.2 Sensitive receptors included are those identified as 'High or moderate Sensitivity' as stipulated in the EIA SMR.

2.2.3 All sites with an impact potential score of 5 will go forward for a detailed assessment, irrespective of receptor sensitivity. For sites with an impact potential score of 4, if the potentially contaminative land use is within 50m of a sensitive land use and/or overlies a Principal or Secondary A aquifer, then the site goes forward for detailed assessment. For sites with the land required for the construction of the Proposed Scheme with an impact potential score of 3 or 2, if the potentially contaminative land use immediately adjoins a sensitive land use and/or overlies a Principal or Secondary A aquifer, then the site goes forward to a more detailed assessment (Stage C). However, professional judgement should be used to determine whether sites near the line of the tunnel but not near a portal or vent shafts fall out of the assessment. For example, depending on the vertical alignment, the tunnel could be too far underground for potential contamination to migrate and form a linkage.

2.2.4 At each of the above stages professional judgement will need to be used to check that the screening system is highlighting the most significant sites.

2.2.5 The output from this stage will be the completion of a set of drawings showing the location of land contamination sites identified by the screening process and going through to the qualitative risk assessment phase (Stage C).

3 Contamination risk assessment

3.1 Stage C

3.1.1 Stage C comprises an estimation of the risk of impact associated with each site, based upon the Conceptual Model (CM) at baseline, construction and post-construction stages. Stage D then compares the risk of impact at construction and post-construction stages with the baseline, to determine the change in risk and hence the potential for a significant effect.

3.1.2 Stage C has two steps:

- for each site, develop three (baseline, construction and post-construction) CM; and
- estimate the risk magnitude of the contaminant linkages that are considered to exist by assessing the probability (likelihood) of pollution/harm occurring and the consequence of that pollution/harm, through a qualitative risk assessment (see Table 1 to Table 3). This is undertaken for the baseline, construction and post construction phases. The estimation of risk is undertaken using the matrix presented in Table A6 in Appendix A together with the associated definitions in Table A7 and Table A8. To make the screening process more efficient and to ensure consistency across community areas, automated CM spreadsheets have been prepared for single and grouped sites. These worksheets may be used for all community areas.

3.1.3 All sensitive receptors (see Table A5 in Appendix A) need to be considered at the CM stage, not just those that were instrumental at the screening stage in identifying the site as requiring a CM. Further receptor information for grouped site CM that have been evaluated in stages C and D in Volume 5 are to be recorded in Section 2 of the Background Information and Data document (BID).

3.1.4 Receptor sensitivity for the CM are described in the EIA SMR and the receptors as listed in Table A5 (Appendix A) of this Technical note.

3.1.5 The results of Stage C are presented in three CM as qualitative risk assessments (baseline, construction and post-construction). The construction and post construction risk assessments assume that appropriate mitigation has been undertaken in accordance with the draft CoCP and that the operation of the railway is in accordance with appropriate environmental legislation and good practice.

3.1.6 Only one CM is prepared for the grouped sites for each of the baseline, construction and post-construction stages.

Table 1: Baseline CM and qualitative risk assessment

Source	Receptor	Pathway	Probability	Consequence	Risk at baseline without mitigation
Contaminant linkages					

Source	Receptor	Pathway	Probability	Consequence	Risk at baseline without mitigation

Table 2: Construction CM and qualitative risk assessment

Source	Receptor	Pathway	Probability	Consequence	Risk with construction stage mitigation
Contaminant linkages					

3.1.7 Table 2 assumes standard construction mitigation practices presented in draft CoCP. Assumes construction includes remediation where required.

Table 3: Post construction CM and qualitative risk assessment

Source	Receptor	Pathway	Probability	Consequence	Risk with permanent works mitigation
Contaminant linkages					

3.1.8 Table 3 assumes remediation has been undertaken and construction works completed. It should be noted that remediation or mitigation may continue into the post-construction (i.e. operational) stage to control or treat ground gas and or groundwater (if required) at landfill or mining sites.

3.2 Stage D

3.2.1 During Stage D, the significance of the effects of land contamination is assessed by comparing the difference in risk of each contaminant linkage at baseline to those at construction and at post construction stages. This provides a way of assessing both the adverse and beneficial effects during construction and the post construction period. provides a template of how this may be presented using the definitions in Table A9 in Appendix A. Where there has been a decrease in environmental risk, the Proposed Scheme is having a beneficial effect on the environment in the long term. These tables (Table 4 and Table 5) are reported in the Environmental Statement (ES) Volume 2 and also in the Volume 5 technical appendix.

Table 4: Assessment of temporary (construction) and permanent (post-construction) effects

Contaminant Linkage	Baseline risk	Construction risk	Post-construction risk	Construction significance	Post-construction significance
	Risk	Risk	Risk	Significance	Significance
Overall Significance					

3.2.2 Overall significance should be reported as a range (e.g. neutral to minor beneficial effect). The effects should be reported as either being significant or not significant. All effects with a rating of minor or neutral, whether beneficial or adverse, are not significant.

3.3 Reporting of significant effects

3.3.1 Those sites identified in ES Volume 5 as having significant effects are carried forward and reported in the ES Volume 2 Community Area report. Significant effects are to be reported for both construction and post construction phases. A particular site may have more than one contaminant linkage, as detailed in Table 5 and Table 6.

Table 5: Summary of temporary (construction) effects

Name and area ref	Receptor	Main baseline risk	Main construction risk	Temporary effect
One contaminant linkage E.g.: Infilled ponds at Example MA01-01	Human health (direct contact, ingestion, inhalation of vapours from contaminated soils, waters and inhalation of ground gases on site)	Moderate/low	N/A (exposure pathways removed)	Moderate beneficial (significant)
Two contaminant linkages Tank within farmyard at Example Farm MA01-02	Human health (direct contact, ingestion, inhalation of vapours from contaminated soils, waters and inhalation of ground gases on site)	Moderate/low to moderate	N/A (exposure pathways removed)	Moderate beneficial (significant)
	Human health (direct contact, ingestion and	Moderate	N/A (exposure pathways removed)	Moderate beneficial (significant)

Name and area ref	Receptor	Main baseline risk	Main construction risk	Temporary effect
	inhalation of vapours from contaminated water offsite)			

Table 6: Summary of permanent (post-construction) effects

Name and area ref	Receptor	Main baseline risk range	Main post-construction risk range	Post-construction effect
Tank within farmyard at Example Farm MA01-01	Human health (direct contact, ingestion, inhalation of vapours from contaminated soils, waters and inhalation of ground gases on site)	Moderate/low to moderate	N/A (exposure pathways removed)	Moderate beneficial (significant)
	Human health (direct contact, ingestion and inhalation of vapours from contaminated water offsite)	Moderate	N/A (exposure pathway removed)	Moderate beneficial (significant)
	Controlled waters – groundwater (Principal aquifer)	High	Very low	Major beneficial (significant)
	Controlled waters – surface water	Moderate/low	Very low	Moderate beneficial (significant)
	Property (direct contact with contaminated soil and water)	Moderate/low	Very low	Moderate beneficial (significant)

Appendix A

Table A1: Classes of vertical alignment

Code	Definition
V	A viaduct where main intrusion into ground will be from localised foundations of structures
E/S	Embankment > +1m assumed constructed of chemically suitable material, extent of interaction will be dependent on ground conditions but as a minimum will comprise strip and removal of soft/hard spots but could include more intrusive works such as overdig and/or sort/treat and replace or installation of land drains or structural support, installation of piles, stone columns etc. Near surface pathway for non-leachable or non- volatile contamination will be removed Surface or at Grade -1m to +1m the extent of interaction will depend on ground conditions
C	Cuttings >-1m, cut and cover tunnels, tunnel shafts, tunnel portals. These earthworks solutions are likely to interact with contamination located within the construction footprint and migrating contamination from sites located outside the construction footprint. They are likely to remove primary contamination as a result of the works but may complete a contaminant linkage by introducing a new receptor to contamination migrating from outside the construction footprint
T	Bored tunnels, with no disturbance of surface are considered to be below the level of primary soil contamination but depending on permeability of the surrounding geology may interact with contaminated groundwater or migrating ground gases and may complete a contaminant linkage by introducing a new receptor to contamination outside the construction footprint. This can be mitigated by design

Table A2: Proximity zone definition

Zone no	Definition
Zone 1	All land on or within the footprint of the line and including a 10m margin either side of the land required for construction of the Proposed Scheme and including side shoots such as road realignments, utility upgrades, spoil borrow or storage areas etc.
Zone 2	All land within 50m of the edge of Zone 1 land
Zone 3	All land from between 50 and 250m from the edge of Zone 1 land

Table A3: Potentially contaminative land uses

Class	Generic description	Typical land-uses
Class 1	Low risk of potential contamination, or less hazardous chemicals in use	Farms (i.e. ancillary buildings and areas for storing chemicals, fuel etc.)
		Warehouses
		Goods yards
		Hospitals
		Builders' yards
		Retail and Business Parks
		Light commercial industries, small businesses
		Infilled ponds (in excess of 0.5Ha)
		Borrow Pits
		Localised shallow mineral extraction
		Infilled Brick works/marl pits (in excess of 0.5 ha), quarries and claypits (in excess of 0.5Ha and not listed as landfills)

Class	Generic description	Typical land-uses
		Other – use to be detailed
Class 2	Medium risk of potential contamination, more hazardous chemicals in possible use	Engineering workshops
		Railways/disused Railway lines
		Rail goods yards, Engine sheds and workshops
		Airports
		Dry cleaners (retail)
		Sewage works
		Cement/asphalt works
		Car breakers
		Garage workshops
		Waste transfer facilities
		Paper works
		Power stations
		Glass works
		Timber treatment works
		Foot and mouth and Anthrax burial sites
		Metal manufacturing and plating
		Depots
		Scrap yards
		Coal mining pit heads and spoil mounds
		Industrial estates
		Cemeteries
		Mine entries - coal shafts; air shafts
		Marshland/Peat deposits
		Other (use to be detailed)
Class 3	High risk of potential contamination, hazardous chemicals likely to be present	Gas and cokeworks
		Active landfills and historical landfills
		Metal mining and associated spoil heaps
		Petrol filling stations
		Oil depots
		Iron and steel works
		Historical foundries
		Chemical works
		Tanneries
		Asbestos works
		Textiles and dye works

Class	Generic description	Typical land-uses
		Animal processing and abattoirs
		Printers
		Evidence of fuel/storage tanks
		Dry cleaners (industrial)
		Printers (industrial)
		MoD land/explosives/chemical weapons
		Combination of heavy industrial sites
		Other (as detailed)

Table A4: Impact potential scoring method

Potentially contaminative land-use class (see Table A3)	Proximity to route (see Table A2 and below)	Vertical alignment (see Table A1 and below)	Impact potential score
Class 1 Low risk	Zone 1	E/S	1
		V	2
		C	3
		T	0
	Zone 2	E/S	1
		V	1
		C	2
		T	0
	Zone 3	E/S	0
		V	1
		C	1
		T	0
Class 2 Medium risk	Zone 1	E/S	2
		V	3
		C	4
		T	2
	Zone 2	E/S	2
		V	2
		C	3
		T	2
	Zone 3	E/S	1
		V	2
		C	3
		T	1
Class 3 High risk	Zone 1	E/S	3
		V	4
		C	5
		T	3

Potentially contaminative land-use class (see Table A3)	Proximity to route (see Table A2 and below)	Vertical alignment (see Table A1 and below)	Impact potential score
	Zone 2	E/S	3
		V	3
		C	4
		T	3
	Zone 3	E/S	2
		V	3
		C	4
		T	2

Table A5: Criteria for assessing receptor sensitivity

Receptor sensitivity	Receptor
High	Residential areas, schools and playing fields Surface water bodies of high quality and/or Principal aquifers Nationally designated areas e.g. SSSI
Moderate	Retail and business parks (public and work places) Allotments and market gardens Surface water bodies of moderate quality, and/or Secondary A Aquifers Regionally designated areas e.g. local nature reserves or LGS
Low	Commercial or industrial development Secondary B and undifferentiated aquifers

Table A6: Estimation of risk magnitude

		Consequence			
		Severe	Medium	Minor	Negligible
Probability	High likelihood	6	5	4	3
	Likely	5	4	3	2
	Low likelihood	4	3	2	1
	Unlikely	3	2	1	1

The descriptions of the classified risks are as follows:

6 (Very high risk)

There is a high probability that a contaminant linkage could exist between a source and a designated receptor resulting in detriment to the receptor. Investigation and remediation will be required prior to (or as part of) construction. During construction further mitigation and monitoring measures (in accordance with the draft CoCP) are likely to be required.

5 (High risk)

It is likely that a contaminant linkage exists and could be realised affecting a receptor. Investigation and remediation is very likely to be required.

4 (Moderate risk)

It is possible that an effect could arise to a designated receptor through a contaminant linkage. However, it is either relatively unlikely that the effect would be severe, and more likely for it to be moderate to minor. Further investigative work is likely to be required to clarify the risk. Some remediation works may be required.

3 (Moderate/low risk)

It is possible that a contaminant linkage exists but it is likely (at worst) that if this linkage is present the effect to the receptor would be minor. Further investigative work (which is likely to be limited) to clarify the risk may be required. Any subsequent remediation works are likely to be relatively limited.

2 (Low risk)

It is a low possibility that a contaminant linkage exists. Should the linkage present the effect to the receptor (with regards to controlled waters) would be minor or negligible and the effect on human health would be negligible. No investigation or remedial works are likely to be required.

1 (Very low risk)

It is unlikely that a contaminant linkage exists between a source and a designated receptor.

Table A7: Classification of probability

Classification	Definition of the probability of harm/pollution occurring
High likelihood	The contaminant linkage exists and it is very likely to be realised in the short term, and/or will almost inevitably be realised in the long term and/or there is current evidence of it being realised
Likely	The source, pathway and receptor exist for the contaminant linkage and it is probable that this linkage will be realised. Circumstances are such that realisation of the linkage is not inevitable but possible in the short term and likely over the long term.
Low likelihood	The source, pathway and receptor exist and it is possible that it could be realised. Circumstances are such that realisation of the linkage is by no means certain in the long term and less likely in the short term.
Unlikely	The source, pathway and receptor exist for the contaminant linkage but it is improbable that it will be realised even in the long term

Table A8: Classification of consequence

Classification	Definition of consequence
Human health receptors – site end users	
Severe	Acute damage to human health based on the potential effects on the critical human health receptor
Medium	Chronic damage to human health based on the potential effects on the critical human health receptor
Minor	Minimal short- term effects on human health based on the potential effects on the critical human health receptor
Negligible	No appreciable impact on human health based on the potential effects on the critical human health receptor
Controlled water receptors	

Classification	Definition of consequence
Severe	Pollution of a Principal aquifer within a source protection zone (inner and outer) or potable supply characterised by a breach of drinking water standards. Pollution of a surface watercourse characterised by a breach of an Environmental Quality Standard (EQS) at a statutory monitoring location or resulting in a change in General Quality Assessment (GQA) grade of river reach. Discharge of a hazardous or polluting substance to groundwater.
Medium	Pollution of a Principal aquifer outside a source protection zone (inner and outer) or a Secondary A aquifer characterised by a breach of drinking water standards. Pollution of an industrial groundwater abstraction or irrigation supply that impairs its function. Substantial pollution but insufficient to result in a change in the GQA grade of river reach.
Minor	Low levels of pollution of a Principal aquifer outside a source protection zone or an industrial abstraction, or pollution of a Secondary A or B aquifer. Low levels of pollution insufficient to result in a change in the GQA grade of river reach, pollution of a surface watercourse without a quality classification.
Negligible	No appreciable pollution, or pollution of a low sensitivity receptor such as a secondary (undifferentiated) aquifer or a surface watercourse without a quality classification.
Ecosystem receptors	
Severe	For sites with designations as follows – Site of Special Scientific Interest, National Nature Reserve, Special Protection Area (and potential sites), Special Area of Conservation or Ramsar. Irreversible adverse change in the functioning of the ecological system or any species of special interest that forms part of that system.
Medium	For sites with designations as follows – Site of Special Scientific Interest, National Nature Reserve, Special Protection Area (and potential sites), Special Area of Conservation or Ramsar. Substantial adverse change in the functioning of the ecological system or any species of special interest that forms part of that system.
Minor	Harm to ecosystems of a low sensitivity such as sites of local importance. No appreciable harm to ecosystems with statutory designations.
Negligible	Limited harm to ecosystems of low sensitivity such as sites of local importance
Property receptors – buildings, foundations and services including the operational Proposed Scheme	
Severe	Collapse of a building or structure including the services infrastructure
Medium	Significant damage to a building or structure including the services infrastructure impairing their function
Minor	Damage to buildings/structures and foundations but not resulting in them being unsafe for occupation. Damage to services but not sufficient to impair their function
Negligible	No appreciable damage to buildings/structures, foundations and services

Table A9: Significance criteria

Significance criteria	Definition
Major adverse effect	An increase in contamination risk of 4 or 5 risk levels in the risk matrix, e.g. from land that has a very low contamination risk in the baseline becomes a high or very high risk
Moderate adverse effect	An increase in contamination risk of 2 or 3 risk levels in the risk matrix, e.g. land that has a low contamination risk in the baseline becomes a moderate or high risk
Minor adverse effect	An increase in contamination risk of 1 risk level in the risk matrix, e.g. land that has a low contamination risk in the baseline becomes a moderate/low risk

Significance criteria	Definition
Neutral effect	No change in contaminated land risks
Minor beneficial effect	A reduction in contamination risk of 1 risk level in the risk matrix, e.g. land that has a moderate/low contamination risk in the baseline becomes a low risk
Moderate beneficial effect	A reduction in contamination risk of 2 or 3 risk levels in the risk matrix, e.g. land that has a high contamination risk in the baseline becomes a moderate/low or low risk
Major beneficial effect	A reduction in contamination risk of 4 or 5 risk levels in the risk matrix, e.g. land that has a very high contamination risk in the baseline becomes a low or very low risk

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Land quality – Operational effects

Contents

1 Introduction

1.1.1 The purpose of this technical note is to set out the scope of the land quality assessment for the operational phase of the Proposed Scheme.

1.1.2 There are several strands to the land quality assessment of operational issues:

- contamination at depots;
- contamination from other buildings/areas (e.g. stations, auto-transformer station sites);
- ongoing management of contamination mitigation or remediation measures required to safely operate the railway. These may arise during the construction phase and continue into the operational phase and could include: ground gas capture and control systems, groundwater or mine water treatment systems and monitored natural attenuation; and
- contamination from the operation of high speed trains on the tracks.

1.1.3 These issues will be addressed in turn in this technical note.

1.1.4 The methodology of assessment of existing contamination on depot sites, railway stations and the track area is covered in Technical Note: Land quality – Detailed methodology for land contamination assessment. Guidance on potential approaches that could be followed when specifying mitigation and remediation measures is detailed in Technical Note: Land quality – Potential mitigation measures.

1.1.5 Sterilisation of mineral resources located within influencing distance of the railway is a construction stage effect that persists throughout the operational phase of the Proposed Scheme. The assessment of this is described in the Technical Note: Land quality – Mineral and geological resources and is therefore not considered further in this technical note.

2 Operational issues

2.1 Infrastructure Maintenance Base-Rail/Rolling Stock Depot

2.1.1 The Proposed Scheme includes a Rolling Stock Depot (RSD). In addition will be two Infrastructure Maintenance Bases for Rail (IMB-R). There will also be a depot at Annandale.

2.1.2 The proposed IMB-R sites would each cover a significant area of land and would house plant and materials that are required for rail maintenance. The facilities located at each IMB-R site are likely to include (but are not necessarily limited to) the following:

- workshop;
- stabling roads, e.g., for ballast trains;
- welfare facilities;
- car park;
- material storage areas;
- a re-fuelling siding;
- train washing facilities; and
- administration offices.

2.1.3 The RSD will be responsible for maintenance of rolling stock to be used on the route. As such the facilities will likely contain the following:

- workshop/maintenance building;
- carriage cleaning facilities;
- heavy repair facility;
- controlled emissions toilet facility;
- rolling stock battery servicing facilities;
- overhead cranes;
- fluid and hazmat storage;
- water and wash fluid replenishment facility;
- water discharge; and
- stabling roads.

2.1.4 The depot at Annandale will provide stabling and light maintenance facilities which could contain the following:

- workshop/maintenance building;
- carriage cleaning facilities;
- controlled emissions toilet facility;
- rolling stock battery servicing facilities;

- overhead cranes;
- fluid and hazmat storage;
- water and wash fluid replenishment facility;
- water discharge; and
- stabling roads.

2.1.5 These sites will likely store, handle and use a variety of potentially contaminative materials which will be used in these operations. Such materials will potentially include:

- clean and used ballast and sub-ballast materials;
- temporary handling and storage of materials, before consignment of waste;
- fuels, including diesel and petrol;
- cleaning fluids;
- fuel oils;
- metals;
- paints;
- solvents and degreasers;
- grease, lubricating and hydraulic oils;
- herbicide/pesticide storage;
- miscellaneous construction materials;
- waste water/train sewage, including chemical toilet reagents;
- switches and crossovers motors and gearboxes; and
- pressurised gas cylinders.

2.1.6 An assessment will be undertaken within the Land quality section of the Environmental Statement (ES) of the operational sites' potential for contaminative releases and the types of safeguards (mitigation measures) that would be required to prevent future land contamination from the operation of the depots.

2.1.7 Because of their proposed storage and use, an assessment of the contaminative materials will be undertaken, considering the potential for contaminative releases. The operation of the sites will be governed by environmental regulations and good practice however, the assessment will note any particular safeguards (mitigation measures) that may also be required.

2.2 Stations and other buildings/areas

2.2.1 There will also be a number of other buildings or areas (in addition to the trackside) which could be the location of potentially contaminative activities. These include:

- stations; and
- auto-transformer stations.

2.2.2 The stations will generally give rise to a much smaller range of contaminative materials than depots, and given modern design standards, the likelihood of significant contamination from the operation of stations is not considered significant and will be scoped out of the assessment.

2.2.3 There are various types of transformer stations:

- auto-transformer feeder stations;
- mid-point auto-transformer stations;
- auto-transformer stations;
- express feeder auto-transformer stations; and
- package substations.

2.2.4 The only contamination risk with transformer sites is the small potential for ground contamination from accidental spillage of coolants. Where appropriate, the transformers will incorporate secondary containment to minimise external leakage/spillage. Therefore, it is considered that the risk of significant contamination of ground or groundwater is very low and can therefore be scoped out of the assessment.

2.3 Track and trackside area maintenance

2.3.1 Potential for contamination from the maintenance of track and trackside areas will be limited. Track switch locations will require maintenance and lubrication. The quantities of lubricants required are low, and the lubricants themselves are water repellent and can be bio-degradable, such that any effects on the underlying ground, groundwater and drainage system would be reduced. The track for the Proposed Scheme would either be laid on crushed stone (i.e. ballasted track) or on concrete slabs supported on a continuous structural layer (i.e. slab track). Sleepers will be predominantly concrete (not wooden) and therefore not subject to protection by wood preservatives. Vegetation maintenance will be required and this will likely require the use of herbicides to keep vegetation under control. There will be trackside parking areas at track access locations and these may be subject to small amounts of oil from vehicle fuel or oil leaks.

2.3.2 Track and trackside maintenance will be subject to environmental controls and management systems. Overall, the degree of contamination from track and trackside maintenance is not therefore expected to be significant and can therefore be scoped out of the assessment.

2.3.3 During operation of the railway, there is a risk of pollution resulting from criminal activities (e.g. trespassing and/or vandalism) although this would be limited by conventional rail security measures. Such criminal activities could cause contamination for example, if equipment is stolen or damaged or if fly tipping were to occur. Overall, the risk of contamination from criminal activities is not expected to be significant and can therefore be scoped out of the assessment.

2.4 Operations

2.4.1 The operational trains are powered through overhead electric conductors. The operation of the trains on the tracks will give rise to local generation of potential contaminants through wear and tear of contact areas causing mainly metal release from the overhead conductors. There is also the possibility of leakage of hydraulic or lubricating oils from the gear boxes and axle boxes of trains or from points machines but this is not expected to be significant.

2.4.2 Maintenance trains will be powered by the overhead electrical system but will also have diesel engines (for motive power whilst the overhead electrical system is switched off and other ancillary uses).

2.4.3 There will be no release of sewage on the track from on-board toilets as these will be sealed systems.

2.4.4 The main releases from contact wear issues are:

- wear of the (mainly) copper contact wire and pantograph contact pad;
- abrasive losses from brake wear (i.e., brake pads and wheel linings); and
- wheel to rail contact and abrasion wear generating iron and carbon.

2.4.5 Some studies have been undertaken on these wear issues, as detailed in Appendix A of this technical note.

2.4.6 The biggest of the operational abrasion losses are likely to be those of copper from abrasion of the contact wire. Abrasive losses of carbon, iron and magnesium are considered to be low and not significant. Data from a number of railway operators indicate that the scale of loss of copper from abrasion of the contact wire would lead at most to only small increases in copper concentrations in near surface topsoils adjacent to the railway.

2.4.7 It should also be noted that trackside drainage systems will be required to cope with contamination in surface run-off to comply with Environment Agency pollution prevention guidance.

3 Summary

3.1.1 Given the nature of the materials used and stored at the IMB-R, RSD and depot sites and the anticipated high standards of storage and control, it is considered that there is a low to moderate risk of operational contamination. The sites will be considered within the land quality assessment, taking into account the expected mitigation.

3.1.2 Based on the station operations and infrastructure design the likelihood of significant contamination from the operation of stations is not considered to be significant and so contamination from stations will be scoped out of the assessment.

3.1.3 There is a minimal risk of contamination from auto-transformers stations, feeder stations and the package substation and therefore they will be scoped out of the Land quality assessment.

3.1.4 It is unlikely that track and trackside maintenance, and criminal activity will give rise to a risk of significant contamination effects and so will be scoped out.

3.1.5 The scale of loss of copper from abrasion of the contact wire will lead only to small increases in copper concentrations in near surface topsoil adjacent to the railway. Therefore, contamination from abrasion losses will be scoped out of the assessment.

Appendix A

Contact/wear studies

The most widespread study was undertaken in Switzerland on its 7,200km rail network. Abrasion losses of operating components across that network was estimated, and the data presented both as annual losses of various metals and oils, and as mass/km length of track. Of the common contaminative metals the greatest losses (and therefore the highest potential for contamination) were from copper which abrades from the contact wire, losses from which were estimated at 5,280 grams/kilometre/year per conductor. Because abrasion occurs at a high level (above the train), there is a greater propensity for copper particles to be distributed outside the railway corridor through wind dispersal, in comparison with abrasion losses at track level (e.g. from brakes). Abrasion at track level is predominantly of iron with some carbon (from wheel and rail contact and brake wear) and neither is considered to be a contaminative material.

Dutch railways have also estimated copper losses from contact wire abrasion and have estimated a loss of 0.15 grams/train/kilometre. Assuming 360 trains per day, this would give a rate of loss of 9,860 grams/kilometre/year per conductor.

In the UK, copper losses have been estimated from typical replacement times for contact wire. The contact wire needs replacement when the abrasion losses on the underside of the wire reduce the wire diameter to two thirds of its original diameter. It is estimated that this occurs after 50 years of use. Based on a contact wire diameter of 13.2mm, this loss equates to 7,120 grams/kilometre/year per conductor.

The above three estimates, although not identical, are of the same order of magnitude. Differences between estimates would be expected given that there will be a number of variables which contribute to copper losses on the contact wire which may differ between countries and railway operators.

Based on the above figures an estimate has been made of the potential copper pollution from the operation of the Proposed Scheme. The copper particles abraded from the contact wire are very small and are likely to be spread over a considerable width both on the track and adjacent to the track. Assuming that the width of deposition is 20m either side of the track centreline and that over a period of time the additional copper becomes mixed with the topsoil to a depth of 300mm, the additional copper load within the topsoil would be between about 0.2 and 0.4mg/kg copper/year. This is not considered to be significant. Assuming a project life of 120 years for the Proposed Scheme, the additional copper load within the topsoil is estimated to be between 24mg/kg copper/year and 48mg/kg copper/year. These values are comparable to the natural background values along the route of generally 20 to 80mg/kg (http://mapapps2.bgs.ac.uk/bccs/home.html).

It should be noted that, given the limited data available for high speed lines, the figures above were generated, in the main, by low speed lines with higher levels of braking and turning which would arguably lead to greater abrasion losses.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Land quality – Potential mitigation measures

Contents

1 Introduction

1.1.1 The purpose of this technical note is to provide guidance with regard to potential approaches that could be followed when specifying mitigation measures in particular remediation, in the Land quality section of the Environmental Statement (ES) for the Proposed Scheme. The approaches presented are not necessarily exhaustive, or applicable to every circumstance and may need to be applied in combination. The land quality assessment includes three strands: land contamination, mineral resources and geological resources. This technical note explains how mitigation measures will be considered in the ES for each of the following cases:

- in terms of land contamination (soil, groundwater and ground gas), this note supports the general principle that the expected forms of contamination (wherever it is found in land required for the Proposed Scheme and when it has been fully defined) will be mostly amenable to remediation using established in-situ or ex-situ treatment technologies, in preference to excavation and off-site disposal;
- the mitigation of significant effects for mineral resources principally relate to consultation and negotiations regarding prior extraction where practicable. Such discussions would occur with the site and mineral owners and the mineral planning authority; and
- for geological resources, mitigation will involve measures to protect or mitigate the potential impacts on the identified resource.

1.1.2 In all cases, the mitigation measures anticipated will be described in the ES, together with any significant effects remaining after mitigation (termed the residual significant effects). Where the Proposed Scheme is likely to improve environmental conditions over and above the baseline, these beneficial effects will be identified. Mitigation measures for construction and operational effects will be described separately.

1.1.3 Construction mitigation measures will be applied during the construction work, which is set out in the draft Code of Construction Practice (CoCP).

1.1.4 The amount of remediation required in the case of land contamination should allow safe development of the site, suitable both for its proposed use, and for the wider environment. Once remediated (which may include systems of ongoing management and control) there should be no significant adverse residual impacts and there may well be a beneficial effect on the surrounding environment through the severance of existing contaminant linkage(s).

2 Land contamination

2.1 Legal basis

2.1.1 With regard to contamination, HS2 Ltd may need to remediate land over which the Proposed Scheme passes, where:

- the Proposed Scheme exacerbates any existing contaminant linkage(s), where these linkages are not the responsibility of HS2 Ltd;
- HS2 Ltd is liable for addressing a particular contaminant linkage(s);
- the Proposed Scheme causes a pollutant linkage(s) to be put in place; and/or
- the Proposed Scheme compromises permanently the ability to remediate existing contamination (within the land required temporarily or non-operationally) at some later date.

2.1.2 In the United Kingdom, the Water Resources Act 1991 and subsequent amendments state that it is an offence to cause or knowingly permit the pollution of controlled waters, which includes both groundwater and surface water. Where construction of the Proposed Scheme changes the groundwater and/or surface water quality adversely, then liability will fall on to the party who caused or knowingly permitted pollution.

2.1.3 Under Part IIA of the Environmental Protection Act (1990) as amended, contaminated land is defined as land in such a condition, by reason of substances in, on or under the land where significant harm is being caused or there is a significant possibility of such harm being caused. Substances include solids, liquids and gases. In the context of the Proposed Scheme, remediation would need to eliminate, reduce or manage contaminants such that they do not cause significant harm to people, property, controlled waters and the wider environment.

2.1.4 Any remediation or other mitigation undertaken would need to be sufficient such that the land could not be identified currently as 'contaminated land' under the Environmental Protection Act 1990[1, 2].

2.2 Guidance

2.2.1 Guidance on the management of investigation, assessment and remediation of contaminated land is contained within the Environment Agency Land Contamination Risk

[1] *Environmental Protection Act 1990.* London, Her Majesty's Stationery Office. Available online at: http://www.legislation.gov.uk/ukpga/1990/43/pdfs/ukpga_19900043_en.pdf.

[2] Department for Environment, Food and Rural Affairs (2012), *Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance (Section 4.3).* Her Majesty's Stationery Office, London. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223705/pb13735cont-land-guidance.pdf.

Management (LCRM) framework[3], which replaces CLR11 Model Procedures for the Management of Land Contamination[4]. Detailed guidance on examples of various remediation methodologies is contained within numerous publications produced by the Environment Agency, Construction Industry Research and Information Association (CIRIA), Building Research Establishment (BRE) and other organisations. This includes:

- Remedial Treatment Data Sheets[5];
- Selection of Remedial Treatments for Contaminated Land. A Guide to Good Practice[6];
- Guidance on construction over abandoned mine workings[7];
- Remedial Treatment of Contaminated Land Vol I – XII[8];
- Technical Options for Managing Contaminated Land[9];
- Definition of Waste: Development Industry Code of Practice[10];
- Guidance on the Assessment and Monitoring of Natural Attenuation of Contaminants in Groundwater[11];
- Abandoned Mines and the Water Environment SC030136-41, Environment Agency 2008; and
- PIRAMID: Passive In-situ Remediation of Acidic Mine/Industrial Drainage, 2003 University of Newcastle Upon Tyne.

2.2.2 This is not an exhaustive list and there are many other documents which describe methodologies and the basis for choosing between them. The CL:AIRE Water and Land Library[12] provides a broader range of guidance on detailed technologies.

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[3] Environment Agency (2021), *Land contamination risk management (LCRM).* Available online at: https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm.

[4] Environment Agency (2004), *CLR11 Model Procedures for the Management of Land Contamination.* Available online at: http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/scho0804bibr-e-e.pdf.

[5] Environment Agency, *Remedial Treatment Data Sheets.*

[6] Construction Industry Research and Information Association (2004), *Selection of Remedial Treatments for Contaminated Land. A Guide to Good Practice.*

[7] Construction Industry Research and Information Association (1984), *Construction over abandoned mine workings.*

[8] Construction Industry Research and Information Association (2005), *Remedial Treatment of Contaminated Land Vol I – XII* (SP164).

[9] Safegrounds and Construction Industry Research and Information Association (2004), *Technical Options for Managing Contaminated Land.*

[10] Contaminated Land: Applications in Real Environments (CL:AIRE) (2011), *Definition of Waste: Development Industry Code of Practice.* Available online at: http://www.claire.co.uk/projects-and-initiatives/dow-cop/28-framework-and-guidance/111-dow-cop-main-document.

[11] Environment Agency (2000), *Guidance on the assessment and monitoring of natural attenuation of contaminants in groundwater.*

[12] Contaminated Land: Applications in Real Environments (2016), *Water and Land Library*. Available online at: https://www.claire.co.uk/information-centre/water-and-land-library-wall.

2.3 Development of remedial strategies

2.3.1 It is assumed that prior to a remedial strategy being formulated, sufficient investigation, monitoring and risk assessment will be undertaken in order to identify the nature and extent of contamination that needs to be remediated.

2.3.2 An options appraisal in line with LCRM and Sustainable Remediation Forum (SURF-UK)[13] is usually undertaken as part of the pre-construction works to identify and evaluate the option or options that would be most appropriate. This appraisal process would include, but is not limited to, assessment of ground investigation data to facilitate the development of the remedial strategy for the site.

2.3.3 Contamination remediation methodologies for soil will be chosen following the hierarchy given below:

- on-site treatment and subsequent reuse on site;
- nearby off-site treatment and re-importation to site and reuse (e.g. use of a hub and cluster approach or a soil treatment centre);
- off-site treatment (possibly at a treatment hub or cluster) and reuse on other projects; and
- off-site disposal (with or without treatment).

2.3.4 The last option may be appropriate for materials that cannot be suitably treated (e.g. recently deposited domestic waste) or materials for which there is no suitable use (even after treatment) in the vicinity of its source area (i.e. it is not economically feasible to treat).

2.3.5 The choice of contamination remediation methodologies for groundwater will depend on a number of factors including the:

- nature of the contaminants, (variability and extent);
- nature of the aquifer including depth to groundwater table;
- access to all relevant areas at the ground surface;
- time allowed for remediation (which may include monitored natural attenuation (MNA), see paragraph 2.4.9);
- interaction of the groundwater discharge and the Proposed Scheme surface water drainage network;
- location and nature of the discharge point(s) of impacted water to surface water; and
- target remediation criteria to be used.

2.3.6 The choice of contamination remediation methodologies for ground gas and vapours (including landfilled waste induced gases) will depend on a number of factors including the:

[13] Sustainable Remediation Forum – UK (2017). Available online at: https://www.claire.co.uk/projects-and-initiatives/surf-uk.

- extent and nature of the gas and vapour source;
- concentration, generation rate and flow of the gases and vapours;
- presence of both natural and man-made pathways activated as a result of the Proposed Scheme; and
- identification of sensitive receptors and a viable pollutant linkage.

2.3.7 It is envisaged that there will be no requirement for further land contamination mitigation associated with operation of the Proposed Scheme. It is likely that where mitigation works have been carried out during the construction stage, there may be a requirement for on-going monitoring (e.g. of groundwater, leachate and/or gas/vapour) extending into the operational stage.

2.3.8 A number of treatment technologies may be used at any one site in order to treat one or more contaminants in one or more media (e.g. in soils and in groundwater).

2.4 Remedial methodologies

2.4.1 There are a wide variety of potential treatment methodologies; those that are most likely to be used for the Proposed Scheme are described in this section. This is not an exhaustive list, and other technologies may be considered where appropriate. These methods may require procurement of planning permission and/or an Environmental Permit, prior to commencement.

Soil remediation technologies

Reuse

2.4.2 Contaminated soils may be reused within the Proposed Scheme, whether treated or not, as long as a risk assessment shows that they are suitable for use in the area in which they are proposed to be used. Additional rules governing the reuse of soils are contained within the 'The Definition of Waste; Development Industry Code of Practice[14].

Bio-remediation

2.4.3 This usually involves excavation and placing of contaminated soils in bio-piles or windrows, followed by aeration, and where required, addition of composting materials, nutrients and microbial inoculants (microbes introduced into the soil). This technique is useful for remediation of certain types of hydrocarbon contamination. Treatability studies are generally required and remediated soil can be usually reused on site following treatment.

[14] Contaminated Land: Applications in Real Environments (2011), *Definition of Waste: Development Industry Code of Practice.* Available online at: http://www.claire.co.uk/projects-and-initiatives/dow-cop/28-framework-and-guidance/111-dow-cop-main-document.

Soil stabilisation

2.4.4 This approach may require excavation and batch treatment of soil with additives such as lime, cement and other proprietary materials to alter the physico-chemical characteristics of the soil, to reduce the leachability of contaminants within the soil and/or reduce the permeability of the soil. It can also be undertaken in-situ using suitable mixing systems such as ploughs and augers. This technique is useful for a wide range of contaminants, both organic and inorganic.

Soil washing

2.4.5 This technology requires excavation and batch or continuous treatment of soils to remove contaminants (or the soil matrix that contains the contaminants). In practice the finer particles (clays and silts) with contaminants adhered to them are separated from the coarser particles (sands and gravels) which can then be reused. Wash water can be recycled, but contaminated residues may need to be disposed of at a landfill site. It can be used on soils with a wide range of contaminants, but the soils themselves need to have a reasonably high proportion of re-usable granular materials (>70%) for the process to be economic.

Thermal technologies

2.4.6 There are a number of in-situ and ex-situ thermal technologies which are used to remediate soils. In-situ technologies typically involve heating of the soil in the ground using steam, electrical resistance heating and other methods to mobilise organic contaminants and render them easier to extract via vacuum extraction systems. Ex-situ technologies include thermal desorption where contaminated soils are excavated, fed into the heating chamber of the thermal desorption plant and heated up to a specified temperature (or sequence of temperatures) in order to change the physical state of the volatile contaminants (i.e. from liquid or solid to gas). Treated soil can then be re-used as appropriate.

Cover systems and vertical cut-offs

2.4.7 Contaminated soils may be left in the ground and the pollutant linkage broken by placing a cover system on top of the contaminated soil and/or providing a cut-off around the contaminated soil. Cover systems most often comprise clay systems sometimes accompanied by geotextiles, capillary break systems etc. Alternative geo-synthetic clay systems are also used. Vertical cut-offs may comprise bentonite, concrete or sheet steel barriers. No remediation trials are generally necessary and they can be installed quickly if required. However, contaminants are not removed or destroyed and aftercare maintenance and monitoring will be necessary.

Off-site disposal

2.4.8 Some contaminated materials, classified by HS2 Ltd as "U2: hazardous, unacceptable and untreatable materials" are not amenable to treatment and reuse, and will need to be disposed of off-site in appropriately licensed landfill sites. Such materials may include asbestos containing materials (ACM) and recent domestic waste.

Groundwater remediation technologies

Monitored natural attenuation

2.4.9 Monitored natural attenuation (MNA) consists of the monitoring of groundwater to confirm whether natural attenuation processes (physical, chemical and biological) are acting at a sufficient rate to ensure that the wider environment (external to the immediate area of the contamination plume) is essentially unaffected (i.e. within agreed remedial targets) such that remedial objectives will be achieved within a reasonable timescale, typically less than 30 years.

Low permeability barriers and permeable reactive barriers

2.4.10 This approach involves installation of a (generally) vertical barrier system to either control groundwater flow or to channel contaminated groundwater (a contaminant plume) through one or more permeable gates where contaminants can be removed or deactivated by chemical and/or biological means.

In-situ hydrocarbon remediation approaches

2.4.11 Groundwater may be treated in-situ by a number of different methods, some of which may be used in combination. Typically, such methods will involve one or more of the following:

- soil flushing (to remove hydrocarbon contaminants from the unsaturated zone);
- vacuum extraction of vapours in the unsaturated zone;
- removal of floating product (non-aqueous phase liquids (NAPL)) by pumping, skimming or vacuum extraction etc;
- introduction of compressed air into the groundwater to volatilize dissolved organics (air-sparging), followed by vacuum extraction;
- introduction of reducing and/or oxidising chemicals into the water to promote breakdown of hydrocarbon contamination (e.g. reductive dechlorination); and
- introduction of additional microbes into the unsaturated zone or groundwater to promote biological breakdown of hydrocarbon contamination.

Pump and treat

2.4.12 This technique involves pumping and removal of contaminated groundwater from the ground, ex situ treatment (e.g. air-stripping, carbon adsorption) and re-injection or discharge of treated water. Distribution of the pumping and re-injection wells can be used to create hydraulic control of the aquifer to prevent further migration of contaminated groundwater.

Ground gas remediation and management

2.4.13 The choice of remediation methodologies for ground gas and vapours may include any or a combination of the following:

- vertical or horizontal gas cut-offs;
- gas membranes within building floor slabs;
- active or passive gas venting below building floor slabs;
- positive pressure systems; and
- monitoring systems.

Ground gas cut-offs

2.4.14 Cut-offs to prevent ground gas migration may be either vertical or horizontal and typically comprise an impermeable membrane (such as high density polyethylene (HDPE)) through which the gases cannot penetrate. Bentonite cement slurry walls are also used to create vertical barriers in the ground. The biggest issue in using membrane systems is ensuring that during placement (and subsequently) the membrane is not damaged or torn, such as to allow migration pathways. Cut-offs are often used in conjunction with venting layers.

Ground gas venting

2.4.15 Ground gas venting controls the migration of ground gases such that they can vent to atmosphere in a location which does not cause any significant risks. Venting materials include natural soils (gravel, aggregates) and man-made materials (such as polystyrene vent formers). These are often used in conjunction with cut-offs. Venting can be enhanced by the addition of fan systems which draw air through the vent media and enhance the effectiveness of the vent.

Positive pressure systems

2.4.16 These comprise fan systems which feed air into a vent medium such as gravel or a sub-floor void and create a slight positive pressure which eliminates soil gas venting into the vent zone. They are most effective when applied to sub-floor voids below buildings.

Removal of gas generating material

2.4.17 Gas generating material (such as localised deposits of domestic waste and peat) may be excavated and removed. This is often undertaken when the gas generating material also causes other problems such as excessive settlement. Excavated material should be re-used wherever practical, for example peat maybe incorporated into top soil materials.

Monitoring

2.4.18 Gas monitoring may be used when gas concentrations are generally low enough not to cause an issue, but occasional high concentrations may occur. The monitoring needs to be linked to a management plan. Within buildings, such systems monitor gases on a semi-continuous basis and can sound alarms when concentrations rise above pre-set criteria.

Impact of Climate Change

2.4.19 Use of any or all of the above remediation measures singularly or in combination, should consider the potential impact of climate change upon the efficacy of the relevant technology/technologies. This will be considered as part of the route-wide Climate change assessment.

3 Minerals

3.1.1 Mitigation of mineral-related effects will depend on the type of impacts associated with the mineral resource. These are:

- complete or partial sterilisation of the resource;
- severance[15] and/or isolation of the resource; and
- constraint on use of the resource (e.g. cutting an access road).

3.1.2 The mitigation measures to be considered are therefore likely to include:

- use of the resource prior to or during construction of the Proposed Scheme (e.g. use of sands and gravels within the construction of the Proposed Scheme by excavating a borrow pit and stockpiling the resource for later use). Over-excavation may be required in order to remove all the usable resource, followed by infilling with suitable materials;
- provision of additional access to a site (in the case of severance); and
- provision of alternative access to a site.

3.1.3 Whilst the Proposed Scheme, being a national infrastructure project could be used to justify the sterilisation of the mineral resources adjacent to the route, such an approach would conflict with the principle of the National Planning Policy Framework[16] and would be expected to inhibit synergies and opportunities for reduction of transport movement. However, any mineral lying below the built structures and track of the Proposed Scheme will be retained in-situ to provide suitable support to foundations and embankments.

[15] In this context, severance refers to the Proposed Scheme splitting an actual or proposed mining/mineral site into two or more areas, such that separate accesses would be required to work the whole site.

[16] At the time of assessment, the relevant version of the NPPF was Department for Communities and Local Government (2019). National Planning Policy Framework. Available online at: https://www.gov.uk/government/collections/revised-national-planning-policy-framework.

In July 2021, an updated version of the NPPF was published: Ministry of Housing, Communities and Local Government (2021). National Planning Policy Framework. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf.

The key principles of sustainable development set out in NPPF 2019 have been retained in NPPF 2021 and therefore it is considered the NPPF 2019 remains an appropriate basis to influence the assessment and design of the Proposed Scheme for the ES. Where reference is made to NPPF in this SMR or the ES, it refers to the NPPF 2019.

4 Geological resources

4.1.1 Mitigation of geo-conservation effects will depend on the type of impacts associated with the geo-conservation resource. These are:

- complete or partial loss of the resource;
- severance or isolation of the resource; and
- constraints on access to the resource (e.g. cutting an access road).

4.1.2 The mitigation measures to be considered are therefore likely to include:

- partial or full 'replacement' of a geological resource at the same stratigraphical horizon but in a geographically different area (could be either adjacent to the Proposed Scheme or remote from it);
- if an alternative location cannot be found then intensive investigation and recording of the site before it is constructed upon, including removal of rock and fossil specimens; or
- providing alternative or additional access to sites where the access or the site has been severed.

5 Mitigation interactions

5.1.1 Use of in-situ remediation measures are usually beneficial in terms of potential environmental effects. However, an important aspect in the identification of mitigation measures is that there is appropriate consideration of the effects that the selected mitigation measures may have on the wider environment.

5.1.2 Table 1 presents some of these potential effects, taking examples from the mitigation measures described above.

Table 1: Examples of other effects arising from mitigation measures

Mitigation/remediation method	Potential effects
Bio-remediation, soil washing, soil stabilisation, ex-situ thermal technologies.	Typically, these require large areas for stockpiling and equipment, which may require additional temporary land–use and effects on ecology, agricultural land, landscape, etc.
Off-site disposal.	Would increase total required amount of soil to be landfilled (to be taken into account in waste topic and earthworks balance), traffic impacts and air quality impacts.
All groundwater methods.	Effects on groundwater, such as changes to levels and yields at springs or wells, or changes in water quality associated with breakdown products from chemical oxidation or reduction.
Vertical cut offs.	Changes to groundwater flow paths and interference with base flow into surface water bodies.
Cover systems.	Reduction in rain water infiltration to groundwater and the potential to exacerbate flooding on adjoining land.
Provision of alternative access to the mineral resource.	Sterilisation of part of a mineral resource as a result of the Proposed Scheme cutting access to the resource.
Replacement of geological resources.	Would require additional land and therefore may have effects on ecology, agriculture, landscape.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Land quality – Mineral and geological resources

Contents

1 Introduction

1.1.1 This technical note presents the basis of the minerals and geological resources assessment of the Environmental Statement (ES) for the Proposed Scheme. It is based on the HS2 Phase 2a methodology.[1]

1.1.2 This technical note explains the basis for the assessment of significance with regard to geological issues, other than existing contaminated land (which is considered in Technical note – Land quality – Detailed methodology for Contaminated Land Assessment). The issues considered in this technical note include:

- mineral resources; and
- geological conservation resources.

1.1.3 Assessment of contamination arising from current and historical mining activities will be undertaken in accordance with the methodology set out in the other land quality technical notes. Issues associated with ground settlement resulting from mining activities will not be assessed, as they do not form part of the land quality assessment.

1.1.4 Mineral resources in this context are defined in the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR) as a mineral body including aggregates, salt, coal, Petroleum Exploration and Development Licences (PEDL) and other hydrocarbons, Shale Prospective Areas (SPAs) and sites of local geological interest.

1.1.5 Mineral resources include opencast, shallow and deep coal mining, sand and gravel extraction, building stone and aggregate production from quarries, and the exploitation of other identified geological materials (e.g. salt and coal bed methane, PEDLs and other hydrocarbons). These are dealt with in the context of their value as an asset if impacted by the Proposed Scheme.

1.1.6 Geological conservation resources include geological and geomorphological Sites of Special Scientific Interest (SSSI) and Local Geological Sites (LGS) (previously known as Regionally Important Geological Sites).

1.1.7 Sources of information for mineral and geological conservation resources are provided in Technical note – Land quality – Introduction to Land quality.

1.1.8 Groundwater (hydrogeological) resources and flooding are considered in Technical note – Water resources and flood risk – Groundwater assessment method.

[1] High Speed Two Ltd (2017), High Speed Rail (West Midlands – Crewe), *Environmental Statement, Environmental Impact Assessment Scope and Methodology Report, Technical note: Land Quality – Mining and Minerals Resources and Geology.* Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627189/E24-B_CT-001-002_Part_B_WEB.pdf.

2 Proposed methodology

2.1 General

2.1.1 Minerals and geological resources are assessed by considering the sensitivity or value of the resource and the magnitude of the impact on the resource from the construction and operation of the Proposed Scheme. These two elements are then combined in a matrix to provide an estimate of the significance of the effects on the resource.

2.1.2 The following definitions in Table 1 are based on those provided in the EIA SMR as a guide to the significance of the effects.

Table 1: Significance of effects

Magnitude of Impact	Description
Major adverse	Considerable detrimental or negative impact (by extent, duration or magnitude) of more than local importance or in breach of recognised standards, policy or legislation. Always considered significant
Moderate adverse	Limited detrimental or negative impact (by extent, duration or magnitude) which may be considered to be significant
Slight adverse	Slight, very short or highly localised detrimental or negative impact without a significant consequence
Negligible	Imperceptible impact to an environmental resource or receptor
Slight beneficial	Slight, very short or highly localised advantageous or positive impact without a significant consequence
Moderate beneficial	Limited advantageous or positive impact (by extent, duration or magnitude) which may be considered to be significant
Major beneficial	Considerable advantageous or positive impact (by extent, duration or magnitude) of more than local importance or exceeds beneficially the minimum requirements of recognized standards, policy or legislation. Always considered significant

2.2 Geological conservation resources

2.2.1 This section presents the sensitivity/value and impact magnitude tables for geological conservation resources, together with the significance matrix.

Table 2: Sensitivity/value of geological resources

Sensitivity/value	Description
Very high	Geological or geomorphological SSSI of international importance
High	Geological or geomorphological SSSI
Medium	LGS (Local Geological Sites)
Low	Other local geological conservation resource

Table 3: Impact on geological resources

Magnitude of Impact	Description
Major	Complete loss of resource
Moderate	Partial loss of feature/resource or a significant impact on its setting, and/or accessibility
Minor	Slight loss of feature/resource, or a slight impact on its setting and/or accessibility
Negligible	No significant impact
Positive[2]	Creation of a new feature/resource (e.g. a new permanently accessible geological exposure) or a new geological understanding (e.g. through ground investigation)

Table 4: Significance of effects on geological resources

	Sensitivity/Value			
Magnitude of impact	**Very high**	**High**	**Medium**	**Low**
Major	Major adverse effect	Major adverse effect	Moderate adverse effect	Minor adverse effect
Moderate	Moderate adverse effect	Moderate adverse effect	Minor adverse effect	Minor adverse effect
Minor	Minor adverse effect	Minor adverse effect	Negligible effect	Negligible effect
Negligible	Negligible effect	Negligible effect	Negligible effect	Negligible effect
Positive	Major beneficial effect	Moderate beneficial effect	Minor beneficial effect	Negligible

2.3 Mineral resources

2.3.1 This section presents the sensitivity/value and impact magnitude tables together with the significance matrix for mineral resources, including:

- over-arching Minerals Plans for all minerals;
- sand and gravel deposits;
- coal mining (open cast, shallow and deep);
- salt and brine deposits and associated cavities;
- historical marl pits, and clay reserves for brickmaking;
- presence of reserves of building stone; and
- presence of potential hydrocarbon resources, including PEDLs, shale gas, coal bed methane and oil deposits.

[2] There are very few possible outcomes where the Proposed Scheme would have a beneficial effect upon a geological resource. Therefore, there is no graduation given of beneficial effects from minor, to moderate to major beneficial.

Table 5: Sensitivity/value of current mineral resources

Sensitivity/value	Description
Very high	Mineral resource of national importance (strategic) currently being worked (where a licence to extract is in place, if applicable) or where planning permission or consent has been granted for future extraction
High	Non-strategic mineral resource currently being worked, or Specific Sites/Preferred Area for mineral works within a Mineral Planning Authority's (MPA) Local Plan
Medium	Mineral Safeguarding Areas within a MPA Local Plan
Low	Mineral Consultation Areas[3] within a MPA Local Plan, or other areas of mineral with no MPA Local Plan designation

Table 6: Impact on current mineral resources

Magnitude of Impact	Description
Major	Complete loss of resource
Moderate	Major loss of resource or significant severance of a resource
Minor	Minor loss of resource with no severance
Negligible	No significant impact
Positive	Project allows definition/exploration/sustainable working of resource, thereby reducing impact (e.g. traffic)

Table 7: Significance of effects on mineral resources

	Sensitivity/Value			
Magnitude of impact	**Very high**	**High**	**Medium**	**Low**
Major	Major adverse effect	Moderate adverse effect	Moderate adverse effect	Minor adverse effect
Moderate	Moderate adverse effect	Moderate adverse effect	Minor adverse effect	Minor adverse effect
Minor	Minor adverse effect	Minor adverse effect	Negligible effect	Negligible effect
Negligible	Negligible effect	Negligible effect	Negligible effect	Negligible effect
Positive	Major beneficial effect	Moderate beneficial effect	Minor beneficial effect	Negligible

[3] Although classified as low risk, Mineral Consultation Areas should be excluded from the land quality assessment, owing to the significant geographical areas which they cover.

Annex J – Technical notes: Landscape and visual

The following technical notes are contained in this annex:

- Landscape and visual – Approach to landscape value, susceptibility and sensitivity;
- Landscape and visual – Approach to night time ‘darkness’ survey and assessment;
- Landscape and visual – Zone of theoretical visibility production methodology;
- Landscape and visual – Approach to verifiable photomontages; and
- Landscape and visual – Approach to photography.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Landscape and visual – Approach to landscape value, susceptibility and sensitivity

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Tables

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1 Introduction

1.1.1 This note provides guidance on the revised methodology for determining the sensitivity of landscape character to be applied in the landscape assessment of the significant effects of the Proposed Scheme. The note also provides advice on how and why the methodology differs from the methodology adopted in the Phase One Environment Statement (ES). This note is a development of the methodology used for Phase 2a and has been refined further reflect current thinking on landscape assessment methodology in the years since the latest edition of the industry guidance on landscape and visual assessment (Guidelines for Landscape and Visual Impact Assessment, 3rd Edition or GLVIA3[1]) was published.

[1] Landscape Institute and Institute of Environmental Management and Assessment (2013), *Guidelines for Landscape and Visual Impact Assessment*, Third Edition.

2 Phase One methodology

2.1.1 In the original Phase One ES landscape character assessment methodology, the sensitivity of the landscape character to change was assessed using the three criteria of condition, tranquillity, and value. These were determined using professional judgement, site visit data and existing documentation including local authority character assessments and Conservation Area appraisals where available. This was developed with reference to the Guidelines for Landscape and Visual Impact Assessment (GLVIA) second edition[2] and some preliminary thoughts from the Landscape Institute on the content of the GLVIA third edition (GLVIA 3), which were unpublished at the time of producing the Scope and Methodology Report (SMR) for Phase One.

2.1.2 For the assessment of sensitivity of landscape character, a combination of attributes requires consideration. This is summarised in Table 1.

Table 1: Criteria for assessing landscape sensitivity (Phase One methodology)

Sensitivity	Where the character area:
High	Is valued at the international, national, regional or borough/district scale Is predominantly characterised by landscape components that are rare and distinctive and/or listed Is designated as a conservation area, registered park and garden or public open space Has an elevated tranquillity Has limited tolerance to change Has components that are not easily replaced or substituted (e.g. mature trees) Has limited scope for effective mitigation in character with the existing landscape Is well maintained and in a good condition
Medium	Is locally valued Has moderate levels of tranquillity Is fairly tolerant of change Has components that are easily replaced or substituted Has scope for effective mitigation in character with the existing landscape Is of a fair condition
Low	Has limited landscape value Has few or no distinctive components, or components that detract from the overall character of the site Has limited tranquillity Is tolerant of change Has components that are easily replaced or substituted Has scope for effective mitigation in character with the existing landscape, and opportunities for an improvement in character Is in a poor condition

[2] Landscape Institute and Institute of Environmental Management and Assessment (2002), *Guidelines for Landscape and Visual Impact Assessment,* Second Edition.

3 Phase Two methodology

3.1 Phase 2a methodology

3.1.1 The methodology was reviewed for HS2 Phase 2a to align it with the European Landscape Convention (ELC) definition of landscape as "an area, as perceived by people, whose character is the result of the action and interaction of natural and /or human factors".

3.1.2 The importance of the ELC definition is that it focuses on landscape as a resource - as the ordinary and every day in addition to the special or highly valuable. The Phase 2a approach was set out in the Technical Note: Approach to Landscape Sensitivity[3].

3.2 Methodology for the Proposed Scheme

3.2.1 A further refinement of the methodology has now been undertaken for the Proposed Scheme to determine landscape sensitivity in the context of the ELC definition of landscape.

3.2.2 GLVIA 3[4] reiterates the definition of landscape as a 'place' that results from: "the *interplay of the physical, natural and cultural components of our surroundings. Different combinations of these elements and their spatial distribution create the distinctive character of landscapes to be mapped, analysed and described. Character is not just about physical elements and features that make up landscape, but also embraces the aesthetic, perceptual and experiential aspects of the landscape that make places distinctive."* (GLVIA 3 p. 21).

3.2.3 The HS2 Design Vision[5] sets out three core principles of 'People', 'Place' and 'Time'. To achieve this design vision, the HS2 Landscape Design Approach (LDA)[6] guides and directs professionals to accomplish an integrated design that is driven by an understanding of the surrounding landscape and sense of place. The design should result from the manner in which different components of the environment - both natural and cultural - interact together and with people in physical, perceptual and aesthetic terms as shown in Figure 1.

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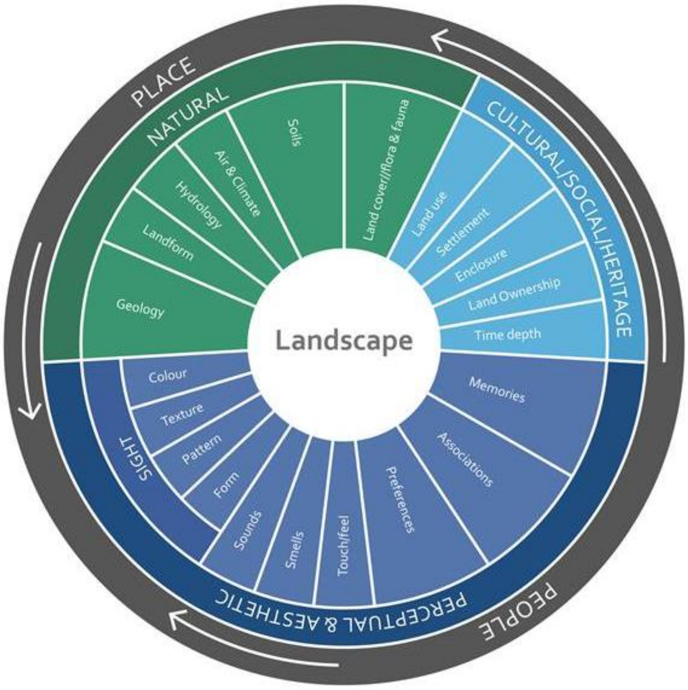
[3] High Speed Two Ltd (2017), High Speed Rail (West Midlands – Crewe), *Environmental Statement, Volume 5, Technical appendices, Environmental Impact Assessment Scope and Methodology Report Technical Note: Approach to landscape sensitivity*. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627189/E24-B_CT-001-002_Part_B_WEB.pdf.

[4] Landscape Institute and Institute of Environmental Management and Assessment (2013), *Guidelines for Landscape and Visual Impact Assessment*, Third Edition.

[5] High Speed Two Ltd (2017), *HS2 Design Vision*. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/607020/HS2_Design_Vision_Booklet.pdf.

[6] High Speed Two Ltd (2016), *Landscape design approach*. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/550791/HS2_Landscape_Design_Approach_July_2016.pdf.

Figure 1: Landscape as the interaction of people and place



4 Revised methodology for the Proposed Scheme

4.1 Approach to landscape assessment

4.1.1 The sensitivity of each landscape character area will be formed of judgements about the value attached to the landscape character and the susceptibility of the landscape character to the specific types of change that may arise from the Proposed Scheme.

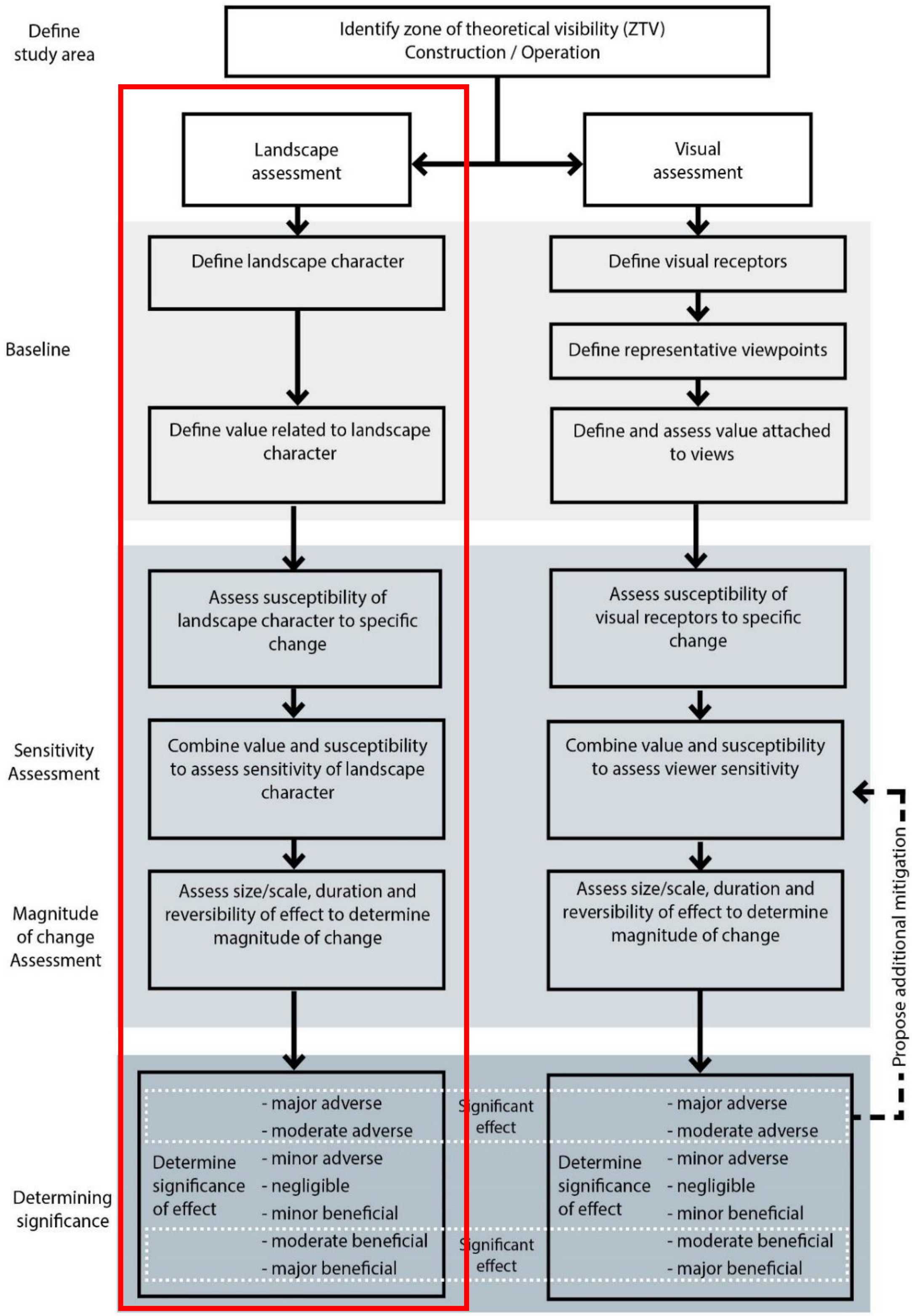
4.1.2 As in the Phase One and Phase 2a ES, the determination of landscape value for the Proposed Scheme will form part of the landscape character baseline. However, the judgements on susceptibility and the subsequent assessment of sensitivity to change of each landscape character area will form part of the landscape assessment, rather than form part of the landscape character baseline. This is demonstrated in Figure 2.

4.1.3 Guidance on the factors that need to be considered when reviewing published landscape character assessments is presented below in Section 4.2.

4.1.4 Guidance on the different criteria that will be used for judging landscape value and the susceptibility of landscape character areas to changes resulting from the Proposed Scheme is presented below in Sections 4.3 and 4.4.

4.1.5 An overall judgement will be made on the sensitivity of landscape character to changes resulting from the Proposed Scheme. Guidance on the approach to making this assessment, which will be based on judgements of the value attached to landscape receptors and their susceptibility to changes resulting from the Proposed Scheme, is provided in Section 4.5.

Figure 2: The approach to landscape assessment (highlighted in red)



4.2 Identification of landscape character areas

4.2.1 Landscape character areas will be identified within the study area, which is informed by the extent of the zone of theoretical visibility for the construction and operational stages. This process will involve:

(1) a desk-top review of relevant background documents and spatial data;

(2) field survey work;

(3) classification, mapping and description of landscape character areas and/or types.

4.2.2 The background document review will include a check for any published landscape character assessments for the study area. The degree to which published landscape character assessments can be used for the landscape characterisation study will depend on several factors, as identified in 'An Approach to Landscape Character Assessment'[7]. These factors include:

- date carried out and methodology used;
- date and provenance of data;
- the original purpose of the existing LCA;
- scale of the assessment and its appropriateness for the proposed use;
- whether, or not, and if so to what extent were stakeholders engaged in the assessment process;
- age of the assessment and amount of landscape change since its compilation;
- the extent of cross-boundary join-up at the edges of the study area; and
- whether aspects of landscape character require more scrutiny, or emphasis.

4.3 Determining landscape value

GLVIA3 guidance

4.3.1 Landscape value may be defined as "the relative value that is attached to different landscapes by society, bearing in mind that a landscape may be valued by different stakeholders for a whole variety of reasons." (GLVIA 3 Para. 5.19, p.80).

4.3.2 GLVIA 3 Para. 5.19 also notes that "Value can apply to areas of landscape as a whole, or to the individual elements, features and aesthetic or perceptual dimensions which contribute to the character of the landscape." and "Landscapes or their component parts may be valued at the community, local, national or international levels. A review of existing landscape

[7] Natural England (2014), *An Approach to Landscape Character Assessment*. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/691184/landscape-character-assessment.pdf.

designations is usually the starting point in understanding landscape value, but the value of undesignated landscapes also needs to be carefully considered…"

4.3.3 GLVIA 3 Para. 5.44 states that the baseline survey should cover:

- "the value of the Landscape Character Types or Areas that may be affected, based on review of any designations at both national and local levels, and, where there are no designations, judgements based on criteria that can be used to establish landscape value;" and
- "the value of individual contributors to landscape character, especially the key characteristics, which may include individual elements of the landscape, particular landscape features, notable aesthetic, perceptual or experiential qualities and combinations of these contributors."

4.3.4 GLVIA 3 Para. 5.45 provides guidance on the contribution of designations to landscape value, stating that "The value of the landscape receptors will to some degree reflect landscape designations and the level of importance which they signify, although there should not be over-reliance on designations as the sole indicator of value. Assessments should reflect:

- internationally valued landscapes recognised as World Heritage Sites;
- nationally valued landscapes (National Parks, Areas of Outstanding Natural Beauty, National Scenic Areas or other equivalent areas);
- locally valued landscapes, for example local authority landscape designations or, where these do not exist, landscapes assessed as being of equivalent value using clearly stated and recognised criteria; and
- landscapes that are not nationally or locally designated, or judged to be of equivalent value using clearly stated and recognised criteria, but are nevertheless valued at a community level."

4.3.5 GLVIA 3 Para. 5.24 states that "Desk study of relevant documents will often, but not always, provide information concerning the basis for designation. But sometimes, at the more local scale of an LVIA study area, it is possible that the landscape value of that specific area may be different from that suggested by the formal designation. Fieldwork should help to establish how the criteria for designation are expressed, or not, in the particular area in question. At the same time it should be recognised that every part of a designated area contributes to the whole and care must be taken if considering areas in isolation."

4.3.6 GLVIA 3 Para. 5.26 states that "The European Landscape Convention promotes the need to take account of all landscapes, with less emphasis on the special and more recognition that ordinary landscapes also have their value."

4.3.7 GLVIA 3 Para. 5.29 states that:

"Areas of landscape whose character is judged to be intact and in good condition, and where scenic quality, wildness or tranquillity, and natural or cultural heritage features make a particular contribution to the landscape, or where there are important associations, are likely to be highly valued".

"Many areas that will be subject to LVIA will be ordinary, everyday landscapes. In such areas some of the possible criteria may not apply and so there is likely to be greater emphasis on judging, for each landscape type or area, representation of typical character, the intactness of the landscape and the condition of the elements of the landscape. Scenic quality may also be relevant and will need to reflect factors such as sense of place and aesthetic and perceptual qualities. Judgements may be needed about which particular components of the landscape contribute most to its value."

4.3.8 The value attached to each landscape character area will be assessed as part of the baseline study and will inform later judgements about the significance of effects (Figure 2).

Criteria for establishing landscape value

4.3.9 The landscape value of each landscape character area will be established through consideration of the following six criteria:

- geology, landform, hydrology and soils;
- land cover, fauna and flora;
- cultural, social and heritage;
- associations and memories;
- aesthetic qualities; and
- perceptual and experiential qualities.

4.3.10 For each criterion, the value is determined using a five-point scale (1-High, 2- High/Medium, 3-Medium, 4- Medium/Low and 5- Low) using professional judgement with reference to site visits, feedback from public consultation, a review of available background documentation and consultation with relevant disciplines such as ecology and biodiversity, noise, historic environment, agriculture, soils and water resources.

4.3.11 While the criteria that influence landscape value remain constant, they will be considered differently for urban and rural scenarios and appropriate professional judgement will be applied. This principle has also underpinned the assessment criteria.

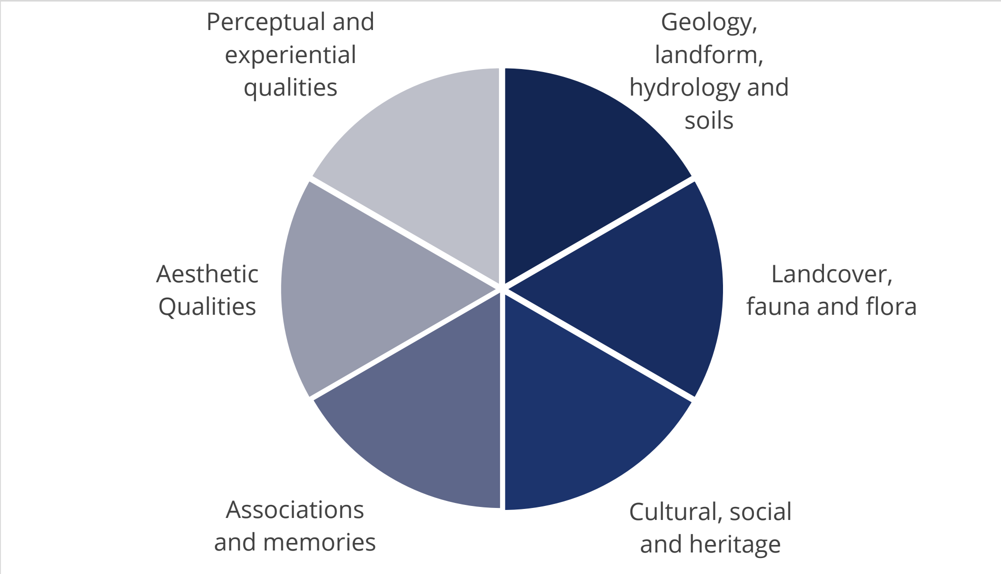
4.3.12 Identification of features and areas of landscape importance in geomorphological, heritage and ecological terms will consider the level to which they influence landscape character. The extent and distribution of valued features and areas within any one LCA also needs to be considered.

4.3.13 The value of the natural, cultural, perceptual and aesthetic components of the landscape, and their overall contributions to landscape character, are likely to be different for each LCA. Some components may provide a particularly strong, or particularly weak, contribution to landscape distinctiveness and sense of place.

4.3.14 The approach to depicting landscape value is shown in the following Figure 3. The scores for each attribute are recorded in GIS using a 5-point scale and outputs generated for each LCA. For some criteria, the information available for judging value may be limited. For example, in the case of 'Associations and Memories', a review of local literature or a review of public consultation responses may not clearly reveal the values of a local community. In such cases, the relevant segment of the graphic may be 'greyed out' to reflect this limitation.

4.3.15 A succinct justification for the overall value assessment judgement will be provided. The supporting text for the landscape value assessment should be a broad description, with an emphasis on the higher value criteria.

Figure 3: Graphic to illustrate application of assessment levels for landscape value criteria



4.3.16 An overall level of value for each landscape character area will be determined using professional judgement. The relative value of these criteria may vary and an emphasis should be placed on those criteria most relevant to character and change, irrespective of perceived landscape quality or importance.

4.3.17 The attributes underpinning the six criteria are described in Table 2. Potential data sources to inform the assessments of landscape value are at Appendix A.

Table 2: Criteria for judging landscape value

1. Geology, landform, hydrology and soils
These landscape components have intrinsic value, which in combination with other features, contribute to positive landscape character. Geology is the fundamental building block of landscape character as it affects, amongst other things, relief, drainage patterns, vegetation cover, the location/evolution of settlements and vernacular building materials and styles. Sites and areas that are complex in geological and geomorphological terms may also be designated for their value to earth science. Landforms can have readily recognisable shapes, peaks, slopes and distinctive silhouettes, and can have value as landmarks and scenic features and for their contribution to skylines. An analysis of the physical and aesthetic components of landforms will be important when considering alteration of existing topography and drainage patterns or creation of new ones. Hydrological elements including rivers, streams, floodplains and wetlands, need to be identified and assessed. The value of these landscape components varies with scale, location and context. The quality and distribution of soil types is reflected in variations in landscape character, cultural expression, settlement evolution, vegetation patterns and biodiversity. Soils have value as a growing medium for food, timber and other crops, as a store for carbon and water, as a reservoir of biodiversity and as a buffer against pollution.

Value criteria

Value criteria	
High	Value criteria: • Distinctive and valued geological/geomorphological features and sites of importance for geological science (e.g. Geological Sites of Special Scientific Interest or Geological Conservation Review sites). They may have high actual or potential educational value, may be of historical importance and may contain rare or unique features. • Distinctive landform and topographical variation that provides a particularly strong contribution to a sense of place, such as an abrupt change in relief or a landmark feature. • Valued hydrological features making a particularly strong contribution to landscape character/ sense of place. • Predominance of Grade 1 agricultural land, where notably contributing to landscape character.
Medium-high	Value criteria: • Geological/ geomorphological features and sites of high regional significance, typically linked to a high educational potential and classified as a Regionally Important Geological/geomorphological Site (RIGS). Some of these sites may also have historical value or demonstrate well-developed geological or geomorphological features. • Landform and topographical variation making a strong contribution to a sense of place, such as a change in relief or a notable feature. • Many hydrological features that provide a strong contribution to landscape character/sense of place. • Predominance of Grade 2 agricultural land, where notably contributing to landscape character.

Medium	Value criteria: • Some geological/ geomorphological features and sites of high regional significance, typically linked to a high educational potential and classified as a Regionally Important Geological/geomorphological Site (RIGS). Some of these sites may also have some historical value or well-developed geological or geomorphological features. • Limited landform and topographical variation. • Hydrological features that provide a notable contribution to landscape character/sense of place. • Grade 3 agricultural land
Medium-low	Value criteria: • A landscape that is not known to include any exceptional or notable geological/geomorphological features, although it may still be 'representative' of its underlying geology or surface geomorphology. • Landform and topographical variation making a limited contribution to a sense of place. • Hydrological features that provide a limited contribution to landscape character/sense of place.
Low	Value criteria: • A landscape that has been altered by development, or other human activities, such that the majority of features of geological or geomorphological significance have been buried or lost. • Landform and topography which is commonplace. • Absence of hydrological features. • Grade 4 agricultural land

2. Land cover, fauna and flora

Landscapes with a strong and positive character in good condition and with features worthy of conservation. This applies to landscapes with semi-natural natural habitats and valued natural features such as woodland and hedgerows with good connectivity. The presence of ecological designations and protected areas such as SSSI as well as ancient woodland, are indicators of landscape value.

Value criteria

High	Value criteria: • The condition of land cover features and elements that contribute to urban or rural landscape character are consistently very good • Little or no fragmentation resulting from changes in land use and development of infrastructure (roads, pylons etc.) • A strongly unified landscape that contributes to a strong sense of place. • A very good representation of the landscape type that also may contain some rare features. • All or most landscape elements are well-maintained. • No detracting elements.

	• Diverse range of wildlife habitats of very high importance form strong structural components within the landscape.
Medium-high	Value criteria: • The condition of land cover features and elements that contribute to urban or rural landscape character is good but may not be uniform throughout the landscape. • Little fragmentation resulting from changes in land use and development of infrastructure (roads, pylons etc.) • A unified landscape that contributes to a strong sense of place. • A good representation of the landscape type that may also contain some rare landscape features. • Most landscape elements are well-maintained. • Few detracting elements are evident. • A range of wildlife habitats of high importance form structural components in the landscape.
Medium	Value criteria: • The condition of land cover features and elements that contribute to urban or rural landscape character are reasonably good, but not uniform throughout the landscape. There will be evidence of deterioration in condition in places. • Some fragmentation resulting from changes in land use and development of infrastructure (roads, pylons etc.), giving a partly interrupted character and localised sense of place. • A good to fair representation of the landscape type that may contain some rare landscape features. • Most landscape elements are well-maintained, but some detracting elements are evident. • Some wildlife habitats are evident, though they are small in area or fragmented, they form notable features within the landscape.
Medium-low	Value criteria: • The condition of land cover features and elements that contribute to urban or rural landscape character is poor throughout the landscape. • There is a weak sense of place. • A limited representation of the landscape type, containing few rare landscape features. • Low levels of landscape maintenance. • Changes in land use and development of infrastructure (roads, pylons etc.) may have resulted in notable fragmentation and loss of landscape structure. • Wildlife habitats are of local importance but are fragmented and overall only form a small proportion of the area.
Low	Value criteria: • The condition of land cover features and elements that contribute to urban or rural landscape character are degraded. • Sense of place is very weak. • A poor representation of the landscape type containing few or no rare landscape features.

	• Low levels of landscape maintenance. • Many detracting or incongruous elements evident. • Changes in land use and development of transport/communications infrastructure may have resulted in high levels of fragmentation and loss of landscape structure. • Wildlife habitats are non-existent or highly fragmented.

3. Cultural, social and heritage

Cultural, social and heritage components are determined by land use, land management, buildings, settlement pattern, and field patterns. The historic landscape is concerned with how the present-day landscape came to be as it is and involves consideration of historical layers. Historic landscape characterisation can inform landscape character assessment by providing information about the historic dimension of present day rural and urban landscapes. Many historic areas and features – buildings, designed landscapes and archaeological sites and monuments – have importance as heritage assets and as landscape features. Heritage encompasses landscapes, historic places, sites and built environments, as well as past and continuing cultural practices, knowledge and living experiences. Cultural and social landscapes have often evolved organically and can be (1) designed landscapes, (2) historic site landscapes, or (3) vernacular landscapes which evolved through use by the people whose activities or occupancy shaped that landscape. Landscapes with a sense of historic continuity and cultural associations may be designated as locally valued landscapes or nationally designated historic landscape components and their settings. Landscape settings may include the relationship of one heritage asset to another and may include an extensive area of countryside in cases where a heritage asset makes use of a 'borrowed landscape'. Landscapes may also be valued in social terms through recreational features and use. The recreational value of landscapes will be demonstrated by the extent to which the experience of the landscape makes an important contribution to recreational use and enjoyment.

Value criteria

High	Value criteria: • A landscape with a high concentration of cultural, social and heritage features that have national or international designations and surrounding landscape that contributes to their settings. Indicator would be the presence of an international designation such as a World Heritage Site or a national designation such as a National Park. • A high concentration of buildings in local vernacular and materials which are valued and of national significance and/or impart a very strong sense of time depth and make a very strong contribution to landscape character. • In rural areas, a high value recreational landscape has a prevalence of features and areas for amenity and recreational enjoyment such as country parks, Common Land, open access land, village greens, and popular recreational facilities. • Landscape contains well used visitor amenities or tourist facilities, characterised by prevalence of footpaths, bridleways and cycleways and/or national or long-distance trails, or other promoted routes. • In urban areas, a landscape featuring parks, open spaces and leisure facilities and where such facilities are particularly important in the context of need and deficit. Likely to be characterised by prevalence of routes such as canal towpaths, greenways, cycle routes and urban paths/bridleways. • Where the Historic Landscape Character (HLC) has been judged as High.

Medium-high	Value criteria: • A landscape with cultural, social and heritage features that have national or international designations and surrounding landscape that contributes to their settings. • The landscape includes designated areas and features recognised through local or regional designation of local or regional significance. • The landscape contains buildings in local vernacular and materials. • In rural areas, a landscape with many features and areas for amenity and recreational enjoyment such as Country Parks, Common Land, Open access land, village greens, popular recreational facilities. • Landscape contains well used visitor amenities/tourist facilities characterised by a good network of local footpaths, bridleways and cycleways and/or national or long-distance trails. • In urban areas, a landscape with a good network of parks, open spaces and leisure facilities or where such facilities are important in the context of areas of need and deficit. Likely to be characterised by a good network of routes such as canal towpaths, greenways, cycle routes and urban paths/bridleways.
Medium	Value criteria: • A landscape with cultural, social and heritage components with some representation of historic areas or features of conservation interest. • Landscape recognised through local designation or through literary or artistic works of local significance. • A landscape with a notable sense of historic continuity containing some buildings of local vernacular style and materials. The heritage assets and their settings are likely to make a notable contribution to overall landscape character. • In rural areas, a landscape with some features and areas for amenity and recreational enjoyment such as Country Parks, Common Land, Open Access Land, village greens, recreational facilities, visitor amenities or tourist facilities. May include some local footpaths, bridleways and cycleways and/or National or long -distance trails. • In urban areas, a landscape containing parks, open spaces and leisure facilities or where such facilities are relatively important in the context of areas of need and deficit – may have moderately well-used public spaces/town squares, or green spaces with evidence of use and which have the potential to meet future needs. Likely to be characterised by some recreational routes such as canal towpaths, greenways, cycle routes and urban paths/bridleways. • Where the HLC value has been judged as Medium.
Medium-low	Value criteria: • A landscape with cultural, social and heritage components that have a low representation of historic areas or features of conservation interest. • The landscape may contain some distinctive components such as buildings of local vernacular materials and styles. • Heritage assets and their settings make only a limited contribution to landscape character. • In rural areas, a landscape with few or fragmented visitor facilities or recreational opportunities including public rights of way or areas for recreational amenity and enjoyment.

	• In urban areas, a landscape with few or no parks or open spaces and recreational opportunities. Likely to be characterised by a poor network of paths and other recreational routes.
Low	Value criteria: • A landscape with few or no cultural, social or heritage areas and features. • The landscape contains few or no distinctive components or areas of note (e.g. local vernacular building materials and styles). • Any heritage assets and their settings are likely to make no or very limited contribution to landscape character. • In rural areas, this may be a landscape with no or very few visitor facilities or recreational opportunities. • In urban areas, this may be a landscape with no or very few quality parks or open spaces and recreational opportunities. Likely to be characterised by a very poor network of paths and other recreational routes. • Where the HLC has been judged as Low.

4. Associations and memories
Landscapes have intangible value in terms of memories and associations, i.e. the thoughts, attachments and interpretations evoked by a landscape. People's perceptions, and experiences, of landscapes vary greatly but every landscape has meanings and associations, irrespective of its type, quality and use. These memories and associations contribute to a sense of place, which may be perceived from one experience of a landscape or built up over time from multiple experiences. Art, stories, poetry and songs can provide ways to pass on experiences and attitudes about a landscape, which may include feelings and longings for past landscapes and past ways of life. The level, quality and nature of the interactions between people and landscape may help us understand the significance of the meanings that develop. These meanings are important for a wide range of reasons and can help build cultural cohesion and greater health and well-being for individuals and also help create more sustainable landscapes. Memories can be influenced by individual or group factors, physical factors (e.g. location, and scale) and social factors (e.g. place experiences). The identification of memories and associations is a challenging area in the landscape assessment process as there may be very limited information available to inform judgements on value. An understanding of memories and associations will initially be developed from a desk-top review of art, literature, descriptive writings, music, myth/legend/folklore and local community publications such as guidebooks and websites set up by parish councils and local history societies. It will depend upon the detail available and may be subsequently informed by community stakeholder engagement responses.

Value criteria

High	Value criteria: • A landscape that has a very strong representation of known community memories and associations expressed through articles, literary works or artistic works of national significance, or through community stakeholder engagement responses.
Medium-high	Value criteria: • A landscape that has a strong representation of known community memories and associations expressed through articles, literary works or artistic works of national or regional significance, or through community stakeholder engagement responses.

Medium	Value criteria: • A landscape that has a good representation of known community memories and associations expressed through articles, literary works or artistic works of local significance, or through community stakeholder engagement responses.
Medium-low	Value criteria: • A landscape that has a medium-low representation of known community memories and associations expressed through articles, literary works or artistic works of local significance, or through community stakeholder engagement responses.
Low	Value criteria: • A landscape that has a low representation of known community memories and associations.

5. Aesthetic qualities

Landscapes can help fulfil a universally recognised human desire for beauty, which may be expressed through cultural and artistic responses. Landform, water, planting, buildings, structures and monuments and their visual relationships are key contributors to aesthetic quality. It is these landscape components and associated characteristics that, individually or combined, give rise to the distinctive scenery of an area. Aesthetic or scenic attractiveness is the measure of aesthetic quality based on commonly held perceptions of beauty of the forms, patterns, colours, textures, visual composition and cultural features of a landscape. Some components of a view may contribute to, or create, visually harmonious or visually discordant compositions.

The aesthetic value of a landscape (urban or rural) derives from the ways in which people draw sensory and intellectual stimulation from the qualities of a landscape, taking into account what other people have written or said. These qualities include the aesthetic elements of space, unity, sense of place and belonging, legibility, coherence of mental image, the richness of activities, and social/cultural perceptions. They also include the quality of natural landscapes and their elements, the quality and design of urban buildings/public spaces and their elements, the visual scale of streets and natural landscape components, the quality of views and vistas, continuity, enclosure, texture, form, line, colour, balance, movement, pattern, complexity, diversity etc.

Value criteria

High	Value criteria: • Areas with very scenic/special qualities and/or comprising a very aesthetically-pleasing composition of characteristic landscape elements and features that are intact with no visual detractors. Indicator would be the presence of a national designation such as an AONB. • In rural areas, this will be a landscape where landforms, vegetation patterns, water characteristics, and cultural features combine to provide high levels of scenic attractiveness. • In urban areas, these landscapes are likely to create a highly distinctive sense of place that include visually coherent groups of well-designed buildings, public realm and streets. • Public realm areas will have many valued aesthetic qualities and an exceptional sense of place.

Medium-high	Value criteria: • Areas comprising an aesthetically-pleasing composition of characteristic landscape elements and features that are distinctive, in good condition but may have some visual detractors. Indicator would be the presence of a local landscape designations where still included in local planning documents (Landscapes of County Importance (LoCI)). • In rural areas, a landscape where landforms, vegetation patterns, water characteristics, and cultural features combine to provide high levels of scenic attractiveness albeit with some evidence of disturbance or decline. • In urban areas, these landscapes will have a distinctive sense of place, and will include visually coherent groups of well-designed/well-proportioned buildings, reasonably well related to streets and public realm.
Medium	Value criteria: • A landscape exhibiting a recognisable landscape structure with moderate levels of aesthetic appeal, containing some conspicuous visual detractors. Components are likely to be in good to fair condition, but aesthetic qualities are not remarkable. • In rural areas, a landscape where landforms, vegetation patterns, water characteristics, and cultural features combine to provide moderate levels of scenic attractiveness. • In urban areas, these landscapes are likely to include moderately coherent visual groupings of buildings with some distinctive built form and aesthetic qualities, but some visually detracting features. Public realm is likely to have a good sense of place, but occasional buildings, structures and spaces may detract from the visual unity.
Medium-low	Value criteria: • Areas with some valued landscape components, positive landscape characteristics and visual attributes. They are likely to exhibit limited coherence and structure and limited levels of aesthetically-pleasing composition. These areas are likely to have a notable number of visual detractors. Components are likely to be in fair condition, but with clear evidence of erosion or loss. • In rural areas, a landscape with marked presence of elements that adversely affect special / scenic qualities, or one of low scenic quality or with many of the scenic / special qualities eroded. • In urban areas, a landscape where many of the scenic and special qualities have been eroded, for example, by the presence of extensive large-scale or industrial development with resultant unattractive, visually conflicting or degraded areas. This may also be a landscape with a low occurrence of built form with aesthetic qualities, or with areas that have very limited variety with resultant visual monotony.
Low	Value criteria: • Areas with landscape components of very limited value, or very few positive landscape characteristics and visual attributes. • Areas are likely to have many degraded, disturbed or derelict features and areas. Possibly exhibiting mixed land uses that weaken the underlying landscape structure. • Urban areas likely to be a poor-quality environment that lacks cohesive form and structure and with very little or no visual interest. • In rural areas, this may be a landscape with a greater presence of prominent or large-scale built elements. • In urban areas, this may be a landscape with the presence of discordant or degraded built form or industrial development.

6. Perceptual and experiential qualities

Landscape perception is about our response to the landscape: how it makes us feel and the reactions it evokes in us. The scale and context of one's place within the landscape may alter one's perception of the landscape. Perceptions may also vary with the seasons or according to time of day.

Our perceptions are determined by a range of sensory factors including sight, smell, sound and touch. Perceptual qualities of a landscape may include a wide range of positive emotional responses, including senses of safety/security, tranquillity, naturalness, intimacy, excitement, wildness, remoteness, tameness, or inspiration. They may also include some negative emotional responses, e.g. unsettling, threatening, inaccessibility and monotony.

An understanding of the perceptual and experiential qualities of a landscape will initially be developed from a desk-top review of literature (e.g. published landscape character assessments) and from field survey work. It may be subsequently informed by community stakeholder engagement responses.

Value criteria

High	Value criteria: • A landscape with many positive perceptual attributes and qualities, e.g. peace, solitude, intimacy, remoteness and tranquillity. • Likely to be a landscape with a very distinctive sense of place and with no or very few detractors.
Medium-high	Value criteria: • A landscape with a good representation of positive perceptual attributes and qualities, e.g. peace, solitude, intimacy, remoteness and tranquillity. • Likely to be a landscape with a distinctive sense of place and with few detractors.
Medium	Value criteria: • A landscape with ordinary levels and occurrences of positive perceptual attributes and qualities, e.g. peace, solitude, intimacy, remoteness and tranquillity. • Likely to be a landscape with a moderately strong sense of place and/or with some detractors.
Medium-low	Value criteria: • A landscape with few positive perceptual attributes and qualities, e.g. peace, solitude, intimacy, remoteness and tranquillity. • Likely to be a landscape without any particularly strong sense of place and/or with several detractors/negative perceptual qualities present.
Low	Value criteria: • A landscape with no or very few positive perceptual attributes and qualities. • Likely to be a landscape with a very poor sense of place and/or with many detractors/negative perceptual qualities present.

4.4 Determining landscape susceptibility

4.4.1 GLVIA 3 Para. 5.40 states that susceptibility to landscape change means “the ability of the landscape receptor … to accommodate the specific nature of a proposed development and/or change in land use without undue consequence for the maintenance of the baseline situation and/or the achievement of landscape planning policies and strategies”.

4.4.2 Judgements on landscape susceptibility therefore should take account of the extent to which the valued landscape attributes will be able to accommodate the proposed development without undue consequences.

4.4.3 Susceptibility is assessed using a five-point scale (low/medium-low/medium/medium-high/high) for each of the criteria as described in Table 2, which are:

- geology, landform hydrology and soils;
- land cover, fauna and flora;
- cultural, social and heritage;
- associations and memories;
- aesthetic qualities; and
- perceptual and experiential qualities.

4.4.4 However, not all these criteria will be applicable for assessing susceptibility and this is indicated in Table 3. In such cases, the relevant segment of the graphic will be ‘greyed out’ to reflect this.

4.4.5 Professional judgement will be used to assess which of the criteria are susceptible to change. Table 3 below sets out the factors considered in determining the level of susceptibility for each assessment criterion. Susceptibility is considered using a five-point scale from high to low, and professional judgement will be applied to identify the level of susceptibility, considering baseline field survey work and desktop research, including reviews of local authority character assessments, landscape planning policies and strategies, historic landscape character assessments and conservation area character appraisals where available.

Table 3: Criteria for judging susceptibility of landscape to change

1. Geology, landform, hydrology and soils	
Open, highly prominent and distinctive or intricate and complex landforms with sharp changes in level are more likely to be susceptible to change arising from development than flat and indistinct landforms. These criteria also considers whether potential development would interrupt the relationship between distinctive landform features such as escarpments, or prominent hills or open plains. In some locations development would affect skyline character.	
High	Susceptibility criteria: • Very intricate or rugged landscapes or landscapes with sharp changes in level. • An abundance of landscape features such as escarpment, ridges, prominent hills. • Development is likely to appear on the skyline. • Complex arrangements of water features which are seen in close association with each other.
Medium-high	Susceptibility criteria: • Intricate or varied landforms with notable changes in level. • A number of landscape features such as escarpment, ridges, prominent hills. • Undulating or valley landscapes whose skyline character would be more vulnerable to change arising from the Proposed Scheme. • Presence of a number of water features which combine to influence the landscape character.
Medium	Susceptibility criteria: • A landform with some gradual changes in level. • A landscape with a number of distinctive landscape features. • Presence of a single water feature which forms a part of the landscape character.
Medium-low	Susceptibility criteria: • A predominantly smooth, flat or uniform landscapes with some gradual changes in level. • A landscape with few distinctive landscape features. • No water features.
Low	Susceptibility criteria: • A smooth, flat or uniform landscape with no distinctive landscape or water features.

2. Land cover, fauna and flora	
Landscapes with a small scale, complex and intricate landscape pattern arising from landcover elements including settlement, field pattern or vegetation cover are more likely to be susceptible to change arising from development than landscapes with a simple landcover pattern. Landscapes enclosed by buildings, trees and woodlands can offer more opportunity to accommodate development without affecting landscape character. Intact field boundaries can help screen development but can also be susceptible to loss or degradation.	
Susceptibility criteria	
High	Susceptibility criteria: • Landscapes with a very strong pattern and continuity of land cover components that work well together to form a strong landscape character – e.g. urban or historic features, flora and fauna. • Landscapes with complex landcover pattern/features and associated high levels of diversity in terms of flora/fauna.
Medium-high	Susceptibility criteria: • Landscapes with a strong pattern and continuity of land cover components that work well together to form landscape character – e.g. urban or historic features, flora and fauna. • Landscapes with a variety of landcover pattern/features and associated good levels of diversity in terms of flora/fauna.
Medium	Susceptibility criteria: • Landscapes with some pattern and continuity of land cover components that work well together to form landscape character – e.g. urban or historic features, flora and fauna. • Landscapes with some variety of landcover and/or some variation in terms of landcover, flora or fauna.
Medium-low	Susceptibility criteria: • Landscapes that are more fragmented or disrupted in terms of land cover components e.g. where the connectivity between urban or historic features, or woodlands, flora and fauna has been lost through later landscape change/changes in management etc. • Landscapes with relatively simple landcover and/or low levels in variation in terms of landcover, flora or fauna.
Low	Susceptibility criteria: • Landscapes that are very fragmented or disrupted in terms of land cover components e.g. where the connectivity between urban or historic features, or woodlands, flora and fauna has been completely lost through later landscape change/changes in management etc. • Landscapes with a single type of landcover and no variation in flora or fauna.

3. Cultural, social and heritage	
Landscapes with a historic landscape pattern such as pre enclosure intimate field pattern are likely to be more susceptible to change than a landscape with a more recent expansive field system. A landscape with old stone boundaries is more susceptible to change than one containing post and wire fencing. A landscape containing designed landscapes where components such as a stately home, water feature and follies interrelate with each other is more susceptible to change due to severance.	
Susceptible criteria	
High	Susceptibility criteria: • Landscapes with high concentrations of cultural, social or heritage components and settings, such that direct loss or severance would create much disturbance to historic landscape character. • A landscape with an abundance of historic, small enclosed fields with characteristic boundaries.
Medium-high	Susceptibility criteria: • Landscapes with a medium concentration of cultural, social or heritage components and settings, such that direct loss or severance would create disturbance to historic landscape character. • A landscape with an abundance of historic, small enclosed fields with characteristic boundaries although the boundaries may not be in the best of conditions.
Medium	Susceptibility criteria: • Landscapes with small concentrations of cultural, social or heritage components and settings, such that direct loss or severance would create some disturbance to historic landscape character. • A landscape with a mix of historic field patterns and larger fields with less defined boundaries.
Medium-low	Susceptibility criteria: • Landscapes with few cultural, social or heritage landscape components. • A landscape which consists of predominantly large expansive fields with post and wire fencing or hedgerows forming the boundaries.
Low	Susceptibility criteria: • Landscapes with no cultural, social or heritage landscape components.

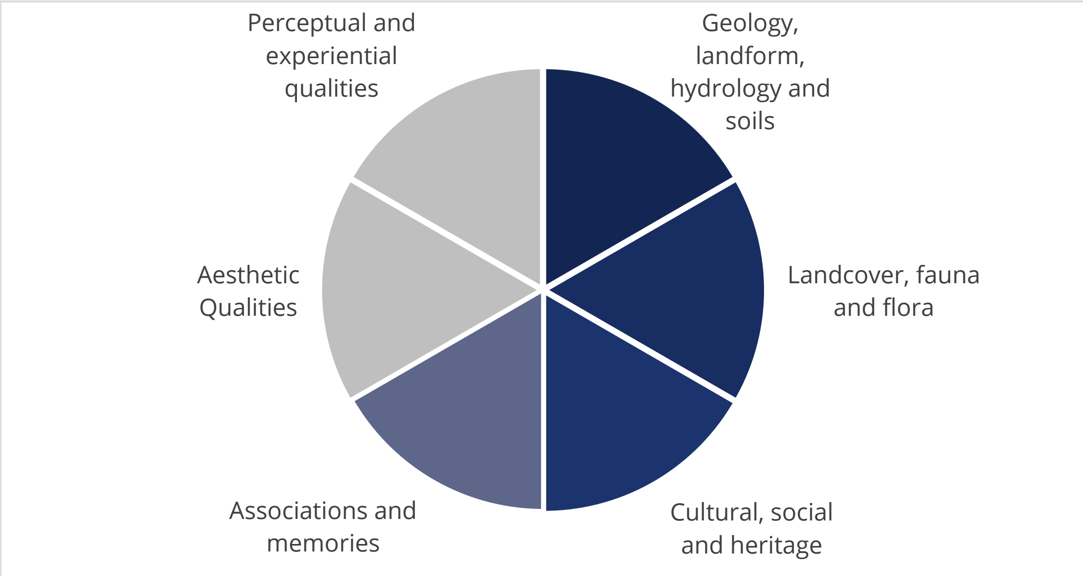
4. Associations and memories	
Evidence that the landscape is associated with: locally important written descriptions of the landscape; artistic representations of it in any media; events in history; notable people; or important cultural traditions or beliefs. Assessment of susceptibility will consider how vulnerable the identified memories and associations of a landscape would be to the development. It will depend upon the detail available and may be subsequently informed by community stakeholder engagement responses.	
Susceptibility criteria	
High	Susceptibility criteria: • Landscapes with very strong and well-documented cultural and social associations, where direct loss or severance of memory and associational components would adversely impact on wide audience of people's appreciation of the landscape or lead to a changed perception of place, or memory of place.
Medium-high	Susceptibility criteria: • Landscapes with strong and well-documented cultural and social associations, where direct loss or severance of memory and associational components would adversely impact on people's appreciation of the landscape or lead to a changed perception of place, or memory of place.
Medium	Susceptibility criteria: • A landscape with some cultural and social associations, where direct loss or severance of memory and associational components may impact on small groups of people's appreciations of the landscape or lead to a changed perception of place, or memory of place.
Medium-low	Susceptibility criteria: • A landscape with few apparent cultural and social associations.
Low	Susceptibility criteria: • A landscape with no apparent memories or associations.
5. Aesthetic qualities	
Not applicable	
High	• Not applicable
Medium-high	• Not applicable
Medium	• Not applicable

Medium-low	• Not applicable
Low	• Not applicable
6. Perceptual and experiential qualities	
Not applicable	
High	• Not applicable
Medium-high	• Not applicable
Medium	• Not applicable
Medium-low	• Not applicable
Low	• Not applicable

4.4.6 The assessed level for each criterion should be inputted into the landscape susceptibility assessment 'wheel' in the Volume 5 template, the colours of which will be automatically populated using GIS (see ES Volume 5 Landscape and Visual Guidance Note and in the following Figure 4).

4.4.7 For some criteria, the information available for judging landscape susceptibility may be very limited or there may be no information at all. For example, in the case of 'Associations and Memories', a review of local literature or public engagement responses may not clearly reveal the values of a local community and therefore the resultant susceptibility to change. In such cases, the landscape susceptibility assessment 'wheel' may be 'greyed out' to reflect this limitation.

Figure 4: Graphic to illustrate application of assessment levels for landscape susceptibility criteria



4.4.8 The supporting text for the landscape susceptibility assessment should reflect the above graphics.

4.4.9 An overall level of susceptibility for each landscape character area will be assessed by bringing together the judgements made for each category described above. This will be based, in line with guidance provided by the Landscape Institute, on professional judgement to understand and articulate which landscape attributes are most important in the context of landscape change that will be introduced because of the Proposed Scheme. This assessment of overall level of susceptibility will be made based on the definitions set out in the following Table 4.

Table 4: Criteria for judging overall level of susceptibility of the landscape to change

Overall level of susceptibility	Definition
High	The overall character and valued landscape characteristics, elements and features have a very low level of ability to tolerate the nature and scale of change resulting from the Proposed Scheme without permanent serious adverse consequences in terms of the maintenance of the baseline situation.
Medium-high	The overall character and valued landscape characteristics, elements and features have a low level of ability to tolerate the nature and scale of change resulting from the Proposed Scheme without permanent consequences of concern in terms of the maintenance of the baseline situation.
Medium	The overall character and valued landscape characteristics, elements and features have a moderate level of ability to tolerate the nature and scale of change resulting from the Proposed Scheme with some concern in terms of the maintenance of the baseline situation.
Medium-low	The overall character and valued landscape characteristics, elements and features have a high level of ability to tolerate the nature and scale of change resulting from the Proposed Scheme with limited concern in terms of the maintenance of the baseline situation.
Low	The overall character and valued landscape characteristics, elements and features have a very high level of ability to tolerate the nature and scale of change resulting from the Proposed Scheme with no concern in terms of the maintenance of the baseline situation.

4.4.10 A succinct justification for the overall susceptibility assessment judgement will be provided for each landscape character area.

4.5 Determining landscape sensitivity

4.5.1 There can be complex relationships between the value attached to landscape receptors and their susceptibility to change but an overall assessment of landscape character sensitivity needs to be made using the five-point sensitivity scale in Table 5.

Table 5: Criteria for assessing landscape sensitivity

Rating	Definition
High	In overall terms, the valued and susceptible attributes of the landscape are of high sensitivity to adverse change resulting from the Proposed Scheme.
Medium-high	In overall terms, the valued and susceptible attributes of the landscape are of medium-high sensitivity to adverse change resulting from the Proposed Scheme.
Medium	In overall terms, the valued and susceptible attributes of the landscape are of medium sensitivity to adverse change resulting from Proposed Scheme.
Medium-low	In overall terms, the valued and susceptible attributes of the landscape are of medium-low sensitivity to adverse change resulting from Proposed Scheme.
Low	In overall terms, the valued and susceptible attributes of the landscape are of low sensitivity to adverse change resulting from the Proposed Scheme.

4.5.2 This assessment will be based, in line with guidance provided by the Landscape Institute, on professional judgement of the relative importance of the value and susceptibility criteria for each character area. This judgement will be made in the context of guidance set out in GLVIA 3, which notes that:

- "An internationally, nationally or locally valued landscape does not automatically, or by definition, have high susceptibility to all types of change.
- "It is possible for an internationally, nationally or locally important landscape to have relatively low susceptibility to change resulting from the particular type of development in question, by virtue of both the characteristics of the landscape and the nature of the proposal."
- "The particular type of change or development proposed may not compromise the specific basis for the value attached to the landscape."

(GLVIA 3, Para. 5.46, page 90).

Appendix A: Potential Sources of Data to Inform Assessments of Landscape Value

Geology, landform, hydrology and soils data sources*:
• Lidar terrain data • Aerial imagery • Ordnance Survey Mapping • British Geological Survey (BGS) geological/soil mapping • BGS Geological Memoirs, where available • Regionally Important Geological Sites (RIGS) data and research done by local geological groups • Hydrology maps • Agricultural Land Classification
Land cover, flora and fauna data sources*
• Green infrastructure plans, strategies, frameworks, audits and opportunity assessments • Ancient Woodland (including inventories of smaller ancient woodland sites 0.25-2ha) • National woodland inventory • Habitats of Principal Importance such as BAP Priority Habitats or Living Landscape Areas/Biodiversity Opportunity Areas • Ramsar Sites, Special Areas of Conservation (SAC), Special Protection Area (SPA) and SSSI • National Nature Reserves (NNR) and Local Nature Reserves (LNR) • Local Wildlife Sites/Community Nature Reserves/Community Orchards and Gardens/Village Greens/ Doorstep Greens/Pocket Parks • Common Land • Ecological surveys • Aerial photography • Components of urban structure such as nodes, hubs and main circulation routes, landmark buildings and spaces • Green infrastructure audits and opportunity assessments • City visions/masterplans/growth frameworks and Local Plans
Cultural, social and heritage; associations and memories data sources*
• Historic landscape characterisation • Artistic and literary references • Historic Environment Record (HER) data • National Heritage List (NHL) • Historic Battlefields • Historic map layers/regression analysis • Research and publications by local history and community groups

• Green infrastructure strategies, plans and frameworks • Open Space, sport, play and recreation studies and strategies (PPG17 studies) including any deficiency and need analysis • Local Plan data • Parish council data/local community facilities/plans aspirations • National Forest data • Accessible Woodlands data • Environmental Stewardship Schemes data • Forestry Commission Forest Design Plans • Ordnance Survey mapping • National Trails and long distance promoted routes • Definitive PROW map (footpaths and bridleways) • Sustrans/National Cycle Network and local cycle route mapping • Open Access land and registered common land • Village greens • Traditionally managed orchard data • Tourist guides • Heritage facilities management plans • Local Plans • Environment Agency Main Rivers dataset • Canal & River Trust asset mapping
Aesthetic qualities data sources*
• Heritage sources noted above • National, regional and district/local Landscape Character Assessments • Landscape management plans such as parkland plans, conservation plans and Forestry Commission estate/Forest Design Plans • Green infrastructure plans, strategies and frameworks • Designated sites/assets (geological/heritage/ecological) and associated citations (including local/national designations as appropriate) • View Management Frameworks • Aerial imagery • Ordnance Survey Mapping • Local Plan data (including Local Landscape Designations) • Environment Agency river and drainage studies, river LCAs

Perceptual and experiential data sources*
• National, regional and district/local Landscape Character Assessments • Aerial imagery • Ordnance Survey Mapping • Campaign to Protect Rural England (CPRE) Tranquillity maps (2007) and Intrusion and Dark Skies mapping • Local Plans • Landscape Institute Technical Information Note 01/2017 on Tranquillity (March 2017)

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Landscape and visual – Approach to night time 'darkness' survey and assessment

Contents

1 Introduction

1.1.1 This technical note has been prepared to provide guidance on undertaking the night time 'darkness' surveys and assessing the potential impacts of lighting as part of the visual assessment, as defined in the Guidelines for Landscape and Visual Impact Assessment (GLVIA)[1]. The assessments of lighting on night-time visibility will be qualitative although they will be informed by any light-spill models and quantitative assessments of illumination levels undertaken by lighting engineers. The impacts of artificial lighting on ecological resources will be addressed in the Ecology sections of the Volume 2 Community area reports of the Environmental Statement (ES) for the Proposed Scheme.

1.1.2 Night time 'darkness' survey work will be required in selected locations to assess potential effects of obtrusive light that would result from a range of construction and operational light sources. The principal objective is to identify the effects associated with obtrusive light on sensitive visual receptors, propose suitable mitigation and assess likely significant residual effects. Obtrusive light or light pollution is any light that strays to areas other than where it is intended and can include light intrusion (spill light), upward light (which can create sky glow) and visual source intensity (glare).

1.1.3 Impacts at night could arise during construction (such as lighting associated with tunnel boring machinery, which would be in operation 24 hours per day) and/or during operation (such as operational and security lighting associated with rolling stock depot (RSD) or the infrastructure maintenance base-rails).

1.1.4 The impact of lighting on the character of the landscape will be assessed where appropriate as part of the landscape assessment, as defined in the 'Approach to landscape susceptibility and landscape sensitivity' technical note.

1.1.5 The survey and assessment work will be undertaken in the context of a review of national and district level planning policies and Institute of Lighting Engineers (ILE) guidance on the effects of artificial lighting on views, tranquillity and dark skies[2, 3].

[1] Landscape Institute and Institute of Environmental Management & Assessment (2013*), Guidelines for Landscape and Visual Impact Assessment Third Edition.*

[2] Both of these datasets are published by the Campaign for the Protection of Rural England (CPRE).

[3] Such locations may include receptors in proximity to the Crewe North RSD and other similar large-scale infrastructure with 24-7 operation.

2 Visual receptors

2.1.1 The following visual receptors will be considered in the night time 'darkness' surveys:

- occupiers of residential properties;
- where appropriate, recreational receptors visiting promoted landscapes or attractions that may be open in the dark (Listed buildings, Registered Parks and Gardens etc.) or recreational receptors such as users of camp sites and other similar tourist facilities;
- people travelling along rural roads/lanes/scenic routes;
- students staying overnight in schools; and
- residents staying in hotels and healthcare institutions.

2.1.2 Other receptors will not be considered on the basis that either they would generally not be present late at night (e.g. recreational receptors other than those identified above) or their immediate context would be brightly lit if they were present at night (e.g. employment /formal sports). Further detail on the sensitivity of visual receptors is provided within the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR).

2.1.3 The absence of artificial light sources in some views is likely to be valued by local communities and this should be recorded wherever possible.

2.1.4 Residential receptors should be considered in terms of potential effects from light intrusion through windows and on properties as a whole.

2.1.5 A series of representative viewpoints will be identified for assessment purposes.

3 Potential sources of visual impact arising from artificial lighting

3.1 Lighting during construction

- typical working hours would require some lighting in the early morning and late evening, particularly during winter months. However, at these times residential receptors which could be affected are likely to have their properties lit and have the curtains drawn/window blinds down, meaning their attention is unlikely to be focused on the landscape. Lighting during typical working hours will not be considered as part of the night time assessment for residential receptors;
- at some locations, including compounds and tunnel portals, continuous working and/or overnight working will be required for periods of time. This will be considered as part of the night time assessment;
- at some locations, including compounds, auto-transformer feeder stations and auto-transformer stations, movement activated security lighting will be required for the duration of construction. This will be considered as part of the night time assessment;
- at some locations, extended working hours would be required intermittently (e.g. for large concrete pours which need to be completed in one exercise). This would typically extend lighting at a site into the late evening. However, on the basis that this would be an intermittent and relatively infrequent exercise, such instances will not be considered as part of the night time assessment; and
- at other locations, continuous working may be limited to night time only (e.g. modification works to existing rail track). This should be considered as part of the night time assessment where it would give rise to the potential for significant night time visual impact.

3.2 Lighting during operation

- at some locations, continuous lighting will be required for periods of time. This will be considered as part of the night time assessment;
- at sidings and depots, operational works may be limited to night time only. This will be considered as part of the night time assessment;
- at some locations, lighting of new road junctions and roundabouts will be required. This will be considered as part of the night time assessment; and
- lighting from moving trains may be intermittently visible to visual receptors up to 12 times per hour in each direction during peak hours (services are anticipated to operate from approximately 05:00 through to 00:00). The effects of the lighting will be highly variable. In some cases, this intermittent lighting, often broken by intervening topography, vegetation and built form would not be present through the night (times when people are most sensitive to additional light) and this scenario will therefore not be

considered as part of the night time assessment. In other cases, this intermittent lighting will be present through the night and this scenario will therefore be considered as part of the night time assessment.

3.2.1 There is the potential for glare in cases where rural roads may be aligned close to and parallel to the tracks, or for strobe lighting effects where lighting may be seen through directional noise barriers. Account will be taken of this where appropriate in the night time assessment, which should be informed by technical assessments undertaken by the lighting engineers.

4 Night time 'darkness' surveys

4.1.1 Selection of locations for night-time survey work will be determined through desk-top research (e.g. tranquillity mapping or dark night skies mapping[4] and any published 'Environmental Zone' classifications), day-time field survey work and construction phase and operational activity information to scope areas and night time visual receptors. Night time 'darkness' visual surveys will be carried out only at locations where there is the potential for significant effects to arise from lighting during construction or operation[5],to identify existing night time visual conditions.

4.1.2 Night time surveys will be undertaken in good weather conditions between 22:00 and 03:00 in summer months and between 18:00 and 05:00 in winter. The time and weather conditions, including the phase of the moon and any starlight/moon light impacts will be recorded.

4.1.3 Generalised descriptions of likely night-time views from representative viewpoints may be provided in cases where there are limitations on access to land. Professional judgement will be used, with appropriate caveats, in such instances to describe the likely visual baseline based on night-time observations in the surrounding areas and day-time observations of any artificial light source structures.

4.1.4 In cases where night-time survey and assessments have been 'scoped in', the night time baseline descriptions and impact assessments will be set out in the relevant Volume 5 technical appendices and will consider:

- visibility, brightness and prominence of the lighting sources within the view (e.g. security lighting within existing railway depots or on motorway junctions);
- the proportion of the view occupied by light sources;
- detail on the foreground, middle ground and background context of the view;
- comments on light spill, glare[6], and sky glow[7];
- 'Environmental Zone' classifications, which will be identified in reflection of the general nature of existing lighting levels of the areas[8] and may be defined as set out in Table 1.

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[4] Both of these datasets are published by the Campaign for the Protection of Rural England (CPRE).

[5] Such locations may include receptors in proximity to depots and other similar large scale infrastructure with 24-7 operation.

[6] 'glare' is the "uncomfortable brightness of a light source when viewed against a darker background": Guidance Notes for the Reduction of Obtrusive Light, Institute of Lighting Professionals (ILP) GN01:2011.

[7] "sky glow" is "the brightening of the night sky": Guidance Notes for the Reduction of Obtrusive Light, ILP GN01:2011.

[8] International Commission on Illumination (CIE) (2003), *CIE 150:2003 Guide on the limitation of the effects of obtrusive light from outdoor lighting installations*.

Table 1: Definition of Environmental Zones

Zone	Type of surroundings	Lighting environment	Examples
E0	Protected	Dark	UNESCO Starlight Reserves, International Dark Sky Parks
E1	Natural	Intrinsically dark	Dark Sky Discovery Sites, National Parks, Areas of Outstanding Natural Beauty etc.
E2	Rural	Low district brightness	Villages or relatively dark outer suburban locations
E3	Suburban	Medium district brightness	Small town centres or suburban locations
E4	Urban	High district brightness	Town/city centres with high levels of night-time activity

4.1.5 Qualitative descriptions on the general after-dark nature of existing lighting in the area will be made rather than quantitative descriptions on the types and levels of lighting within it. Interactive satellite maps of England's dark skies, produced by the Campaign to Protect Rural England (CPRE)[9], and any information available from astrological societies, will also be used to help ascertain existing levels of light.

4.1.6 Whilst night time photographs should be taken where appropriate, practical and safe to do so for field survey record purposes and to inform the writing of the assessment (e.g. the proportion of a view occupied by artificial light sources), no night time photographs will be included in the Volume 5 technical appendices, due to the difficulty of taking night time images that give an accurate representation of the night time environment (long exposures may tend to accentuate sky glow impacts or apparent brightness of spill light areas, while short exposures may make areas appear to be darker than they appear to the naked eye).

[9] The Countryside Charity (2016), *England's Light Pollution and Dark Skies*. Available online at: http://nightblight.cpre.org.uk/maps/?_ga=2.208860177.285529541.1496757195-846886392.1468921309.

5 Potential impacts of lighting as part of the visual assessment

5.1.1 The baseline description and the predicted change in the night time environment will be presented for each representative viewpoint.

5.1.2 Factors that will be considered in assessing the magnitude of change to night-time views are summarised in Table 2.

Table 2: Magnitude of change definitions

Magnitude	Definition
High	Where the Proposed Scheme would result in a significant increase in the extent, brightness or prominence of artificial lighting in the view and/or a significant increase in light spillage, glare or skyglow
Medium	Where the Proposed Scheme would result in a noticeable increase in the extent, brightness or prominence of artificial lighting in the view and/or a significant increase in light spillage, glare or skyglow
Low	Where the Proposed Scheme would result in a slight increase in the extent, brightness or prominence of artificial lighting in the view and/or a significant increase in light spillage, glare or skyglow
Negligible	Where the Proposed Scheme would result in a slight increase in the extent, brightness or prominence of artificial lighting in the view and/or a slight increase in light spillage, glare or skyglow

5.1.3 The magnitude of change and level of significant effect for visual impacts at night will be assessed for each relevant viewpoint at operational stage for year 1 winter only, as the worst-case scenario.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Landscape and visual – Zone of theoretical visibility production methodology

Contents

1 Introduction

1.1.1 This technical note has been prepared to describe the methodology used to produce the zones of theoretical visibility (ZTV) of the Proposed Scheme.

1.1.2 The purpose of a ZTV is to show areas of land within which the Proposed Scheme is theoretically visible at various phases. ZTV are produced at construction and operation phases and are updated when significant design iterations are reached. The broad methodology for producing the ZTV is described in the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR). The ZTV have been produced using one model for the whole route to ensure route-wide consistency.

1.1.3 ZTV have been prepared to show:

- the theoretical visibility of the Proposed Scheme during construction. This excludes cranes on the basis that these would indicate widespread visibility and take emphasis away from understanding the potential extent of significant effects. However, cranes have been considered, where relevant, in the assessment of effects (see Section 3);
- the theoretical visibility of the Proposed Scheme in year 1 of operation. Overhead line equipment (OLE) has been excluded due to its potential to take emphasis away from the understanding of significant effects. However, the OLE is accounted for in the landscape and visual assessment; and
- the theoretical visibility of the Proposed Scheme in year 15 of operation, taking into account the benefit maturing vegetation may have on restricting visibility.

1.1.4 The ZTV are based on the Proposed Scheme used for the assessment of effects which will be presented in the Environmental Statement (ES).

2 Production of the base model

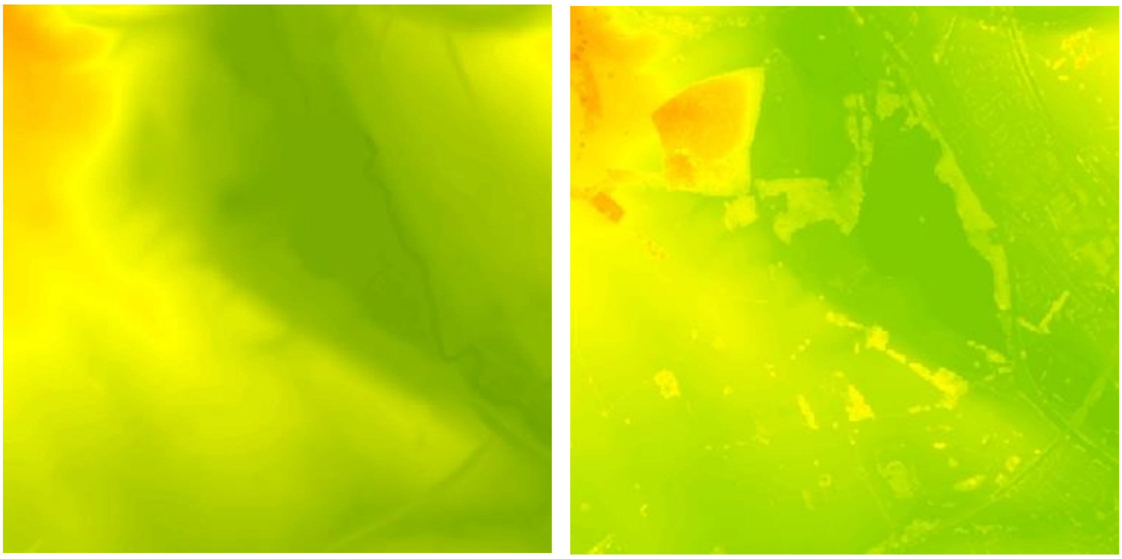
2.1 Baseline construction surface

2.1.1 The creation of a baseline model, on which to run the construction phase visual analysis, is a multiple step process and is wholly reliant on the datasets available.

2.1.2 The datasets used to produce the ZTV of the Proposed Scheme are as shown in Figure 1 and Figure 2. A digital terrain model (DTM) is a bare-earth raster grid referenced to a vertical datum. It does not include vegetation or buildings. A digital surface model (DSM) includes natural features as well as buildings.

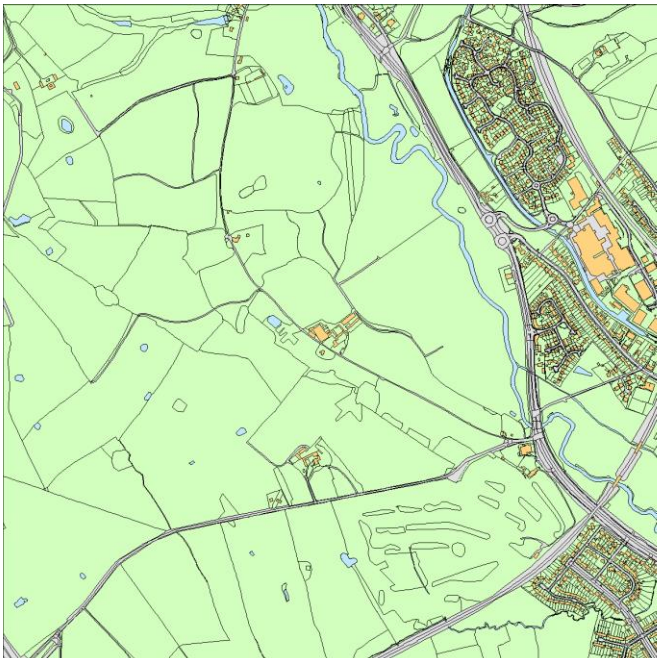
2.1.3 To reflect actual conditions of topography along with buildings and large belts of vegetation, which may act as visual barriers, it is necessary to build a model that takes these into account but does not include any unwanted barriers from a surface model that may not truly reflect the surface. For example, in a DSM, a bridge or an elevated walkway would be interpreted as a visual barrier whereas in fact an observer would be able to see under the element.

Figure 1: 5m DTM in gdb raster format and 2m DSM in .gdb raster format



Source: DEFRA

Figure 2: Ordnance Survey MasterMap

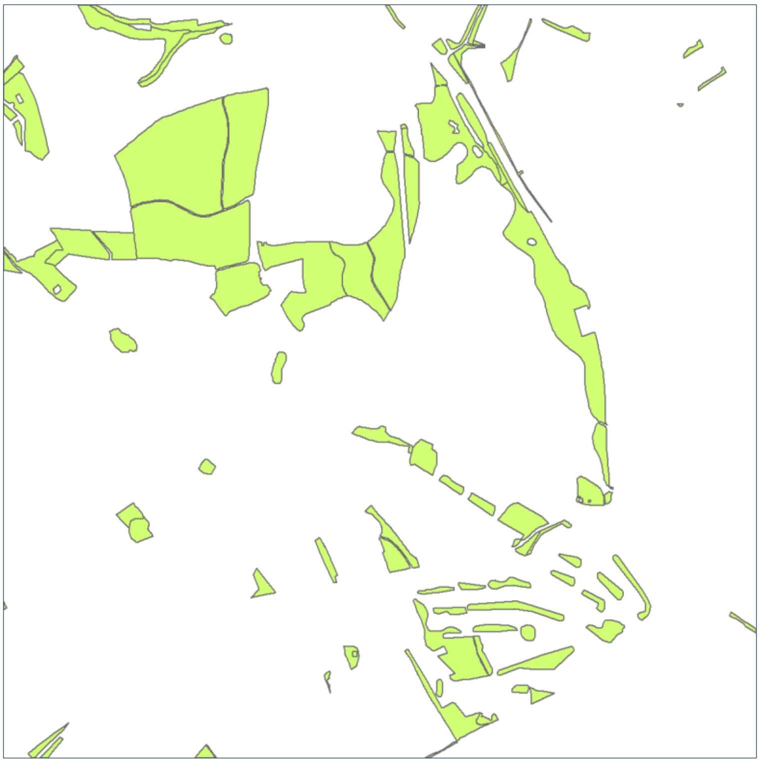


2.1.4 In essence, the following process takes elements such as buildings and large tree belts (Figure 3 and Figure 4) from a DSM and adds them to a DTM.

Figure 3: Extracting buildings from the Ordnance Survey (OS) Mastermap data

2.1.5 The OS Mastermap data is filtered using definition queries to extract the buildings and existing woodland areas, whilst ensuring that any overhead structures such as bridges or elevated walkways are not included. A feature class is then exported for later use (Figure 3 and Figure 4).

Figure 4: Extracting woodland from the OS Mastermap data



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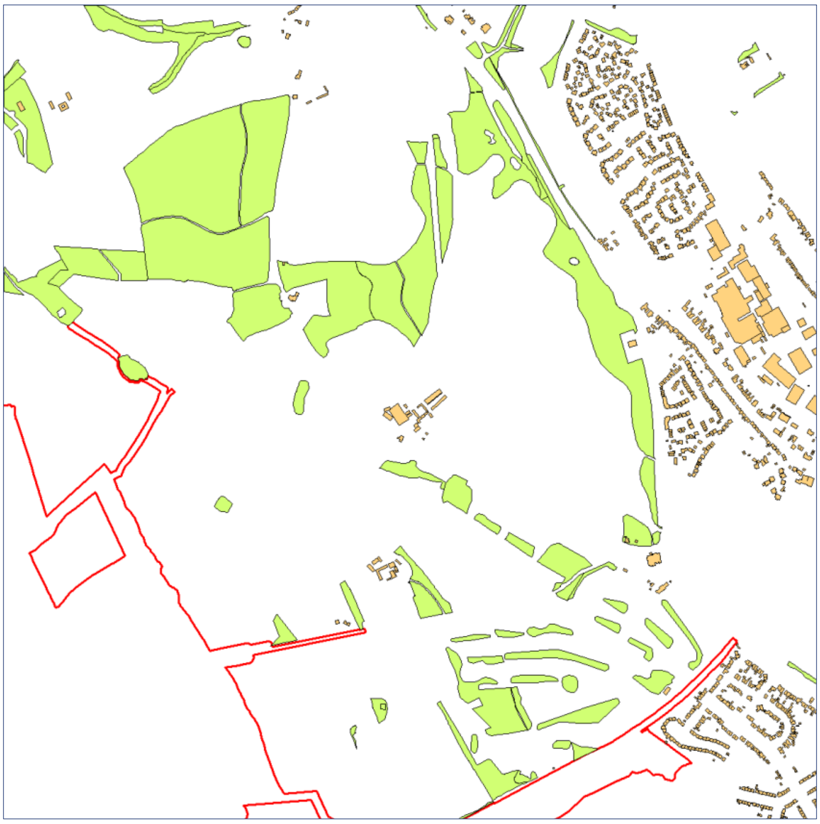
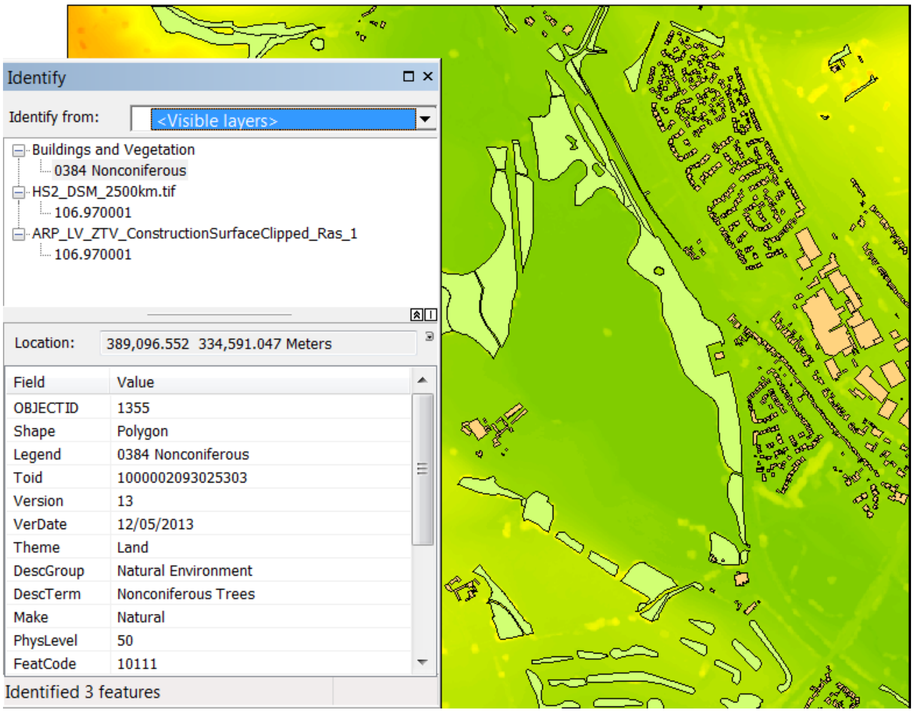
2.1.6 There is an assumption that vegetation within the land required for the Proposed Scheme will be removed during construction. This assumption together with data regarding building demolition is used to remove these features from the data (Figure 5). This ensures that visual barriers expected to be removed during the construction phase of the Proposed Scheme are not included in the ZTV.

Figure 5: The resulting polygon feature classes are used to then extract the height data from the 2m resolution DSM using the 'Extract by Mask' tool in ArcMap



2.1.7 The resulting visual barrier data is then combined with the DTM in ArcMap (Figure 6). During this process the resolution of the final raster is set to 2m to ensure that visual barriers are well defined. This requires resampling of the DTM which is 5m resolution to match the DSM, which is 2m resolution. This is achieved using the nearest neighbour sampling algorithm.

Figure 6: Visual barriers combined with the DTM using the 'Mosaic to New Raster' tool in ArcMap

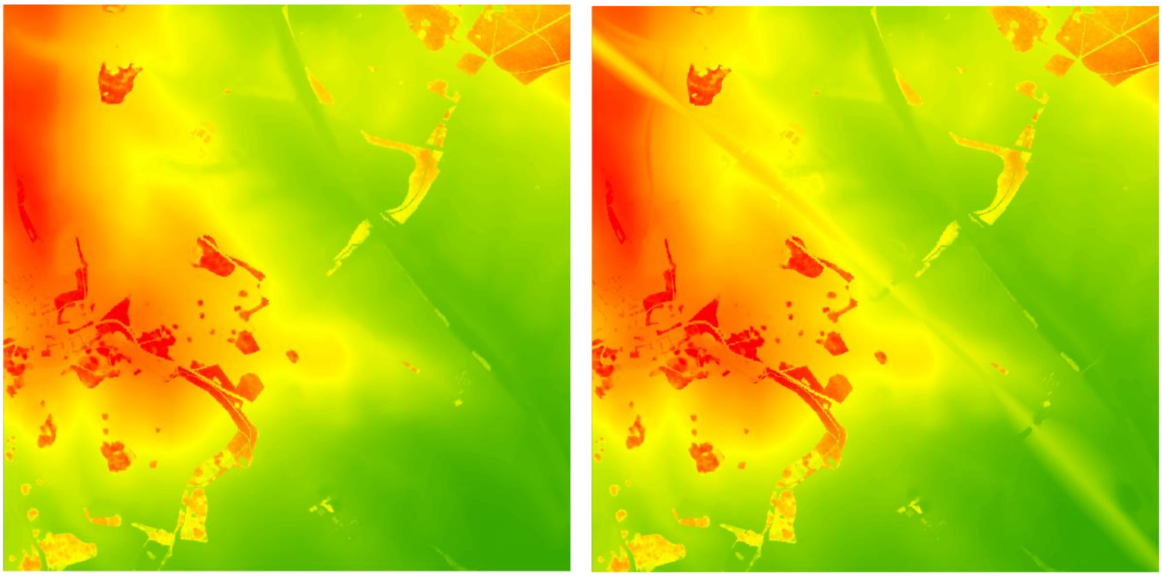


2.2 Operation year 1 model

2.2.1 The Proposed Scheme has a large number of earthworks in the form of cuttings and embankments, which will have an effect on the visibility of the trains. To ensure these variances in vertical alignment are included in the model, the 3D surfaces produced in the CAD files are extracted and converted to raster format at 2m resolution.

2.2.2 The earthworks are then added to the construction surface detailed above in ArcMap, resulting in a raster combining existing condition and the earthworks for the Proposed Scheme at year 1 of operation (Figure 7).

Figure 7: Scheme raster using 'Mosaic to New Raster' tool in ArcMap for Construction and Operation year 1

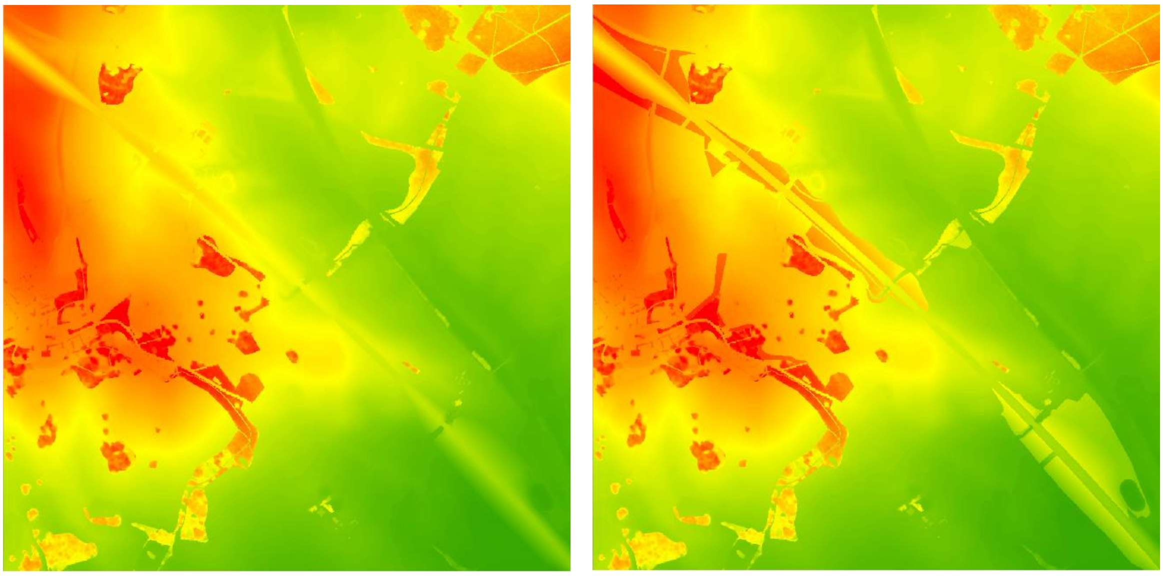


2.3 Operation year 15 model

2.3.1 After 15 years it is assumed that the trees planted for mitigation and screening purposes are expected to have grown 7.5 metres, based on an assumption of 0.5m growth per year. Using this assumption, areas of tree planting data produced in the CAD files are used to create a raster to add to the year 1 model (Figure 8).

2.3.2 The tree planting polygon areas are used to extract data from the operation year 1 surface. This data is then manipulated using the ArcMap Raster Calculator whereby 7.5m is added to each cell value. This results in each cell where planting occurs having a value 7.5 metres above the year 1 surface to represent the tree growth.

Figure 8: Scheme raster using 'Mosaic to New Raster' tool in ArcMap for Operation year 1 and Operation year 15



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3 Modelling the construction phase ZTV

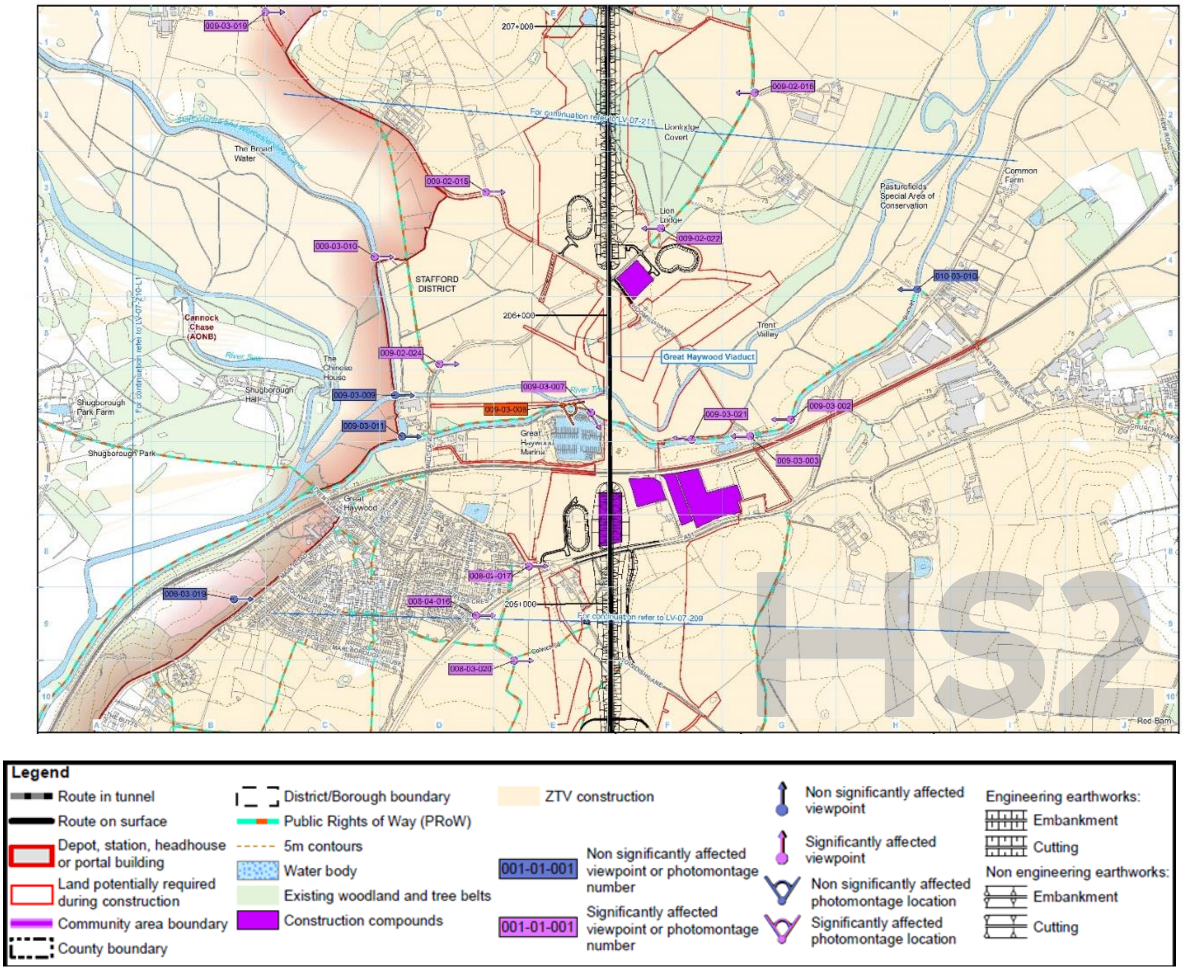
3.1.1 The extent of the visibility of the Proposed Scheme during construction was modelled to present the reasonably practicable worst case scenario, in accordance with GLVIA3. Assumptions were made about the height of typical construction plant operating along the length of the route, and at stations, depots, ventilation shafts, head houses, road diversions and any other known proposed works. These heights were added as a series of points into ArcGIS to enable the ZTV to be produced using the 'Viewshed' tool[1]. For the purposes of modelling the construction phase ZTV that focuses on the likely distribution of significant effects, heights of very tall construction plant such as cranes have been excluded as detailed in Section 1. A viewer eye-level of 1.6m was assumed, and corrections for earth curvature and refraction of light were applied.

3.1.2 Elements modelled to enable production of the construction phase ZTV are detailed below:

- assumption of 5m above existing ground levels for the route above ground, whether it is at grade, on embankments or in cutting. This was selected on the basis of the possible height of typical construction plant expected to be used along the route;
- assumption of 5m above existing ground levels for the length of proposed cut-and-cover tunnels, selected on the basis of the possible height of typical construction plant expected to be used at these structures, excluding cranes;
- assumption of 8m above existing ground levels around the boundary of any known construction compounds, on the basis of the possible height of typical construction plant, storage, stacked welfare facilities etc. that may be present within these areas;
- assumption of 5m above existing ground levels at the location of all tunnel portals, selected on the basis of the possible height of typical construction plant expected to be used at these structures, excluding cranes;
- assumption of 8m above existing ground levels at the location of all ventilation shafts, selected on the basis of the possible height of typical construction plant expected to be used at these structures, excluding cranes;
- assumption of 5m above existing ground levels at the location of any road diversion works, new road bridge works or utility diversion works, on the basis of the possible height of typical construction plant required;
- assumption of 5m above the height of proposed viaducts and overbridges to take account of construction plant and scaffolding required to build the structures, excluding cranes; and
- assumption of 2.4m above existing ground levels (i.e. the standard hoarding height) of the temporary extent of land required to construct the Proposed Scheme.

[1] Viewshed is an ArcGIS tool which analyses where any given point is visible from by determining the raster surface locations visible to a set of observer features.

Figure 9: Example of construction phase ZTV (shown in the context of the Proposed Scheme and assessment viewpoint and photomontage locations)



4 Modelling the operational phase ZTV

4.1.1 The extent of the visibility of the Proposed Scheme during operation was modelled on the basis of the height of the expected operational structures along the line of route, including stations, permanent depots, ventilation shafts, headhouses, road diversions and any other proposed works. The heights modelled take into account where the Proposed Scheme is in cutting, at grade, on embankment or on viaduct. These heights were added as a series of points into ArcGIS to enable the ZTV to be produced using the 'Viewshed' tool. A viewer eye-level of 1.6m was assumed, and corrections for earth curvature and refraction of light were applied.

4.1.2 The base model produced for the construction phase ZTV was amended by:

- removing any buildings to be demolished during construction of the Proposed Scheme, to ensure they did not falsely block potential views when the operational ZTV was run; and
- adding new mitigation earthworks designed to screen the Proposed Scheme.

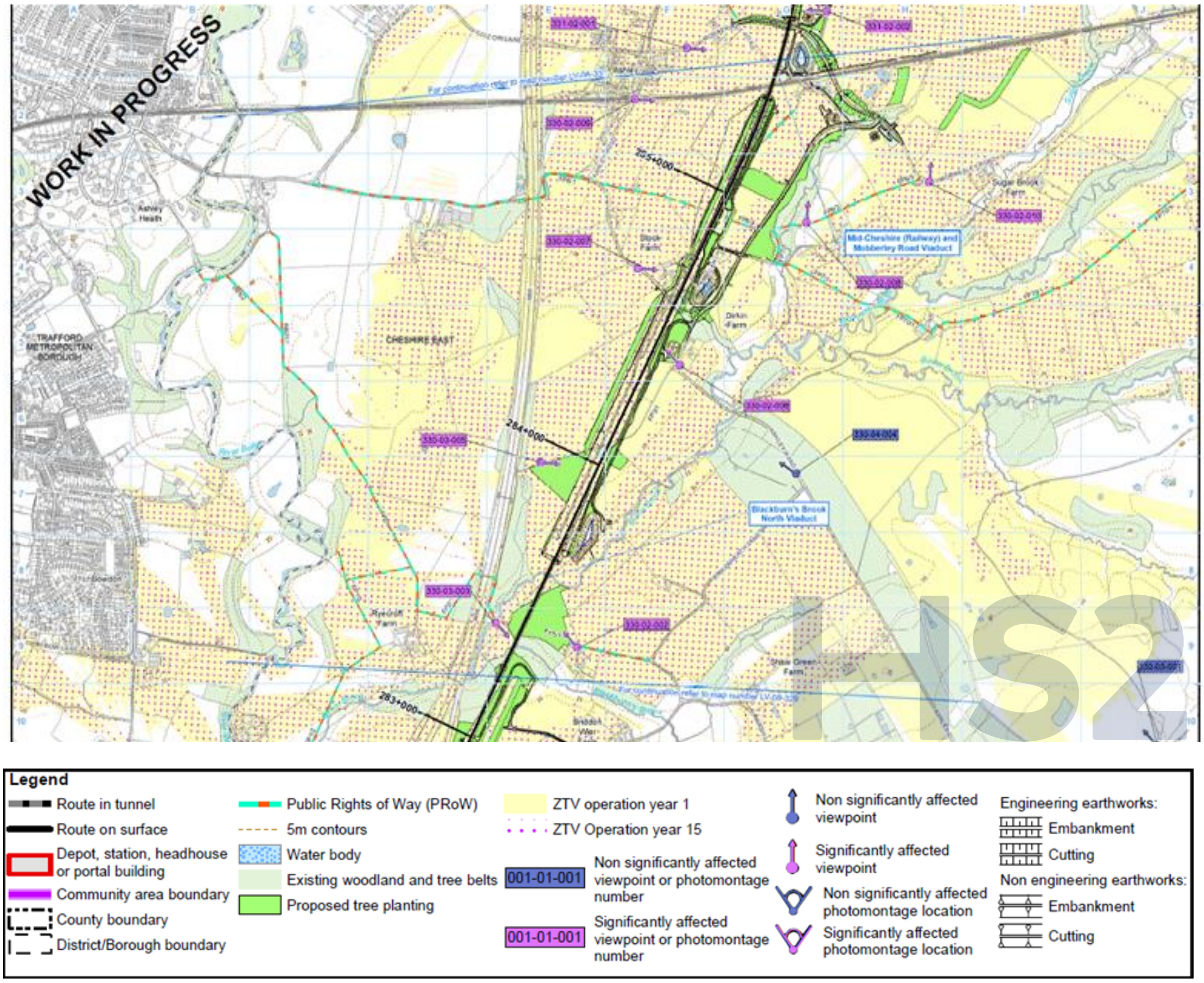
4.1.3 Elements modelled to enable production of the year 1 operational phase ZTV are detailed below:

- 4m above proposed track bed levels to represent the approximate height of the rolling stock;
- the designed height of all tunnel portal buildings, head houses and ventilation shafts;
- the designed height of all buildings associated with the permanent operation of the Proposed Scheme; and
- the height of road diversions or new road bridges.

4.1.4 Overhead line equipment has been excluded from the operational phase ZTV on the basis that these indicate widespread visibility. With the exclusion of overhead line equipment, the operational phase ZTV gives a better indication of the possible spread of significant effects and therefore better informs the assessment process. Narrow vertical elements such as lighting poles have also been excluded.

4.1.5 The year 15 operational phase ZTV was produced using the same parameters as above, but proposed tree planting was incorporated into the base model at an assumed height of 7.5m, serving to reduce visibility of the Proposed Scheme in some locations. Due to the uncertainty of defining assumptions so far into the future, no ZTV has been prepared for the year 30 operational phase assessment.

Figure 10: Example of operational phase ZTV (shown in the context of the Proposed Scheme and assessment viewpoint and photomontage locations)



Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Landscape and visual – Approach to verifiable photomontages

Contents

1 Introduction

1.1 Purpose of the document

1.1.1 This technical note describes the technical process undertaken to prepare verifiable photomontages to support the landscape and visual assessment for the Proposed Scheme.

1.2 Verifiable photomontage definition

1.2.1 A photomontage is the superimposition of an image onto a photograph for the purposes of creating a representation of potential changes to any view.

1.2.2 These technical visualisations 'should allow competent authorities to understand the likely effects of the proposals on the character of an area and on views from specific points.'

1.2.3 Photomontages are distinct from other images that show the nature of the Proposed Scheme as they are technically accurate and illustrate the effects on viewers rather than illustrating specific scheme elements. The Landscape Institute's (LI) Technical Guidance Note Visual Representation of Development Proposals (LI TG 06/19)[1] states in paragraph 1.2.9 that 'Visualisations should provide the viewer with a fair representation of what would be likely to be seen if the proposed development is implemented and should portray the proposal in scale with its surroundings. In the context of landscape/townscape and visual impact assessment, it is crucial that visualisations are objective and sufficiently accurate for the task in hand. In short, visualisation should be fit for purpose'.

1.2.4 A verifiable photomontage is a photomontage based on a replicable, transparent and structured process, so that the accuracy of the representation can be verified by an independent party. Collaboration between all organisations, relevant stakeholders and disciplines is essential throughout the whole project to ensure that the visualisation information is consistent and robust.

1.2.5 The verifiable photomontages that will be included in the Environmental Statement (ES) must meet appropriate standards. The methodologies for their production are based on current best practice and follow recommendations from the LI TGN 06/19 and Guidelines for Landscape and Visual Impact Assessment (GLVIA)[2]. Other relevant industry standard

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[1] The Landscape Institute (2019), *Visual Representation of Development Proposals, Technical Guidance Note 06/19.*

[2] Landscape Institute and Institute of Environmental Management & Assessment (2013), *Guidelines for Landscape and Visual Impact Assessment,* Third Edition. Paragraphs 8.18-8.34.

methodologies for visualisation, such as that published by Scottish Natural Heritage (SNH)[3], have also been consulted as appropriate in the development of the methodology.

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[3] Scottish Natural Heritage (2017), *Visual Representation of Windfarms Guidance*, Version 2.2, February 2017. Available online at: https://www.nature.scot/visual-representation-wind-farms-guidance

2 Selection of photomontages

2.1 Selection of viewpoints

2.1.1 Viewpoints will represent what people with a view of the Proposed Scheme (visual receptors) may be able to see during construction or operation. The process for selecting viewpoints is described in the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR).

2.1.2 Verifiable photomontages will be prepared from a selection of these viewpoints, and in consultation with statutory consultees, where:

- the receptor is highly sensitive to change (the sensitivity of visual receptors is described in the EIA SMR); and
- the level of effect cannot be easily assessed with reference to plans, sections and elevations, or where the precise position of elements has a particular importance in relation to the composition of a view.

2.2 Verifiable photomontage types

2.2.1 The LI TGN 06/19 states in 1.2.8 that 'Depending upon the nature/type of the development or change, visualisations may need to show the development: during construction (if the construction period is of long duration and a notable element of the proposal's visual impact); at specific points in time during operation to illustrate the effectiveness of landscape mitigation; or possibly at decommissioning and restoration (e.g. as with a quarry or landfill site)'.

2.2.2 The landscape and visual impact assessment considers effects for a number of different scenarios through the construction and operational phases of the Proposed Scheme. Verifiable photomontages may be prepared for the following scenarios:

- **construction, winter, daytime –** illustrative representations of how the site may look during the peak phase of construction. Construction photomontages will only be prepared for winter in line with the methodology for undertaking the visual assessment described in the EIA SMR, taking into account:
- demolition, tree removal and vegetation clearance required;
- the extent of land required temporarily to build the Proposed Scheme;
- the type of structure being built in the view;
- the types of operations and construction plant likely to be present in order to construct the structure in the view, including temporary stockpiles and cranes; and
- any measures contained within draft Code of Construction Practice (CoCP) relevant to the particular view.

- **operation, year 1 (2038), winter, daytime –** illustrative representations of how the Proposed Scheme may look during the winter of 2038, taking into account:
- the accurate 3D models prepared to show the geometry of elements of the Proposed Scheme, including the rail line, overhead line equipment and gantries, earthworks, retaining walls, proposed highways including earthworks, balancing ponds, viaducts and bridges, ventilation shafts and head houses;
- the accurate 2D lines prepared to show the geometry of elements of the Proposed Scheme, including fences, noise barriers, planting and habitat creation areas; and
- design principles/intent relating to the appearance of elements described above, including retaining walls, viaducts, bridges, ventilation shafts, head houses, fencing, noise barriers, planting and habitat creation areas.
- **operation, year 1 (2038), summer, daytime –** illustrative representations of how the Proposed Scheme may look during the summer of 2038 taking into account the same elements as above. These have usually only been prepared where it was not possible to obtain a winter photograph due to limitations such as site access.
- **operation, year 15 (2053), summer, daytime –** illustrative representations of how the Proposed Scheme may look in the summer of 2053 during operation, taking into account (in addition to the above) how new planting will mature (assumed as 7.5m growth for all tree planting at year 15).

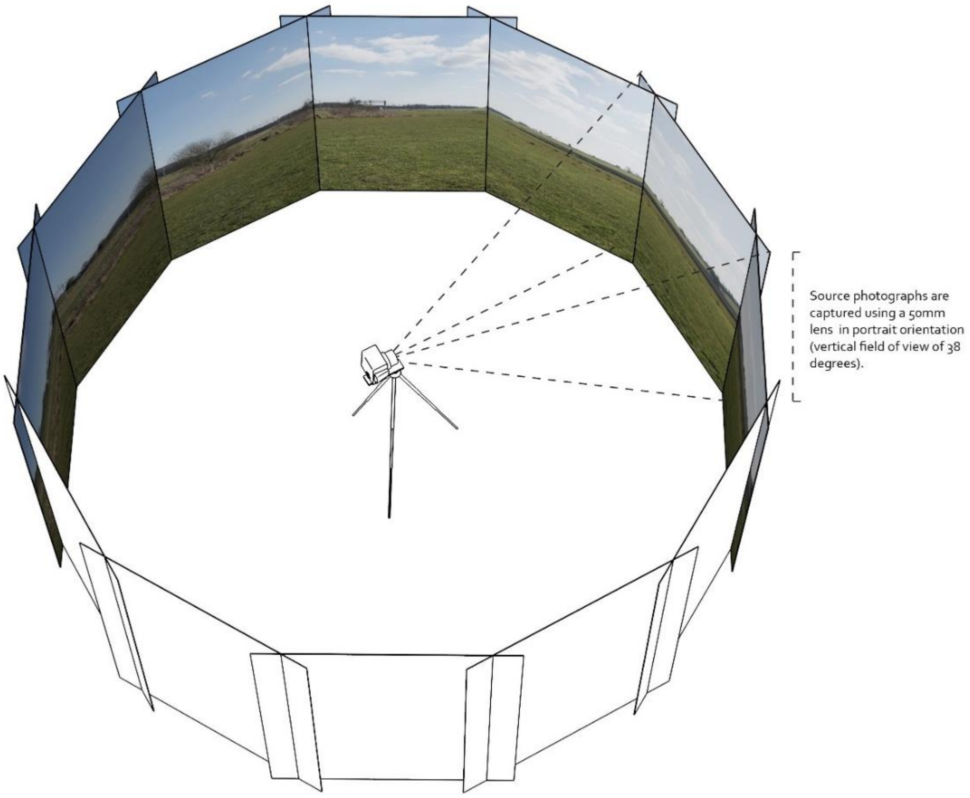
3 Verifiable photography and survey

3.1 Methodology

3.1.1 The verifiable photomontages will be based on accurately taken and surveyed verifiable photography. The first round of Winter photography was undertaken between December 2017 and March 2018. Summer photography was undertaken in August and September 2017 and from June to September 2018. Additional surveys for photography will be undertaken as required and during the appropriate seasons up to and including January 2020.

3.1.2 All photographs will be taken as a series of overlapping portrait photographs (to maximise field of view) rotated around a single point so that a full 360 capture of the viewpoint is obtained. Typically, 24No photographic frames are captured, giving a percentage overlap of approximately 40% within each image. Lens focal length is set to 50mm. A vertical/horizontal field of view of 38/27 degrees will be taken on each of the overlapping photographs. (The principle is shown indicatively on Figure 1). Photographs will be taken using a tripod at a typical viewing height of 1.6m above ground using appropriate exposure based on the light conditions on site.

Figure 1: 360 Capture of verifiable photography – An indicative representation of the process



3.1.3 The photography and surveying are undertaken simultaneously in order that ranging rods can be deployed into the views by the surveyor and to avoid problems with markers in soft ground moving or being removed.

3.2 Verifiable photography specification

3.2.1 All verifiable photography will be taken using a high quality full frame digital camera with a resolution of 7952 x 5304 pixels. Photographs will be taken in suitable weather and light conditions avoiding rain, fog, mist and snow, and avoiding elements which impair or distract from visibility in the view. Refer to Appendix 1 of this technical note for the detailed image specification and data requirements.

3.3 Stitching site photography into panoramas

3.3.1 The site photography will be stitched together using PTGui (professional stitching software), as a crop of an equi-rectangular projection, ultimately published as a series of planar images (to appropriately capture the linear nature of the Proposed Scheme)[4]. Each stitched panorama has a horizontal field of view (HFOV) 360 degree and a vertical field of view (VFOV) of 38 degrees.

3.3.2 The camera tilt and roll are checked on the source photographs to ensure the horizon line is accurately positioned within the exported panorama.

[4] Work commenced on the photomontage in 2017 prior to the LI TGN 06/19, where cylindrical projection is now recommended. However, wide cylindrical images distort the lateral nature of the rail geometry and therefore a series of planar images are extracted in post-production to more effectively communicate the design.

4 Camera matching

4.1.1 The process of camera matching creates a virtual camera in the same location and at the same height as the physical camera used on site to take the photograph.

4.1.2 The orientation of the virtual camera will be matched to the physical camera by aligning the 3D points provided by the surveyor to the marked-up panorama also provided by the surveyor (Figure 2).

Figure 2: Camera matching CAD data within photograph

5 Production of 3D model

5.1 Introduction

5.1.1 The 3D model of the Proposed Scheme will be produced in a series of tiles along the route. All data will be moved to these offsets to avoid accuracy problems caused in the software programme 3D Studio Max (3DS Max) when working on images[5] at a distance from the global origin point. This process will improve how 3DS Max handles the data in the later stages of modelling and ensures accuracy. The CAD drawing units will be in metres.

5.1.2 The 3D model of the Proposed Scheme will be created using:

- the designer's 3D model of the Proposed Scheme including the centreline, rail earthworks, highway centrelines, kerb lines, highway earthworks, mitigation earthworks and balancing ponds. These elements form the digital terrain model of the Proposed Scheme;
- models of all structures including viaducts, highway bridges, pedestrian bridges, tunnel portals, auto-transformer stations;
- models of all buildings including headhouses and ventilation shafts, buildings within maintenance depots and stations; and
- models of all further elements including noise fence barriers, fencing, planting, overhead line equipment, new/relocated pylons etc.

5.1.3 Models of structures and buildings will be created using the designer's 3D models or 2D elevations, sections and plans depending on availability and appropriateness for purpose.

5.1.4 All elements of the 3D model will be resolved from all angles, for example the abutment of bridges and viaducts will be modelled in full to ensure the robustness of the overall 3D model.

5.1.5 Within 3DS Max, all surfaces created as part of the 3D model will be checked to ensure no co-planar faces exist anywhere in the model, with all faces appropriately sub- divided.

5.1.6 All elements within the 3DS Max model files will be named appropriately. There will be no generic names within the model files e.g. box, circle, cylinder etc. to ensure all objects can be selected and all users have full control of the 3DS Max scene.

5.1.7 Textures will be applied at a real-world scale to ensure they appear at the correct scale for the image and 3D model. This is in line with AVR Type 3 as described in Appendix 6.4 of LI TGN 06/19. Due to the outline nature of the design for stations and depots being assessed in

[5] The use of the term 'image' within this technical note relates to an original 'photograph' that has been manipulated.

the ES, these buildings will not have textures applied. See Section 5.2 for more details on AVR types.

5.2 Representation of Stations and Depots

5.2.1 As outlined at 8.22 of GLVIA3, block models are often used to illustrate the scale, massing and arrangement large-scale urban developments where the scheme is not yet fully developed.

5.2.2 As discussed previously, the LI have published guidance on photomontage production - LI TGN 06/19. This document outlines 4 differing levels of detail which may be used in illustrating photomontages, each dependent of the purpose of photomontage and the level of information available.

5.2.3 These differing levels are referred to as Accurate Visual Representations (AVR). AVRs can be either wirelines, massing, rendered or textured visualisation as set out in the London Views Management Framework, which the LI TGN incorporates.

Figure 3: AVR levels as outlined in LI TGN 06/19

5.2.4 As set out in Section of this technical note, most of the photomontages along the route of the Proposed Scheme are produced to AVR Level 3. However, where the design is less prescriptive at this stage and may be subject to more extensive changes during the detailed design phase, i.e. stations and depots, a different approach is required and will be produced to AVR Level 2 with buildings modelled to represent the upper limit of these structures.

5.2.5 Demolitions in the areas surrounding the stations also need to be captured in the photomontages and would be almost impossible to depict with transparent overlays or wirelines (AVR0 or AVR1).

5.2.6 The degree to which other existing buildings and vegetation will screen and filter views towards the proposed stations is a key part of the assessment. Once again, this would be very difficult to achieve using wirelines or transparent overlays.

5.2.7 It is not considered that AVR3 is necessary under the guidance or for the purposes of assessment, nor achievable or cost effective in overall terms for the project.

5.2.8 This will give the assessment teams sufficient information to make informed judgements on the visual magnitude of change and level of effect.

5.3 Model assembly

5.3.1 A 3DS Max model file for each viewpoint will be assembled before rendering (Figure 4). The assembled model will contain the relevant Proposed Scheme digital terrain model tiles and any structures, buildings or further elements (as defined above) that can be seen from the viewpoint.

Figure 4: Model within image prior to blending and rendering

6 Rendering

6.1.1 Each of the views will be rendered using the V-Ray Rendering software. This utilises the physical sun, sky and compass system to replicate the light conditions present in the Base photo (Figure 5).

Figure 5: Base photo

6.1.2 Individual elements will be rendered out (Figure 6) using different map channels to create masks (for example masks for the digital terrain model, earthworks, overhead line equipment, fencing, shadows etc.). These masks will ensure that each visible element of the Proposed Scheme can be independently selected when individually placed into the Adobe Photoshop file for final production.

Figure 6: Model render

7 Post production

7.1.1 The renders of the 3D model will be superimposed onto the base photos in Adobe Photoshop. The visible foreground in front of the Proposed Scheme will then be carefully copied and masked (Figure 7) to ensure the render of the 3D model sits accurately within the depth of the view.

Figure 7: Foreground and tree masking

7.1.2 The textured render of the 3D model will then be further adjusted to match the resolution, colouring and saturation of the base photo to create an accurate impression of what the textures of the buildings and structures will look like. This will be a qualitative exercise and requires interpretation by the designer on how the structures will look.

7.1.3 The masked-out elements will be combined with the render (Figure 8) and then superimposed into the base photo (Figure 9).

Figure 8: Render and masking combined

Figure 9: Image, render and masking combined

7.1.4 A final qualitative check of all of the verifiable photomontages will be undertaken to ensure that they provide objectively accurate views of the Proposed Scheme.

8 Photomontage presentation

8.1.1 For panoramic images all final panoramic photomontages will be extracted into a series of planar images equivalent to 50mm extracts. To minimise image degradation and to capture as much detail as possible, maximising vertical cropping space, planar[6] projection is used. Typically, 4No images are extracted, based upon the vertical field of view of a 50mm lens for ease of presentation on flat media and viewing in the field (Figure 10).

Figure 10: The four images extracted for final panoramic photomontage

8.1.2 For viewing within the ES the series of images will be printed together on A3 landscape sheets, for practicality. Each image represents a vertical/horizontal field of view of 27/38 degrees and usually presented as four images which total a horizontal field of view of 152 degrees. Annotation will be added as appropriate for orientation and to highlight relevant aspects of the Proposed Scheme, where necessary, along with detail on location, distance from viewpoint and direction and angle of view. Full size sets of planar images will be made available on request, for viewing in the field from a specific point.

8.1.3 At this scale the images do not lend themselves to direct comparison out in the field. Therefore, for viewing in the field, it is recommended that images are extracted in planar projection from the photomontages and printed individually. The printed images would be 390mm x 260mm (150% scale), with a field of view of 27 degrees by 18.2 degrees (printed on A3 sheets at 300dpi)[7]. These sizes are suitable for a viewing distance at comfortable arms length.

8.1.4 Guidance recommends that the verified photomontage extracts are viewed at a comfortable arm's length viewing distance and at the height photographed from, in order to closely match what is being seen in the field (Figure 11). It is recommended that the most suitable way to view photomontages is in the field, standing in the precise location where the photograph was taken from. The viewpoint location plan, grid reference and bearing will assist in achieving this.

8.1.5 Although viewing photomontages in the field is desirable, it is acknowledged that this is not always possible. One of the purposes of photomontages is to make up for the fact that not

[6] Although TGN 06/19 recommends cylindrical projection, wide cylindrical images distort the lateral nature of the rail geometry and therefore a series of planar images are extracted in post-production to more effectively communicate the design.

[7] Images will be provided on request to ensure the correct size/resolution is achieved for viewing on site.

all interested parties can visit the site. Every effort has been made to represent the Proposed Scheme fairly and accurately so it can be understood within its landscape context, although it is noted at 8.1.2 above that full size planar images can be made upon request for the purpose of viewing a specific location in the field.

Figure 11: Viewing a verified photomontage

Appendix A – Verifiable photography specification

Image specification for site capture of verifiable photography:

- RAW and JPEG images are captured at 7952 x 5304 pixels.

Image processing:

- processing includes corrections for lens distortions[8], removal of vignetting[9] and chromatic aberrations[10].

Data requirements:

- exchangeable image format[11] (EXIF) data provided in the file properties:
- focal length, aperture, shutter speed and ISO;
- lens and camera body; and
- date and time.

[8] Displacement or errors in the images caused by irregularities in camera lens.

[9] Reduction of an image's brightness or saturation at the periphery when compared to the centre of the image.

[10] Colour distortion in an image caused by the inability of the camera lens to bring the various colours of light to focus at a single point.

[11] Data embedded within the properties of an image

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Landscape and visual – Approach to photography

Contents

1 Introduction

1.1.1 This technical note has been prepared to provide guidance on the methodology for undertaking all photography associated with the Landscape and Visual Impact assessment (LVIA) for the Proposed Scheme Environmental Statement (ES). It takes account of relevant guidance published by the Landscape Institute[1].

1.1.2 The landscape and visual section of the ES will require photographs to be taken for three main purposes:

- photographs to help illustrate the character of each landscape character area (LCA) and to inform the landscape impact assessment;
- photographs to illustrate the winter and summer view from each selected viewpoint and to inform the visual impact assessment; and
- verifiable photographs from some viewpoints from which verifiable photomontages are to be prepared.

1.1.3 A separate technical note has been prepared to provide guidance on verifiable photography and verifiable photomontages[2]. This technical note covers bullet points 1 and 2 on the list above – photography which will be used within Volume 5: Technical appendices of the ES.

1.1.4 All photography will be taken using high quality digital single-lens reflex (DSLR) cameras with a minimum resolution of 6 megapixels and taking account of the following:

- photographs will be taken in suitable weather and light conditions and periods of poor light, heavy rain, fog, mist or snow will be avoided; and
- photographs will be taken at a typical viewing height of approximately 1.6m above ground level.

[1] The Landscape Institute (2017), Visual Representation of development proposals, Advice Note 02/17 which provides guidance on proportional approaches to visualisation depending on audience and purpose, and The Landscape Institute (2011), Advice on photography and photomontage, Advice Note 01/11.

[2] Technical Note: Approach to verifiable photomontages.

2 Landscape character baseline

2.1.1 Photographs will be taken to help illustrate the character of each LCA within the study area for the Proposed Scheme (defined through use of Zone of Theoretical Visibility or ZTV mapping). A selection of annotated images will be presented within Volume 5: Technical appendices of the ES to support the baseline descriptions of each LCA. Photographs will be chosen to illustrate representative aspects of each character area. It is not possible to include photographs of every part of the landscape and so photographs will be taken to illustrate representative aspects of each LCA. The specific requirements for character area photography are that:

- all photographs will be taken in landscape orientation (as opposed to portrait);
- all photographs will be taken using an appropriate focal length which assists the character description;
- a single image will generally be used (avoiding the use of stitching images together excepting those in relation to landscape susceptibility attributes of the LCAs as in the Volume 5 report template);
- a number of photographs will be taken for each LCA to represent key landscape value and susceptibility characteristics; and
- the approximate location of each photograph will be recorded.

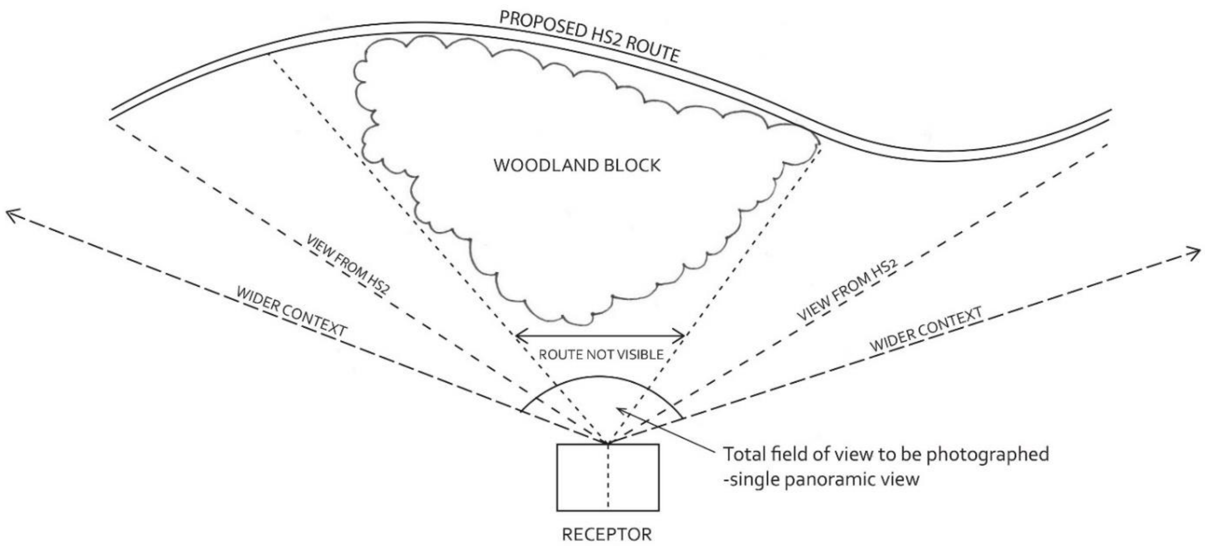
3 Visual baseline

3.1 Introduction

3.1.1 Photographs will be taken to illustrate a representative view from each of the visual receptor locations identified and agreed with stakeholders. Photographs will be taken during both winter and summer to illustrate how the view changes seasonally (or to confirm that the view does not change substantially between winter and summer). The winter and summer photographs will match as closely as possible in terms of precise viewpoint location, field of view and focal length. (Where a verifiable photomontage is required for a viewpoint, a different methodology is used for obtaining verifiable photography, as defined in the Technical note – Approach to verifiable photomontages). The specific requirements for viewpoint photography are:

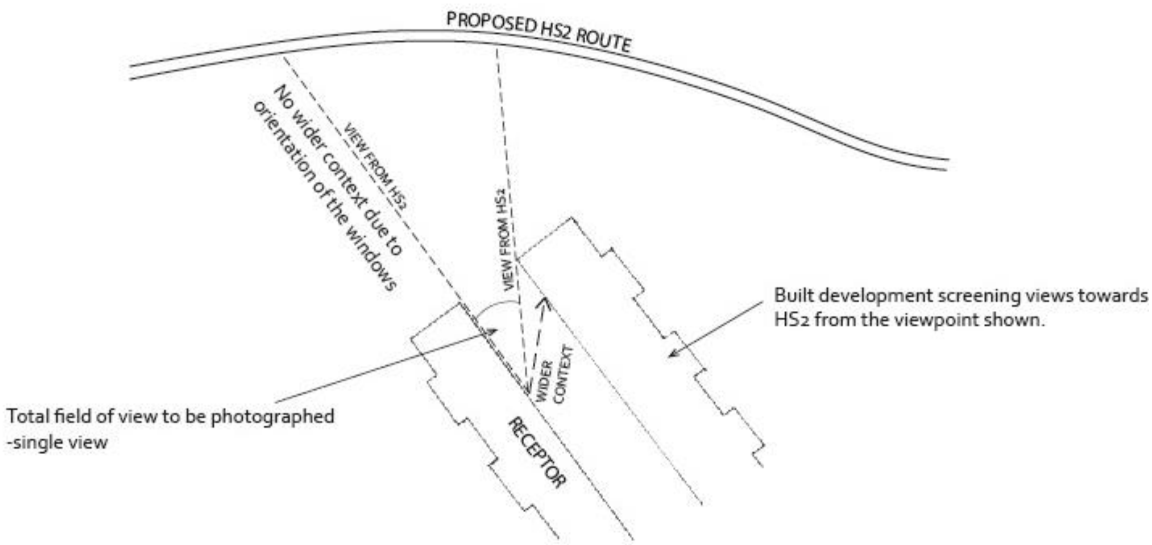
- an appropriate horizontal field of view for each viewpoint. For the majority of locations, this will require multiple photographs to be taken and for these to then be stitched together (see Section 3.3 of this technical note);
- the field of view must, as a minimum, fully capture the extent of any part of the Proposed Scheme (during either construction or operation) visible from each location. There may be cases where two different elements of the Proposed Scheme would be visible in different locations when viewed from a specific location. In this instance, a single panoramic view (comprising multiple photographs stitched together) will be taken (see Figure 1);

Figure 1: Wide field of view



- the final image[3] must illustrate the context of the view towards the Proposed Scheme (i.e. a wider field of view than just the extent in which the Proposed Scheme would be visible); and
- lastly, if the viewpoint is representative of the view from a building (residential, hotels, employment, schools etc.), this should restrict the field of view (see Figure 2).

Figure 2: Restricted field of view



3.1.2 The purpose of winter photography is to illustrate the view when there are no leaves on deciduous trees. Therefore, winter photographs will generally only be taken between the start of December and the end of March.

3.1.3 Conversely, the purpose of summer photography is to demonstrate the screening effect leaves may have. Therefore, summer photos will be taken between the start of June and the end of September.

3.1.4 All viewpoints will be uniquely named and labelled as specified by HS2 Ltd.

3.1.5 All viewpoints will be stored in Geographic Information Systems (GIS) feature classes and have attribute data as specified by HS2 Ltd.

3.2 Recording the location of photographic viewpoints

3.2.1 For all viewpoints the information listed below will be captured by a surveyor, using either a proforma on a tablet PC or a software application (an 'app') such as ESRI Collector, to ensure the identity of the correct location on site:

[3] The use of the term 'image' within this technical note relates to a 'photograph' that has been manipulated.

- the viewpoint number, date and time of the visit;
- sub 5m accuracy coordinates for each camera position using a handheld GPS unit;
- photographic record of the camera position;
- for locations which are to be selected for later verified photography for photomontages, notes to describe the exact camera position where necessary. For such locations it would be advisable to identify the exact camera positions in relation to a feature (joint in paving slabs, manhole cover, distance from a fence post etc.) which can be later identified by the verifiable photographer and verifiable surveyors;
- the GPS coordinates, aerial imagery and Ordnance Survey mapping will be used to confirm the latitude and longitude and National Grid Easting and Northing position of each viewpoint; and
- field notes will be compiled and the GIS feature classes will be populated with the key attributes as specified by HS2 Ltd.

3.3 Taking panoramic photography

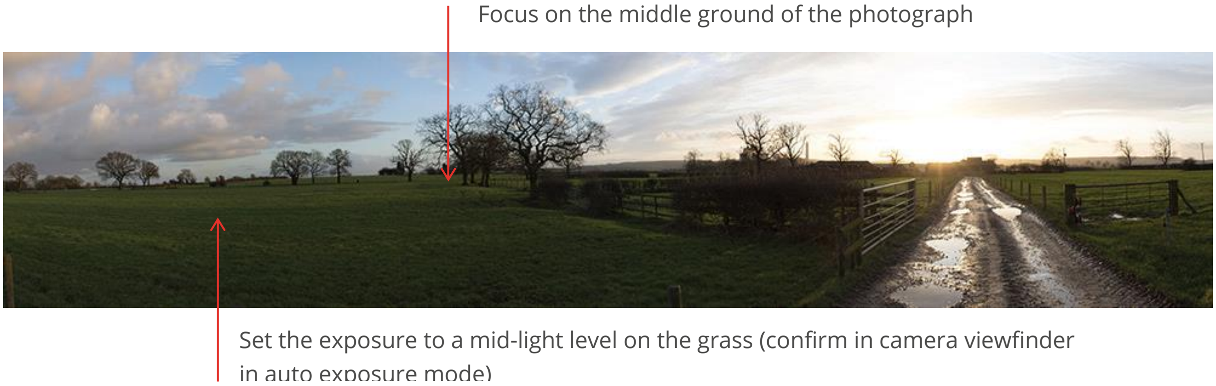
3.3.1 The following methodology will be followed for all panoramic photography for viewpoints:

- widest possible lens setting (typically 18mm on a crop camera) will be used in order to take as much of the landscape as possible for subsequent stitching into panoramic views;
- an overlap of 25-33% between shots;
- in relation to panoramic photography professional judgement will be exercised. Full 360 degree photography will **only** be taken where access (e.g. no proximity to residential properties) and safety allows. In all other cases photographic coverage will be proportionate to the coverage required to illustrate the visual effects of the Proposed Scheme in context. Generally for panoramas 180 degree coverage will be sufficient. In many instances in urban locations photographs will be single frame or 2-3 frame images only;
- when taking photographs, the photographer will turn the camera round with the lens directly over their left foot in portrait orientation (see Figure 3). This is regarded as best practice for taking panoramic photography in the field without a tripod;

Figure 3: Standing position for taking handheld panoramas

- the camera will be focused once to the middle distance and then set to manual focus to ensure all shots are consistent in focus distance (see Figure 4). White balance should be set manually to daylight, as per Landscape Institute Advice Note 01/11; and
- all images should be captured in RAW format.

Figure 4: Technique for photography



3.4 Stitching multiple photographs for viewpoints

3.4.1 As noted above, there are likely to be occasions when the view from a visual receptor will need to be made up of a series of overlapping photographs due to the extent of the site that needs to be recorded (see Figure 5).

Figure 5: Series of 24 overlapping photographs

Viewpoint taken as a series of portrait overlapping photographs

3.4.2 Panoramas will be produced by stitching multiple site photographs into single panoramic images (using PTGui stitching software or manually through use of Adobe Photoshop (see Figure 6)). Stitched photography should be carefully reviewed to ensure no staggering of building edges/pavement junctions/joins etc (see Figure 6).

Figure 6: A stitched panorama

Images stitched together to form panorama

Annex K – Technical note: Socio-economics

The following technical note is contained in this annex:

- Socio-economics – Socio-economics assessment.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Socio-economics – Socio-economics assessment

Contents

Tables

1 Introduction

1.1.1 This technical note provides guidance on the assessment methodology for assessing potential socio-economic impacts and effects considered likely to arise from the construction and operation of the Proposed Scheme.

1.1.2 The technical note builds upon and should be read alongside the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR).

1.2 Socio-economics

1.2.1 The socio-economic assessment will identify impacts on businesses and organisations and effects on employment levels. It will consider the potential for the Proposed Scheme to generate impacts and effects on:

- existing businesses and organisations;
- local economies, including employment; and
- planned growth and development.

1.2.2 The socio-economic assessment will provide inputs to the community assessment and draw on other topic assessments where relevant, such as agriculture, forestry and soils.

1.3 Other environmental impacts

1.3.1 There are a number of other environmental topics, such as air quality, climate, landscape and visual impact, sound, noise and vibration, traffic and transport that inform the socio-economic assessments. An understanding of these environmental topics and their methodologies will be required to give context for potential in combination effects arising from impacts related to these topics.

1.4 Structure of the technical note

1.4.1 This technical note is structured as follows:

- Section 2 provides core definitions for the receptors and resources which are relevant in assessing potential socio-economic effects;
- Section 3 sets out further details of the socio-economic assessment criteria and guidance on how this will be applied; and
- Section 4 provides a list of assumptions which have been applied to the socio-economic assessments.

2 Receptors and resource definitions

2.1 Socio-economic resources and receptors

2.1.1 Socio-economic resources and receptors are set out in the following sections. These resources and receptors are applicable to construction, operation and wider development effects and applicable to all phases.

2.2 Resources: property units

2.2.1 Property units are considered to be those units supporting the employment of persons which may be physically affected by the Proposed Scheme.

2.2.2 Property units consist of identifiable land and property including:

- commercial offices;
- warehousing;
- retail;
- open land storage;
- partial covered land storage;
- surface plant and machinery;
- land used for the production of agricultural produce (crops and/or livestock);
- institutional uses (e.g. public administration, armed forces, police, regulatory bodies);
- community infrastructure, open space and play space and recreational infrastructure where they have employment and/or economic characteristics; and
- communal residential establishments (residential and nursing homes, dormitories).

2.3 Resources: businesses

2.3.1 Businesses are considered to be all legal entities with definable establishments and employing persons within the impact area based on a minimum distance of 250 metres from the edge of the Proposed Scheme (see Socio-economics section in the SMR) or within the envelope of assessment used by other disciplines informing indirect effects – air quality; landscape and visual; sound, noise and vibration; traffic and transport. Legal entities are considered to be:

- sole traders;
- partnerships;
- limited companies;
- public limited companies;

- social enterprises (including companies limited by guarantee, co-operatives, charitable trusts, community interest organisations);
- membership and representative bodies (political parties, professional associations, trade unions, unincorporated societies); and
- public services.

2.3.2 Businesses are considered to carry out a recognisable activity including any of the following from their establishment:

- agriculture, forestry and fishing;
- manufacturing;
- wholesale and retail trade;
- repair of motor vehicles and motorcycles;
- accommodation and food service activities;
- electricity, gas, steam and air conditioning supply;
- water supply, sewerage, waste management and remediation activities;
- construction;
- transportation and storage;
- information and communication;
- public administration and defence;
- compulsory social security;
- other service activities (excluding those covered under the community assessment);
- financial and insurance activities;
- real estate activities;
- professional, scientific and technical activities;
- administrative and support service activities; and
- arts, entertainment and recreation.

2.3.3 The impact on agricultural businesses will be covered under the agriculture, forestry and soils assessment and the results summarised in the socio-economic assessment together with other economic impacts where relevant.

2.4 Receptors

2.4.1 Receptors consist of people in employment associated with a resource including:

- employees in employment;
- sole traders; and
- partners.

2.5 Exclusions

2.5.1 Businesses concerned with health and social care and education and other service delivery activity play a dual role in the assessment in so far as they provide services to people as individuals as well as performing a role as an employing business. Impacts on the delivery of services to people and in combination impacts on employees and organisations are considered under the community assessment whilst impacts on employment will fall under the remit of the socio-economic assessment.

2.5.2 Property units that support embedded infrastructure such as pipeline networks, digital communications or utility network infrastructure are not considered to support employment in a direct sense rather this is a matter for consideration in relation to service diversions/relocations.

2.5.3 For the purposes of assessing the impacts on home-based businesses, all such businesses are considered to be ancillary to the main use as a residence (unless separately rated) unless evidence of actual employment in situ is identified (i.e. actual employment recorded in a reviewed data source and physical evidence of property adaptation/signage). The loss of residences will be captured under the Community assessment. Businesses operated as an ancillary activity will be considered to follow the relocation of any affected household.

2.5.4 The employment associated with the extraction of identified mineral reserves e.g. sand and gravel has not been accounted for due to the unpredictability of extraction activity and likely duration.

2.5.5 Businesses without employment include companies registered to an address or companies remotely operating physical assets e.g. sub-let premises. The latter include owners of tenanted properties e.g. buy to let landlords or institutional owners. In these instances, the impacts affecting occupiers as individuals will be assessed under community impacts.

2.5.6 Businesses operating in the informal economy may be encountered. Businesses who have no formal title to land/property used in pursuit of a business activity are presumed to lie outside the scope of this assessment e.g. car repairs operated from a residential garage.

3 Socio-economic assessment criteria

3.1 Introduction

3.1.1 The Environmental Statement (ES) uses both the terms 'impact' and 'effect' in all environmental topics. An impact will be generally considered to be a physical change caused by the Proposed Scheme (and in this context changes in air quality, noise levels or the quality of a view for example will be 'impacts'). The consequences of impacts on the receptors will be generally termed effects.

3.1.2 For the socio-economic assessments, resources are those assets and facilities which are impacted. Receptors are the operators, users or beneficiaries of those resources. Resources and receptors will vary for each type of impact and effect. So for example, increased construction traffic may have a range of impacts, such as congestion on the roads. The effects of this congestion could be disturbance and disruption for local businesses.

3.2 Impacts and effects

3.2.1 Impacts relevant to the socio-economic assessments fall broadly within the following categories:

- demolition and direct land possession;
- intrusion/disturbance to businesses and community facilities caused by other environmental impacts; and
- the economic consequences for local economies, for example via multiplier mechanisms.

3.2.2 Impacts will generate the following broadly defined effects on receptors and resources:

- loss or gain: a loss or gain to a resource or receptor. For example, a decrease or increase in employment opportunities as a result of construction;
- displacement: displacement means the re-location of receptors from one location to another location within the study area, for example businesses moving from their premises. The assessment recognises that in some cases businesses may cease to trade if they are forced to relocate, and some businesses may relocate outside of the study area (referred to as leakage);
- change in the combined environmental effects on business: The benefits of enjoyment and wellbeing that receptors gain from a resource in line with its intended function. The combination of factors such as: noise and vibration; heavy goods vehicle (HGV) construction traffic; air quality; and visual impacts can affect the level of enjoyment/wellbeing experienced by receptors. The socio-economic assessment will consider when changes of this nature could potentially result in a loss of trade for affected businesses; and
- isolation: In the context of this assessment, isolation will be measured by potential isolation and islanding of businesses. This includes physical islanding (i.e. non-economic)

and the effects of this on businesses. The socio-economic assessment considers when isolation of a business or group of businesses might potentially result in a loss of trade for those affected businesses.

3.3 Assessment criteria

3.3.1 Significance will be determined by assessing both the magnitude of the impact and the sensitivity of resources and receptors for each effect. Taken together magnitude and sensitivity will determine whether effects are considered to be 'significant' or 'not significant'. All effects are to be assessed, including adverse and beneficial.

3.3.2 There are several factors which determine magnitude of impact and sensitivity of resources and receptors. These factors and thresholds of significance vary for each theme of the socio-economic assessments.

3.3.3 The assessment criteria described in Table 1 highlight the types of impacts and effects on resources and relevant receptors. This includes guidance on the factors to consider and thresholds to ensure a consistent approach to assessing significance.

3.3.4 This table has been established using professional judgement and existing precedents and will be used as the starting point for assessment. In some instances it may be considered appropriate to adjust sensitivity and magnitude in the light of specific circumstances.

3.3.5 Table 1 provides a basis for determining both construction phase effects and operational phase effects. Whether a particular resource and receptor needs separate assessment for the construction and operational phases will depend upon the specifics of the Proposed Scheme. Some receptors need different assessments for both construction and operational phases while other receptors will only require an assessment for one of the phases. There will also be instances in which it will be appropriate to take into account the construction phase effects when carrying out the assessment of the operational phase, for example if a facility will be closed down during the construction phase and would only be partly reopened during the operational phase.

Table 1: Guidance on assessing sensitivity and magnitude

Theme	Effects	Effects		Magnitude of effect
		On resources	On receptors	
Existing businesses and organisations – due to land required for construction or operation of the Proposed Scheme and amenity impacts	Businesses (including community) lost due to land required for construction or operation of the Proposed Scheme	Loss or impairment of business activities	Change in employment and skills mix	Individual receptors: • HIGH: Estimated loss/relocation of more than 50 jobs; • MEDIUM: Estimated loss/relocation of between 10 and 50 jobs; • LOW: Estimated loss/relocation of between 2 and 9 jobs; and • NEGLIGIBLE: Loss/relocation of 1 or less jobs. Possible variations: • where the number of employees is a high/low proportion of the size of a local community/business cluster it may be appropriate to increase/reduce the magnitude assessment. Route wide: • HIGH: Estimated loss/relocation of more than 5000 jobs; • MEDIUM: Estimated loss/relocation of between 1000 and 5000 jobs; • LOW: Estimated loss/relocation of between 100 and 999 jobs; and • NEGLIGIBLE: Estimated loss/relocation of less than 100 jobs
	Businesses (including community): Amenity value of infrastructure is changed resulting in an impact on businesses and organisations' operations	Character or quality of businesses and organisations' environment changes	Change in employment and skills mix	The primary test of magnitude will be the nature of the effects on the function of the resource. Also of relevance is the duration of the impact. Magnitude of impact is anticipated to vary significantly depending upon the characteristics of each situation. Generally though the magnitude of socio-economic impacts will depend upon the magnitude of other environmental impacts. The following guide is consequently suggested at the receptor level: Effect on function of resource and implications for receptors: • HIGH: Three or more residual significant other effects; and • MEDIUM: Two significant residual other environmental effects. The amenity assessment will only consider the in combination significant residual effects from other topics so the LOW and NEGLIGIBLE categories are not considered to be applicable with regards to magnitude of impact.

Theme	Effects	Effects		Magnitude of effect
		On resources	On receptors	
				Potentially other effects include relevant elements of: air quality; landscape and visual; sound, noise and vibration; and traffic and transport (in terms of impacts of HGV (construction traffic) movements. Duration: The duration of the impact should be taken in to account. Generally speaking where duration is less than 6 months it may be appropriate to reduce the magnitude of the impact below the initial effect thresholds. Given the uncertainties of estimating such employment losses/relocations at an individual receptor level the individual assessments will be used as an input to estimate an aggregated route-wide level impact: • HIGH: Estimated loss/relocation of more than 500 jobs; • MEDIUM: Estimated loss/relocation of between 100 and 500 jobs; • LOW: Estimated loss/relocation of between 10 and 99 jobs; and • NEGLIGIBLE: Estimated loss/relocation of less than 10 jobs.
	Isolation of infrastructure from receptors resulting in an impact on businesses and organisations'	Physical e.g. Islanding or isolation of resource results in change to business and organisations'	Change in employment and skills mix	Magnitude of Impact will vary depending upon a number of factors including: • closures of roads/ PRoW and duration of closures; • extent of diversions; and • potential delay/disruption. Assessors should use the question prompts in List A (refer to Section 3.4) when weighing up magnitude. Given the uncertainties of estimating such employment losses/ relocations at an individual receptor level the individual assessments will be used as an input to estimate an aggregated route-wide level impact: Route wide: • HIGH: Estimated loss/relocation of more than 500 jobs; • MEDIUM: Estimated loss/relocation of between 100 and 500 jobs; • LOW: Estimated loss/relocation of between 10 and 99 jobs; and • NEGLIGIBLE: Estimated loss/relocation of less than 10 jobs

Theme	Effects	Effects		Magnitude of effect
		On resources	On receptors	
Employment associated with construction	Direct employment opportunities associated with the construction phase	Demand for construction phase services	Demand for construction phase associated jobs and change in opportunities for local employment	Route wide: • HIGH: Estimated creation of more than 10,000 person years[1] of construction employment; • MEDIUM: Estimated creation of between 5,000 and 10,000 person years of construction employment; • LOW: Estimated creation of between 100 and 4,999 person years of construction employment; and • NEGLIGIBLE: Estimated creation of less than 100 person years of construction employment.
	Indirect impacts on the economy of the construction phase	Indirect impacts on other construction sector projects, multiplier impacts on the wider economy	Demand for construction sector jobs and change in opportunities for local employment	Route wide: • HIGH: Estimated creation of more than 10,000 person years of construction employment; • MEDIUM: Estimated creation of between 5,000 and 10,000 person years of construction employment; • LOW: Estimated creation of between 100 and 4,999 person years of construction employment; and • NEGLIGIBLE: Estimated creation of less than 100 person years of construction employment.
Employment associated with operations	Direct employment opportunities associated with the operations phase	Demand for operational phase services	Change in employment and skills and change in opportunities for local employment	Route wide: • HIGH: Estimated net creation of more than 5,000 jobs over baseline; • MEDIUM: Estimated net creation of between 1,000 and 5,000 jobs over baseline; • LOW: Estimated net creation of between 100 and 999 jobs over baseline; and • NEGLIGIBLE: Estimated net creation of less than 100 jobs over baseline.

[1] Construction labour is reported in construction person years, where one construction person year represents the work done by one person in a year composed of a standard number of working days.

Theme	Effects	Effects		Magnitude of effect
		On resources	On receptors	
	Indirect impacts on the economy of the operations phase	Indirect impacts on sectors of the economy, multiplier impacts on the wider economy	Change in employment and skills and change in opportunities for local employment	Route wide: • HIGH: Estimated net creation of more than 5,000 jobs over baseline; • MEDIUM: Estimated net creation of between 1,000 and 5,000 jobs over baseline; • LOW: Estimated net creation of between 100 and 999 jobs over baseline; and • NEGLIGIBLE: Estimated net creation of less than 100 jobs over baseline.

3.4 Assessment criteria checklist

Magnitude of impact

3.4.1 In considering the magnitude of an impact on a resource and its receptors, assessors consider each impact against the checklist of magnitude questions presented in the following List A. The questions are designed to assist in deciding on magnitude and judging whether there could be any specific circumstances in which the magnitude ranking should differ from the thresholds (see Table 1). Not every question may have relevance to the circumstances under consideration.

3.4.2 Some situations/outcomes may not be known for certain. Assessors base their work on an assessed mostly likely situation/outcome.

List A: Questions relevant to the assessment of magnitude of impact

Effect on function of resource and implications for receptors:

- How will the impact affect the functioning of the resource? To what degree can it absorb the change?
- What is the severity/intensity of the impact on people's lives and activities?
  - Do other EIA topics conclude a significant effect?

Duration – temporal scope of effect on receptor:

- What is the temporal scope of the impact?
  - Does the impact occur at specific times of the day?
  - For how long does the impact occur?
  - How regularly does the impact occur?
  - Is the impact temporary or permanent?

Sensitivity of receptors

3.4.3 In considering the sensitivity of receptors to an impact, assessors consider each impact against the checklist of sensitivity questions given in the following List B. Not every question will be relevant to the circumstances of each receptor. The questions are designed to assist in deciding on sensitivity and judging whether there could be any specific circumstances in which the sensitivity ranking should differ from the thresholds (see Table 1).

3.4.4 Some situations/outcomes may not be known for certain. Assessors should base their work on assessed mostly likely situations/outcomes.

3.4.5 For the assessment of combined environmental impacts, sensitivity should be considered as a separate step in the socio-economic assessment process. Where there is an overlap with other disciplines and this is considered by assessors to be important they should ensure that the overall significance rating is consistent with the other relevant assessments.

List B: Questions relevant to the assessment of sensitivity

Scarcity/alternatives for receptors

3.4.6 What is the scarcity of the affected resource and what is the availability of alternatives? Factors to consider include:

- what is the catchment area of the affected resource?
- are there comparable alternative resources available within the relevant catchment area?
- how easy is it to replace the resource? e.g. does it have special site requirements that are difficult to replicate or are its locational requirements generic and relatively easily met elsewhere?
- what is the spare capacity of the alternative resources and is this potentially available to the users of the affected resource?
- what is the likelihood that alternative resources/sites/options will become available?

Capacity to respond to loss/gain for receptors

- what is the receptor's capacity to experience a loss or gain of the affected resource?
- nature of suppliers – are suppliers to the resource unduly concentrated such that their capacity to experience a loss or gain in the affected resource will be magnified in the local economy?
- nature of users – are they concentrated in the local area? Are they a specialised interest group? Are they local/ regional/ national/ international? Does this nature then influence their capacity to experience a loss or gain in the affected resource?

4 Socio-economic assumptions

4.1 Introduction

4.1.1 The key assumptions underlying the socio-economic assessments are set out in the following sections.

Socio-economic assumptions

Direct effects

4.1.2 The impacts of the Proposed Scheme on socio-economic resources (property units supporting employment) and the consequential effects on receptors (users of the resource or its service/goods) is considered in terms of full time equivalent (FTE) jobs gained, lost or relocated.

4.1.3 Loss of trade within a business can be considered as a loss of turnover and represented as a change in employment at the affected business (assuming a positive relationship between growth/contraction in a business' turnover and growth/contraction in employment at that business).

4.1.4 Since the level and intensity of proposed construction activity will vary during the construction period, the level of significant effects on socio-economic resources could vary. The assessment reported is focused on the construction activities and durations which could lead to the greatest potential impact.

4.1.5 Where practicable, land required temporarily during the construction period will be returned to its previous use after construction unless that use cannot continue or resume within a reduced area. Where the use cannot resume, the effect is treated as permanent.

4.1.6 The assessment considers the construction phase (2025-2038) and the first year of operation (2038) which is considered to provide a worst-case forecast of effects.

4.1.7 The different assessments within the socio-economic section (socio-economic resources affected by land required for the Proposed Scheme, isolation and changes in combined environmental effects) are not directly comparable when considering the significance of effect.

4.1.8 For resources affected by land required for the Proposed Scheme the implication is that the employment within these resources will either relocate or be lost and the significance of this has been assessed. For resources affected by isolation and/or changes in combined environmental effects the situation is less clear in terms of employment implications.

4.1.9 With this in mind impacts are assessed and reported at an individual resource level although any employment implications are assessed at route wide level.

4.1.10 The assessment considers the potential reduction in economic output arising as a consequence of direct impacts – the relocation or closure of businesses located on land required for the construction and operation of the Proposed Scheme. For the purposes of this assessment the indicative rate of successful business relocations is judged to be 88% and no employment at these businesses will be lost. The rate of closure of directly affected businesses is therefore 12% and all employment within these businesses is assumed to be lost.

Indirect effects

4.1.11 The socio-economic business combined environmental effects assessment draws on the residual significant effect findings from other topics. These findings are combined to determine whether there is a significant combined environmental effect. Findings from other topic assessments are not directly comparable in terms of their scale of effects.

4.1.12 The business assessment of combined environmental effects considers whether a business may lose trade as a result of its users/customers' ability to use the resource being affected by the Proposed Scheme and the potential employment consequences.

4.1.13 Employment implications on individual socio-economic resources which result from single topic significant residual effects are outside the scope of this assessment. At route wide level, any employment implications of this nature are considered to be limited and not significant.

4.1.14 The socio-economic assessment does not assess localised impacts on tourism/visitors to venues along the route. There is no robust evidence (or method of assessment) to determine whether or not there is a significant displacement of employment at these venues as a result of the Proposed Scheme.

4.1.15 With regards to the combined environment and isolation assessments the sensitivity of receptors will vary from business to business but will be dependent on whether the Proposed Scheme will be likely to have an adverse effect on trade. Businesses located in the hospitality, recreation and culture and retail sectors are most likely to have receptors with high levels of sensitivity given the risk of trade diversion as a result of the Proposed Scheme. In determining sensitivity, consideration is given to catchment of the affected socio-economic resource, alternative unaffected competitor business, attraction of the facility to customers and type and make-up of facility.

4.1.16 For the combined environment and isolation assessments, it is assumed a business establishment experiencing an adverse effect on trade can adopt a number of strategies before reducing employment (e.g. cancel/postpone investment in premises/stock/machinery, reduce staff working hours, family members working longer hours, cancel/postpone plans to expand business, temporary laying-off staff, renegotiate loans or mortgage, increase marketing or advertising activity etc.). Any reduction in employment has been calculated by estimating the total employment of the business(es) affected; then, based on the business activity/sector type, by applying a percentage to represent the likely proportion of employment which could be significantly affected by changes in combined environmental or isolation effects.

4.1.17 Increases in HGV construction traffic flows as a result of construction of the Proposed Scheme will affect the capacity of local businesses and organisations to attract trade. This information is taken from the Traffic and transport assessment. This aspect of the assessment is about the presence of HGV on routes and their proximity to socio-economic resources.

4.1.18 Information on duration of significant residual effects is provided by other environmental topics where available. Where the relevant information is available, socio-economic assessors will use duration to determine when significant residual effects from other topics occur simultaneously.

4.1.19 In cases where certain socio-economic resources have not been explicitly identified in other topics, such as landscape and visual impact, sound, noise and vibration, socio-economic assessors will apply professional judgement based on consultation with relevant topics concerning significant effects. For the purposes of establishing combined environmental effects on business, any significant effects findings established through professional judgement are used in the same way as findings derived by technical assessment and provided directly by the other environmental topics.

4.1.20 Magnitude of impact within the combined environmental effects assessment is anticipated to vary significantly depending upon the characteristics of each situation. Generally the magnitude of impact will depend upon the magnitude of other environmental effects. However, in certain circumstances it is appropriate to acknowledge that some significant residual effects from other topics (for example visual) may not be appropriate to apply to particular socio-economic resources in terms of contributing to a possible impact.

4.1.21 Socio-economic resources identified as part of cumulative schemes may interact with the Proposed Scheme during their construction and as a result of their occupation by new receptors during the time when the Proposed Scheme is being constructed and beyond. During their construction, cumulative projects have the potential to create their own environmental impacts. Additional air quality and dust, landscape and visual, sound, noise and vibration and HGV traffic movement impacts risk compounding those effects generated by the Proposed Scheme. However, given construction of these projects will occur many years into the future, lack of information prevents any meaningful assessment of effect being undertaken.

4.1.22 Employment within socio-economic resources is estimated through a combination of sources, for example, business consultation, Experian employment dataset, employment floor space (obtained from either the Valuation Office Agency or an estimate made via site visits and Geographic Information System (GIS) mapping) and the Homes and Communities Agency (HCA) Employment Density Guide (2015). The estimate is calculated using standard employment density ratios and estimates of floor areas and may vary from actual employment at the sites.

4.1.23 Construction labour is reported in construction person years, where one construction person year represents the work done by one worker in a year composed of a standard number of working days.

4.1.24 It is assumed that the demand for and supply of construction labour will remain largely the same as at present up to the commencement of the Proposed Scheme. Employment effects associated with the construction phase of the Proposed Scheme are presented in gross and net terms, whereas operational employment of the Proposed Scheme is reported as gross. Employment on the classic network is assumed to remain the same as present as released capacity is utilised by new services.

Future baseline

4.1.25 The future baseline is taken to be the existing employment position of those socio-economic resources identified as being directly affected or indirectly affected by the Proposed Scheme. It can be expected, due to changes in socio-economic conditions, that there would be changes in the number and type of business activities of those resources affected from that which is currently observed, for instance businesses may open or close, and sites or premises that are currently occupied may become unoccupied. However in absence of information about the specific economic circumstances of the businesses, their financial plans, owner intentions, or whether the capacity of the commercial site or building is likely to change in the long term, it is not possible to forecast how employment could change with any certainty before commencement of the Proposed Scheme.

4.1.26 The future baseline will also consider the implications of planned development on both new and existing non-agricultural employment receptors with a view to establishing whether there are any significant effects arising from interaction with the Proposed Scheme had these planned developments proceeded in the absence of the Proposed Scheme. Consented development will assume to have been completed by the date of construction (2025) using known characteristics of such development to determine a likely employment effect. Given the impossibility of determining the future employment associated with businesses occupying development in the future, these developments and their related employment will be assumed to remain unchanged for the purposes of assessing any significant effects arising from operations in 2038.

Route-wide

4.1.27 Additionality of the Proposed Scheme is defined as the impact that arises as a result of an intervention (in this case the Proposed Scheme) that would not have occurred in the absence of that intervention.

4.1.28 The route-wide additionality assumptions for the intervention case are set out in Table 2 and inform the assessment of route-wide effects contained in Volume 3 of the ES. Additionality is assessed through the use of rates set out in the English Partnerships Additionality guidance[2] which make allowances for the effect of leakage, displacement and multipliers.

Table 2: Proposed Scheme: Route wide additionality assumptions

	Effect rate	Effect level
Leakage	0%	None
Displacement	25%	Low
Substitution	0%	None
Multiplier	1.5	Medium

4.1.29 Impacts are considered at the UK level for Leakage[3]. Leakage for all types of impact is therefore assumed to be zero.

4.1.30 Displacement[4] refers to the potential change in economic output from businesses as a consequence of the Proposed Scheme. Displacement is estimated in relation to:

- construction employment created by the Proposed Scheme: A low displacement is applied to reflect the uniqueness of the project and high demand for specialist, skilled workers, resulting in a lower likelihood of displacing other construction projects or construction jobs over the relevant time period;
- the contraction in economic output as a consequence of employment losses at businesses directly affected (business relocations or closure) or indirectly affected (changes in combined environmental and isolation effects) during the construction phase is reflected by the resultant displacement effects on other parts of the economy. A low level of displacement is applied to employment identified as being potentially lost in these businesses to reflect the likelihood that these businesses operate in an established and competitive economy; and
- during the operational phase it is assumed that operational jobs will not supplant other economic activities from taking place, and therefore a low degree of displacement is assumed.

4.1.31 Substitution effects arise where a firm substitutes one activity for a similar one to take advantage of public sector assistance[5]. For all types of impact, zero substitution effects are assumed as employment created by the Proposed Scheme (during construction and operation) is not thought to be directly supported by initiatives which generate public sector assistance.

[2] English Partnerships (2008) Additionality guidance.

[3] Leakage: the number or proportion of outputs that benefit those outside of the intervention's target area or group should be deducted from the gross direct effects.

[4] Displacement: the number or proportion of intervention outputs accounted for by reduced outputs elsewhere in the target area should also be deducted.

[5] Such as recruiting a jobless person while another employee loses a job. These effects need to be deducted.

4.1.32 Multiplier effects comprise further economic activity (jobs, expenditure or income) associated with additional local income, local supplier purchases and longer term development effects[6]. The medium level composite multiplier is identified as being typical of the majority of public sector interventions.

4.1.33 Employment loss within agricultural organisations will be estimated by the agriculture, forestry and soils assessment and will be reported in aggregate at route-wide level in the ES.

[6] Composite multiplier: further economic activity (jobs, expenditure or income) associated with additional local income, local supplier purchases and longer term development effects then need to be added.

Annex L – Technical notes: Waste and material resources

The following technical notes are contained in this annex:

- Waste and material resources – Waste forecast and assessment methodology; and
- Waste and material resources – Rationale for landfill significance criteria.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Waste and material resources – Waste forecast and assessment methodology

Contents

1 Introduction

1.1 General

1.1.1 This technical note sets out the detailed methodology for:

- the forecasting of operational waste arisings;
- the identification of the potential impact of all wastes on waste treatment capacity; and
- the route-wide assessment of the likely significant environmental effects associated with the off-site disposal to landfill of solid waste that will be generated by construction and operation of the Proposed Scheme.

1.1.2 The route-wide assessment shall be presented in Volume 3 of the Environmental Statement (ES).

1.1.3 The Construction and Demolition Waste Forecasting Technical Note provides the detailed methodology for the civil engineering teams to use in identifying the tonnage of:

- waste that will be generated by construction and demolition activities undertaken during the proposed construction period; and
- waste that will be generated by occupants of worker accommodation sites during the proposed construction period.

1.1.4 All waste arisings will be reported in tonnes rounded to the nearest whole number.

2 Operational Waste Forecast

2.1 Introduction

2.1.1 Operational waste arisings from the Proposed Scheme will be calculated: on an annual basis; and using an assumption that maximum capacity will be achieved in the first full year of operation (2039).

2.1.2 The scope of operational waste forecasting covers:

- railway station and train waste;
- rolling stock maintenance waste;
- track maintenance waste; and
- ancillary infrastructure waste (relating to waste arising from depots, signalling locations and operations and maintenance sites). Waste from 'maintenance sites' in this context excludes the aforementioned rolling stock maintenance waste and track maintenance waste.

2.1.3 Individual waste forecasts for each of the above listed categories will be combined to provide an overall forecast of operational waste arisings.

Railway station and train waste

2.1.4 Railway station and train waste refers to waste that will arise at each station or at the terminating station for waste removed from trains, and includes:

- waste from individual functions within stations such as retail units, food and beverage outlets etc.; and
- waste removed from trains, which will be the case at terminating stations only.

2.1.5 The waste generation rate used to forecast railway station and train waste has been formulated on the basis of actual annual waste data (including both railway station and train waste) from Network Rail. Data for the numbers of people using stations has been obtained from the Office of Rail Regulation. The number of people using stations has been provided on the basis of the number of entries and exits through ticket barriers.

2.1.6 The annual quantity of waste (in tonnes) that will be generated in railway stations and on trains will be forecast using a waste generation rate of 0.085kg per station user. Recent trends in waste generation data indicate a decline in waste generation per station user; waste forecasts undertaken using this generation rate are therefore likely to represent a worst-case scenario.

2.1.7 Based on a landfill diversion rate of 65%[1]:

- 0.05525kg of waste will be diverted from landfill per station user; and
- 0.02975kg of waste will be landfilled per station user.

2.1.8 This forecasting methodology does not make any distinction between station types; i.e. between terminating stations that include train waste or non-terminating stations that do not include train waste. This is because the majority of waste produced will be station waste (regardless of the type of station) and so there is no consistently discernible difference between the two station types.

Rolling stock maintenance waste

2.1.9 Rolling stock maintenance waste is that which will be generated by the relevant train operating company (or its fleet maintenance contractor) and thus reported separately to ancillary infrastructure waste and track maintenance waste.

2.1.10 In the absence of new data from existing train operating companies, the waste generation rate that will be used to forecast rolling stock maintenance waste is the same as that used previously. The waste generation rate has been adopted from British Standard (BS) 5906:2005 Waste Management in Buildings – Code of Practice. This relates to a waste generation rate of 5litres/m2/week for an industrial unit, which has been converted to an annual tonnage rate using a waste density conversion factor of 1.16 tonnes/m3.[2]

2.1.11 The annual quantity of rolling stock maintenance waste (in tonnes) that will be generated will be forecast and reported according to the CA in which it will arise. This will be done using a waste generation rate of 0.3 tonnes/m2/year applied to the gross floor area of each rolling stock depot within a CFA.

2.1.12 Where a rolling stock maintenance depot forms part of a larger depot (e.g. that also incorporates ancillary infrastructure and track maintenance facilities), the proportion of floor space provided solely for rolling stock maintenance will be used in the waste generation forecast.

2.1.13 A landfill diversion rate of 80% will apply to rolling stock maintenance waste. This figure has been assumed on the basis of professional judgement taking into account the following information:

- Network Rail's previous target to divert 60% of operational waste from landfill by 2014;

[1] Supported by revised EU legislative proposals for waste, targeting a minimum of 65% re-use and recycling of municipal waste by weight by 2035.

[2] Based on an average of waste density conversion factors for heavy scrap metal (1.78 tonnes/m3), light scrap metal (0.74 tonnes/m3) and oils, tars and asphalts (0.95t/m3); taken from Tchobanoglous, G., Theisen, H., Vigil, S.A. (1993), Integrated Solid Waste Management. Engineering Principles and Management Issues. McGraw-Hill.

- Network Rail's average landfill diversion rate (85% for track maintenance wastes); and
- generic landfill diversion data published by Alstom[3] and Bombardier[4] (both of which have significant business activities in rolling stock maintenance) ranging from 80% to 88%.

Track maintenance waste

2.1.14 Track maintenance waste will be generated and reported separately from ancillary infrastructure waste and rolling stock maintenance waste.

2.1.15 Track maintenance waste will be reported as ballast track maintenance waste; slab track maintenance waste or both, depending on the proposed track installation.

Ballast track maintenance waste

2.1.16 The waste generation rate that will be used to forecast ballast track maintenance waste has been formulated on the basis of data provided by Network Rail.

2.1.17 The annual quantity of ballast track maintenance waste (in tonnes) that will be generated will be forecast according to the total length of track within each CA using a waste generation rate of 8.23 tonnes/km/year. This is the same waste generation rate as used for Phase One and Phase 2a.

2.1.18 For any track sections with two or more lines, the distance will be scaled up according to the number of lines (e.g. doubled for a twin track, trebled for three lines etc.). This is because the waste generation rate to be used is based on the length of a composite track comprising of two rails, sleepers, clips and ballast etc.

2.1.19 Based on Network Rail's average landfill diversion rate of 85% across a range of material types for track maintenance waste:

- 7.00 tonnes/km/year of waste will be diverted from landfill; and
- 1.23 tonnes/km/year of waste will be landfilled.

Slab track maintenance waste

2.1.20 The waste generation rate that will be used to forecast slab track maintenance waste has been formulated on the basis that the rails and clips will require replacement at regular intervals but the slab itself is, effectively, maintenance free, having a design life of 60 years.

2.1.21 The annual quantity of slab track maintenance waste (in tonnes) that will be generated will be forecast according to the total length of rail within each CA using a waste generation rate of 0.05495 tonnes/m/year. It is acknowledged that rail replacement is likely to be undertaken

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[3] Alstom has set a target to recover more than 80% of its waste. In 2015, 82 % of waste produced was either recycled or recovered for energy, this increased to 88% in 2016.

[4] Data reported by Bombardier's Transportation Group indicates a landfill diversion performance of 80% in 2016.

in a phased approach, with track expected to last 10 – 15 years. However a worst case scenario has been used as the basis for the chosen waste generation rate, assuming that it in any given operational year, the full length of track may be replaced.

2.1.22 The distance vector will be scaled up to reflect that single-track sections comprise of two rails, clips etc.; double track sections comprise of four rails, clips etc.; and so on.

2.1.23 As slab track maintenance waste consists solely of steel rails and clips, and rubber pads which can be fully recycled or recovered, a landfill diversion rate of 100% shall apply to slab track maintenance waste:

- 0.05495 tonnes/m/year of waste will be diverted from landfill; and
- 0 tonnes/m/year of waste will be landfilled.

Ancillary infrastructure waste

2.1.24 Ancillary infrastructure waste refers to waste that will arise from depots, signalling locations, operations and maintenance sites excluding track maintenance waste and rolling stock maintenance waste (according to the scope of the waste generation rate used).

2.1.25 The waste generation rate that will be used to forecast ancillary infrastructure waste has been formulated on the basis of data provided by Network Rail.

2.1.26 The annual quantity of ancillary infrastructure waste (in tonnes) that will be generated will be forecast according to the total length of track within each CA using a waste generation rate of 0.692 tonnes/km/year. This is the same as the waste generation rate used previously.

2.1.27 For any sections with two or more lines, the distance will be scaled up according to the number of lines (e.g. doubled for a twin track, trebled for three lines etc). This is because the waste generation rate to be used is based on the length of a composite track comprising of two rails, sleepers, clips and ballast etc.

2.1.28 Based on a landfill diversion rate of 65%[5]:

- 0.4498 tonnes/km/year of waste will be diverted from landfill; and
- 0.2422 tonnes/km/year of waste will be landfilled.

[5] Supported by revised EU legislative proposals for waste, targeting a minimum of 65% re-use and recycling of municipal waste by weight by 2035.

3 Assessment methodology

3.1 Background

3.1.1 In March 2020, IEMA published guidance on Materials and Waste in Environmental Impact Assessment[6]; this set out the first industry wide approach to consideration of this topic in environmental impact assessments. A technical review of the methodology proposed by IEMA, has been undertaken. The review concluded that the assessment methodology for the Proposed Scheme in the Environmental Impact Assessment Scope and Methodology Report (SMR), remains the most appropriate approach for assessing the likely significant environmental effects associated with the off-site treatment or disposal to landfill of solid waste that will be generated by construction and operation of the Proposed Scheme.

3.1.2 The assessment methodology that will be used is based on professional judgement and experience with the application of Environmental Impact Assessment (EIA) to Phases One and 2a, rail-related and other large-scale transport infrastructure projects.

3.1.3 The assessment will consider the types and quantities of waste that will be generated during construction and operation, identify the impact on treatment capacity and assess the severity of the likely significant environmental effects that may arise from the quantity of waste requiring off-site disposal to landfill (this being the least preferred waste management option).

3.1.4 This approach takes into account the overall quantity of waste likely to be generated, the types and quantities of waste likely to require off-site treatment and disposal to landfill and the projected availability of treatment and landfill disposal capacity in the defined study area.

3.1.5 The study area is defined in two ways.

- Baseline information, including waste treatment and disposal capacity and waste arisings, will be collated and reported to align with the Proposed Scheme Community Areas.
- Identification of the impact on treatment capacity and the assessment of landfill disposal will be reported to align with the relevant region. The regions are defined in the Environment Agency Waste Data Interrogator.[7]

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[6] Institute of Environmental Management and Assessment (2020), *IEMA guide to: Materials and Waste in Environmental Impact Assessment.* Available online at: https://www.iema.net/resources/reading-room/2020/03/30/materials-and-waste-in-environmental-impact-assessment.

[7] Environment Agency (2015), *Waste management for England 2015*. Available online at: https://www.gov.uk/government/statistics/waste-management-for-england-2015.

3.2 Legislation and guidance

3.2.1 Assessment and mitigation of the likely significant environmental effects of waste generation will be considered with respect to relevant legislation, policy and guidance governing the management of waste in England.

Legislation

3.2.2 The key items of relevant legislation are as follows:

- the Environmental Protection Act 1990 which defines the fundamental structure and authority for waste management and control of emissions into the environment;
- the Waste (England and Wales) Regulations 2011 SI No. 988 (as amended), which transpose the provisions of the EU Waste Framework Directive (2008/98/EC)[8] into English and Welsh legislation;
- the Controlled Waste (England and Wales) Regulations 2012 SI No. 811 (as amended), which sets out the definition of controlled waste to which waste management regulatory controls apply;
- the Environmental Permitting (England and Wales) Regulations 2016 SI No.1154 (as amended), which provide a consolidated system for permitting of waste operations (amongst other activities not relevant in this context). The 2016 Regulations will replace and revoke the 2010 Regulations (SI No. 675 as amended) with the exception of Regulations 1, 67 and 107;
- the Hazardous Waste (England and Wales) Regulations 2005 SI No. 894 (as amended), which set out the regime for the control and tracking of the movement of hazardous waste;
- EU Landfill Directive 1999/31/EC, transposed through the Landfill (England and Wales) Regulations 2010 (as amended); which identify the different types of landfill and requirement for implementation of the waste hierarchy;
- Decision 2000/532/EC (OJ:L226/1/2000) establishing a list of wastes (European Waste Catalogue) - following amendments made to Decision 2000/532/EC in December 2014, the List of Wastes (England) Regulations 2005 SI No. 895 (as amended) has been revoked, in order to reflect changes to EU chemicals classifications. This Decision combines and simplifies existing provisions by establishing a single, integrated Community list of wastes in accordance with Directive 2008/98/EC, on waste; and
- the Site Waste Management Plans Regulations 2008 SI No. 314 were repealed on 1 December 2013. The purpose of the site waste management plan was to identify opportunities to design out waste; as well as identifying the types and quantities of waste

[8] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives.

likely to be produced during construction; the opportunities for sustainable management of the waste to be identified; and to monitor and report on the actual management of these wastes throughout the construction period. HS2 Ltd will apply these principles to the construction of the Proposed Scheme ensuring an integrated approach to the design of the Proposed Scheme, aiming to maximise the beneficial reuse of excavated material where possible and minimise the generation of waste, which will be facilitated through the implementation of the Code of Construction Practice (CoCP) for the Proposed Scheme.

Policy

3.2.3 The Resources and Waste Strategy for England[9], published in December 2018, sets out how resource use will be optimised by minimising waste, promoting resource efficiency and moving towards a circular economy in England.

3.2.4 The Government Review of Waste Policy in England 2011[10] sets out the Government's long-term strategy for the prevention and management of waste in England. It follows the waste hierarchy approach set out in the EU Waste Framework Directive.

3.2.5 The Waste Prevention Programme for England, 2013 sets a number of objectives to help people and organisations make the most of opportunities to save money by reducing waste. The development of a Waste Prevention Programme is a requirement of the Waste Framework Directive (2008/98/EC) and takes forward a commitment in the Government Review of Waste Policy in England 2011.

3.2.6 National Planning Policy for Waste (2014)[11] along with the National Waste Management Plan for England (2013)[12] sets out Government policy on waste planning, which is of relevance to the management strategy for solid waste generated during the construction and operation of the Proposed Scheme.

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[9] HM Government (2018), *Our Waste, Our Resources: A Strategy for England*. Available online at: https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england.

[10] Department for Communities and Local Government (2014), *National Planning Policy for Waste*. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/364759/141015_National_Planning_Policy_for_Waste.pdf.

[11] Department for Communities and Local Government (2014), *National Planning Policy for Waste*. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/364759/141015_National_Planning_Policy_for_Waste.pdf.

[12] Department for Environment, Food and Rural Affairs (2013), *National Waste Management Plan for England, Her Majesty's Stationery Office.* Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/265810/pb14100-waste-management-plan-20131213.pdf

3.2.7 In terms of achieving sustainable development the National Planning Policy Framework (NPPF) identifies that minimising waste and pollution is a fundamental part of the environmental role of the planning system.

3.2.8 Local planning policy will be relevant along the route of the Proposed Scheme.

Guidance

- IEMA guide to: Materials and Waste in Environmental Impact Assessment[6]; and
- CL:AIRE Definition of Waste: Development Industry Code of Practice[13]; and
- Waste and Resources Action Programme (WRAP) guidance developed to achieve better resource efficiency in construction projects.

3.3 Assessment

Construction Waste

3.3.1 The environmental assessment will identify the impact on treatment capacity and consider the likely significant environmental effects associated with the off-site disposal to landfill of solid waste. The forecast will also include waste generation associated with the worker accommodation sites, where applicable.

3.3.2 In quantifying waste arisings requiring disposal to landfill, evidence-based assumptions will be applied for construction, demolition and worker accommodation site waste as follows[14]:

- construction waste – landfill diversion rate of 90%;
- demolition waste – landfill diversion rate of 90%; and
- worker accommodation waste – landfill diversion rate of 55%.

3.3.3 In addition, the following landfill diversion rates shall be applied to individual materials within the waste forecast associated with the clearance of redundant rail infrastructure:

- ballast – 90%;
- rail – 100%;
- sleepers (hard wood) – 100%; and
- sleepers (concrete) – 100%.

[13] Contaminated Land: Applications in Real Environments, *Definition of Waste: Development Industry Code of Practice*. Available online at: https://www.claire.co.uk/projects-and-initiatives/dow-cop

[14] Construction and demolition waste assumptions taken from reference projects (CrossRail, ODA and Tideway) set out in the Technical Note: Rationale for Landfill Significance Criteria, doc.no.: 2EV01-ARP-EV-NOT-000-000035. Worker accommodation waste assumption reflective of municipal waste recycling target of 55% by 2025, set in the EU action plan for the circular economy.

3.3.4 For all other waste generation associated with the construction of rail systems, a landfill diversion rate of 90% shall be applied.

3.3.5 The quantity of excavated material requiring disposal (surplus excavated material) will be derived from the cut and fill balance for the Proposed Scheme.

3.3.6 It will be assumed that 100% of any hazardous waste arisings will require off-site disposal to a hazardous waste landfill (i.e. zero landfill diversion rate).

3.3.7 The total quantity of waste requiring off-site treatment during the proposed construction period (2025 to 2039) will be identified and compared to the total operating capacity within the study area. A professional judgement will be made of the level of impact.

3.3.8 Using the same base data, the total quantity of waste requiring off-site disposal to landfill during the proposed construction period (2025 to 2039) will be assessed with reference to the Rationale for Landfill Significance Criteria technical note.

Operational Waste

3.3.9 The operational waste forecast will be undertaken as described in Section 2 of this technical note.

3.3.10 In quantifying the amount of waste needing to be disposed to landfill, the following assumptions will be applied:

- railway station and train waste – landfill diversion rate of 65%;
- rolling stock maintenance waste – landfill diversion rate of 80%;
- track maintenance waste – landfill diversion rate of 85%; and
- ancillary infrastructure waste – landfill diversion rate of 65%.

3.3.11 The total quantity of waste requiring off-site treatment during the first full year of operation (2039) will be identified and compared to the total operating capacity within the study area. A professional judgement will be made of the level of impact.

3.3.12 Using the same base data, the total quantity of waste requiring off-site disposal to landfill during the first full year of operation (2039) will be assessed against the non-hazardous landfill capacity within the study area, with reference to the Technical Note: Rationale for Landfill Significance Criteria.

3.4 Significance criteria

3.4.1 Technical Note: Rationale for Landfill Significance Criteria sets out the landfill significance criteria to be used has been developed and should be read in conjunction with this technical note.

Cumulative effects

3.4.2 The assessment of cumulative effects with respect to waste and material resources will focus on inter-project effects, i.e. effects that will arise as a result of interactions between the Proposed Scheme and other projects.

3.4.3 Such interactions in this context will be the combined quantity of waste requiring off- site disposal to landfill as a result of the construction and / or operation of the Proposed Scheme and other committed developments (i.e. other reasonably foreseeable developments that are likely to be under construction or will be completed at the same time as the Proposed Scheme).

3.4.4 The total quantity of waste likely to be generated by other committed developments (including that which will require subsequent off-site disposal to landfill) will be assessed qualitatively according to professional judgement based on the known type and extent of development. This is because:

- forecast waste arisings and landfill disposal assumptions may not have been published for other committed developments; and
- published forecast waste arisings and landfill disposal assumptions may not have been developed on the same basis as the Proposed Scheme and so may not be directly comparable.

Off-route effects

3.4.5 Where relevant, this technical note will apply to the assessment of effects arising from off-route elements of the Proposed Scheme, which will also be described in Volume 3 of the ES.

Climate change impacts

3.4.6 Volume 3 Climate Change assessment will assess relevant impacts from construction, demolition and excavation wastes and materials to be used in the Proposed Scheme and hence these will not be considered further within this assessment.

Mitigation, enhancement and off-setting

3.4.7 Mitigation of construction and operational effects will be considered in line with key principles of waste and material resources management including the waste hierarchy, proximity principle and product (or development) lifecycle. Mitigation will also have regard to relevant legislation, policy and guidance.

3.4.8 The nominated undertaker and its contractors will be responsible for managing the waste generated from construction activities in accordance with the draft CoCP.

3.4.9 Significant residual environmental effects will be identified, subsequent to the application of any mitigation measures.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Waste and material resources – Rationale for landfill significance criteria

Contents

1 Introduction

1.1 General

1.1.1 This technical note sets out the rationale for the development of the significance criteria for inert, non-hazardous and hazardous landfill to be used in the assessment of the likely significant environmental effects associated with the disposal of solid waste arising from the Proposed Scheme.

1.1.2 The EU Landfill Directive 99/31/EC defines landfill as waste disposal sites for the deposit of waste onto or into land and identifies three classes of landfill: (i) landfill for hazardous waste; (ii) landfill for non-hazardous waste; and (iii) landfill for inert waste.

1.1.3 The relevant Planning Practice Guidance from the Department of Communities and Local Government (DCLG)[1] states that an EIA is likely to be required for a landfill site for the disposal of household, industrial and/or commercial waste where new capacity is created to hold more than 50,000 tonnes per annum, or to hold waste on a site of 10 hectares (ha) or more. More importantly, it also states that sites seeking only to accept inert wastes (demolition waste etc.) are unlikely to require an EIA (see Appendix A of this technical note).

1.1.4 The assessment methodology is based on EIA practitioners' professional judgement and experience with the application of EIA to rail, and other large-scale transport infrastructure projects such as HS2 Phase One and Phase 2a. This methodology has been chosen in preference to the IEMA methodology, that was published in March 2020, for the reasons outlined in the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR).

1.1.5 The SMR significance criteria for inert, non-hazardous and hazardous landfills are established based on the provision of new capacity, in addition to what is already existing in the study area and take account of the challenge and complexity of replacing lost capacity; irrespective of the quantity of available regional capacity. Waste Planning Authorities have a statutory responsibility to make provision for sufficient waste infrastructure capacity; and future local plans should include provision for new waste landfill sites and/or to identify other suitable placement locations to enable continued capacity to be available as landfill void space is occupied.

[1] Department for Communities and Local Government (2015), *Planning Practice Guidance: Environmental Impact Assessment*.

2 Rationale for inert landfill significance criteria

2.1 General

2.1.1 This section of the technical note sets out the rationale for the development of the significance criteria to be used in the assessment of environmental effects associated with the disposal of inert waste arising from the Proposed Scheme.

2.2 Inert waste legislative guidance

2.2.1 Guidance by the Environment Agency provides a definition for inert waste as per the European Union (EU) Landfill Directive, 99/31/EC article 2(e):[2]

'Inert waste' means waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater'.

2.2.2 The EU Landfill Directive sets rigorous standards to reduce the impact from waste disposed of to landfill including inert waste acceptance criteria.

2.2.3 The Environment Agency Technical Guidance WM3 'Waste Classification: Guidance on the Classification and Assessment of Waste'[3], although intended for hazardous waste assessment, provides a useful waste assessment methodology and guidance on waste classification using the European List of Waste (Commission Decision 2000/532/EC)[4].

[2] Environment Agency (2009), *Environmental Permitting Regulations: Inert Waste Guidance - Standards and Measures for the Deposit of Inert Waste on Land*. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/862051/geho1110btew-e-e.pdf.

Note: this guidance was withdrawn in January 2020 but the definition above remains relevant for the assessment.

[3] Environment Agency (2015), *Waste Classification - Guidance on the classification and assessment of waste - Technical Guidance WM3.* Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427077/LIT_10121.pdf.

[4] European Commission (2000), *European List of Waste (Commission Decision 2000/532/EC).* Available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000D0532:20020101:EN:PDF.

2.2.4 Following amendments made to Decision 2000/532/EC in December 2014, the List of Wastes (England) Regulations 2005 SI No. 895[5] (as amended) has been revoked, in order to reflect changes to EU chemicals classifications. This decision combines and simplifies existing provisions by establishing a single, integrated Community list of wastes in accordance with the EU Waste Framework Directive 2008/98/EC on waste (WFD)[6]. This list is commonly referred to as the European Waste Catalogue (EWC).

2.3 Other major infrastructure projects

2.3.1 EIA for other major infrastructure projects such as Crossrail (the Elizabeth line) have relied on a qualitative assessment. The Crossrail target for diverting clean excavation materials from landfill is 95% with a stretch target of 100%; Crossrail have achieved a rate of 98% to date[7]. The target for diverting construction and demolition waste from landfill is 90% with a stretch target of 95%; Crossrail have exceeded their stretch target, achieving diversion of 98% to date. The forecast material generation for Crossrail is set out in Table 1.

Table 1: Crossrail waste material estimates (2005)

Material classification	Volume (m^3)
Clean excavated material (non-contaminated)	6.0 million
Construction material	1.2 million
Contaminated excavated material	0.5 million
Demolition material	0.3 million

2.3.2 Crossrail have exceeded their excavated material forecast, with the total quantity now at approximately 7.9 million tonnes since construction began.

2.3.3 The Olympic Delivery Authority (ODA) set targets to reuse or recycle 90% of demolition waste by weight, and to divert 90% of construction waste from landfill for construction of the facilities for the London 2012 Olympic Games. The ODA recycled 97.7% of demolition waste and achieved its target for diversion of construction waste from landfill. The London 2012 Olympic Park is constructed on land previously used by a variety of industries, which left a legacy of soil and groundwater contamination. Additionally, 80% of contaminated soil was cleaned and reused through the use of soil washing and bioremediation technologies, equating to 1.3 million tonnes of soil, thereby reducing the quantity of hazardous waste that required landfill disposal.

[5] *The List of Wastes (England) Regulations 2005. (SI 2005 No. 895),* Her Majesty's Stationery Office, London. Available online at: https://www.legislation.gov.uk/uksi/2005/895/contents/made.

[6] European Commission (2008), *Council Directive 2008/98/EC on waste 2008.* Available online at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&from=EN.

[7] Crossrail Ltd (2017), *Crossrail Environment Report 2017*. Available online at: https://learninglegacy.crossrail.co.uk/wp-content/uploads/2018/07/Environment-report-2017.pdf

2.3.4 The Tideway (formerly Thames Tideway Tunnel) project has a target to divert at least 80% of construction and demolition waste from landfill as well as to beneficially use a minimum of 85% of the clean excavated material. The Environmental Statement (ES) (Volume 2: Environmental assessment methodology)[8] does not provide a specific assessment methodology for waste, stating that: '*The excavation, storage and movement of excavated material and waste generated on site have been considered within each of the individual topics: transport, noise and vibration, air quality, land quality, historic environment, townscape and socio-economics within each site volume, rather than as an individual topic*'. The Excavated Materials and Waste Strategy[9] also does not include an assessment methodology or criteria for waste. It does include an appraisal of the disposal of waste on the 'Impact on regional waste infrastructure' but does not provide any statement on its significance.

2.4 Inert waste management infrastructure

2.4.1 The number of material recovery facilities for inert and non-inert (mixed) construction and demolition waste has increased over the past 10 years contributing to improved resource efficiency in the construction industry. There are multiple construction and demolition waste recovery facilities across the former North West planning region along the route of the Proposed Scheme. These are capable of processing inert waste generated by the Proposed Scheme.

2.4.2 Typically, a large proportion of the inert waste that is destined for landfill is used for landfill engineering and capping purposes.

2.4.3 Latest available data published by the Environment Agency[10] shows that inert landfill capacity in England has almost doubled over a period of 18 years from approximately 93 million tonnes in 2000 to almost 184 million tonnes in 2019, as shown in Figure 1. The data shows that inert landfill capacity in the North West region has increased, overall, from approximately 6 million tonnes in 2000 to more than 8 million tonnes in 2019 (see Figure 1).

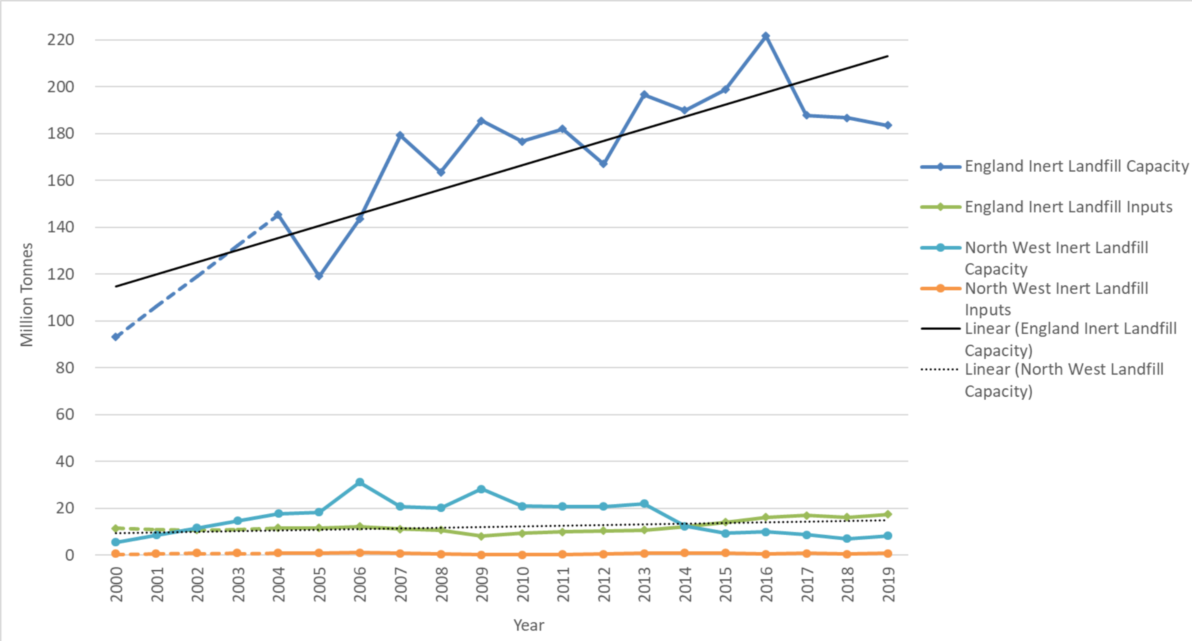
2.4.4 The data shows that inert landfill inputs in England, between 2000 and 2019 have been relatively stable, on average, with a figure of just over 12 million tonnes per annum. The average total inert landfill input for the North West region was just under 0.74 million tonnes over the same period (see Figure 1).

[8] Thames Water (2013), *Environmental Statement Volume 2: Environmental Assessment Methodology*. Available online at: https://www.tideway.london/media/1757/6202-environmental-statement-volume-2-assessment-methodology-sections-1-to-15.pdf.

[9] Thames Water (2014), Environmental Statement Volume 3: Project-Wide Effects Assessment Appendices. Available online at: https://www.tideway.london/media/1782/6203-environmental-statement-volume-3-appendix-a4-annexes-d1-to-d14.pdf.

[10] Environment Agency (2019), *Waste Management 2019 in England: Data Tables.* Available online at: https://data.gov.uk/dataset/d409b2ba-796c-4436-82c7-eb1831a9ef25/2019-waste-data-interrogator.

Figure 1: Inert landfill capacity and inputs in England/North West region (2000 to 2019)*



* Dashed coloured lines represent extrapolated data

2.5 Inert landfill significance criteria

2.5.1 The significance criteria in Table 2 have been developed for inert landfill (excluding hazardous substances) as part of the EIA SMR for the Proposed Scheme. They are relevant for inert waste, which may arise from site clearance works, demolition of existing buildings and structures, and the earthworks associated with the construction of the Proposed Scheme.

Table 2: Inert landfill significance criteria (excluding hazardous substances)

Degree of significance	Inert landfill criteria
Major adverse	Net increase in waste arisings relative to the future baseline leading to a severe, national and regional scale reduction in inert landfill void space capacity. Need for additional large-scale waste treatment and/or disposal capacity of greater than 10,000,000 tonnes per annum. Effect may be judged to be of importance in the national planning context and, therefore, of potential concern to a project depending upon the importance attached to the issue in the decision making.
Moderate adverse	Net increase in waste arisings relative to the future baseline leading to a regional scale reduction in inert landfill void space capacity. Need for additional medium to large scale waste treatment and/or disposal capacity of between 2,000,000 to 10,000,000 tonnes per annum. Effect may be judged to be important in the regional planning context, for example, where effects are permanent or long-term and the effect on local waste treatment and disposal infrastructure is such that additional capacity may be required.

Degree of significance	Inert landfill criteria
Minor adverse	Net increase in waste arisings relative to the future baseline leading to local scale reduction in inert landfill void space capacity. Need for additional small scale waste treatment and/or disposal capacity of up to 2,000,000 tonnes per annum. Effect is of low importance in the decision-making process but may be of relevance to the detailed design and mitigation of a project.
Negligible	No significant increase in waste arisings relative to the future baseline or reduction in inert landfill void space capacity. No appreciable adverse or beneficial effects.
Beneficial	Net reduction in waste arisings and diversion of waste from inert landfill relative to the future baseline resulting in an environmental improvement. Positive effect on waste arisings overall and available capacity of waste treatment and disposal infrastructure.

2.5.2 The upper 'threshold value' for minor adverse effects has been set as 2,000,000 tonnes per annum of inert landfill disposal capacity. This threshold has been based on providing additional small scale inert landfill disposal capacity equivalent to a 10ha inert landfill site assuming an inert waste thickness of approximately 15m (i.e. 1,500,000m^3 of inert landfill capacity or approximately 2,000,000 tonnes using a volume to mass density conversion factor of 1.5 tonnes/m^3)[11]. Based on the threshold described in the Planning Practice Guidance and the inert nature of the waste (i.e. reduced potential of generating greenhouse gas emissions and leachate), it is considered unlikely that landfill and/or land raise would result in pollution of the environment and/or harm to human health. This would need to be confirmed when applying for an environmental permit for an individual site.

2.5.3 The disposal of 2,000,000 tonnes per annum of inert waste would represent about 24% of the inert landfill capacity in the North West region and 1% of the national inert landfill capacity, based on the most recently available figures for 2019 from the Environment Agency[12].

2.5.4 The threshold values for moderate and major adverse environmental effects have been based on professional judgement. These are extrapolations of the threshold value for minor adverse environmental effects, based on an incremental increase of the total inert waste quantity to be disposed of by applying a factor of five to define the moderate adverse environmental effects upper threshold value (i.e. 2,000,000 to 10,000,000 tonnes per annum), and the major adverse environmental effects threshold value (i.e. greater than 10,000,000 tonnes per annum).

2.5.5 The disposal of 10,000,000 tonnes per annum of inert waste represents approximately 100% of the total inert landfill capacity in the North West region, and approximately 5% of inert landfill capacity in England based on the 2019 inert landfill capacity data from the Environment Agency. As discussed, in Section 1.1 the value of the significance criteria thresholds is not predicated on the quantity of regional capacity available.

[11] Department of the Environment (1995), *Waste Management Paper 26B, Landfill Design, Construction and Operational Practice.*

[12] Environment Agency (2019); *Waste Management 2019 in England: Data Tables.* Available online at: https://data.gov.uk/dataset/d409b2ba-796c-4436-82c7-eb1831a9ef25/2019-waste-data-interrogator.

2.5.6 The Proposed Scheme would be constructed over a period of approximately thirteen years (i.e. 2025 to 2038) starting with enabling works followed by the earthworks such as tunnelling etc. Any inert surplus excavated material generated by the Proposed Scheme would not occur all in a single year but extend over several years, reducing the pressure on inert landfill capacity. A wide range of factors influence available landfill capacity, such as the regulatory regime, fiscal measures, waste generation rates and measures to divert waste from landfill (e.g. reuse, recycling/composting and energy recovery). This makes the forecasting of future landfill capacity difficult and inexact. It is recognised that landfill capacity is a limited resource, however, data from the Environment Agency indicates an increase in inert landfill capacity in the North West region and in England as a whole between 2000 and 2019 (see Figure 1).

3 Rationale for non-hazardous landfill significance criteria

3.1 General

3.1.1 This section of the technical note sets out the rationale for the development of the significance criteria to be used in the assessment of the significance of environmental effects associated with the disposal of non-hazardous waste arising from the Proposed Scheme.

3.2 Non-hazardous waste legislative guidance

3.2.1 Non-hazardous waste means waste which is not inert but also not hazardous (see Section 4 for hazardous waste). It will comprise waste generated during the construction (e.g. worker accommodation site waste) and operation (e.g. railway station and train waste) of the Proposed Scheme.

3.2.2 Non-hazardous waste is also covered by the WFD, and UK waste policy, legislation and guidance.

3.2.3 Non-hazardous waste landfill sites typically accept a wide range of non-hazardous waste (including inert waste) including that collected by local authorities (municipal waste) and as generated by local businesses and industrial facilities. There are no numerical waste acceptance criteria for non-hazardous waste but the European List of Waste provides absolute non-hazardous waste entries for wastes which are deemed to be non-hazardous. However, the main requirement is to ensure that the waste landfilled is not hazardous. Guidance on waste classification is provided in Technical Guidance WM3.

3.2.4 The WFD provides a list of wastes, known as the European Waste Catalogue (EWC). The EWC is a catalogue of all wastes, grouped according to generic industry, process or waste type. It differentiates between non-hazardous and hazardous by identifying hazardous waste entries with an asterisk (*).

3.3 Other major infrastructure projects

3.3.1 As stated in Section 2 of this technical note, EIAs for other major infrastructure projects such as Crossrail have relied on a qualitative assessment and have not developed assessment criteria for the disposal of non-hazardous waste.

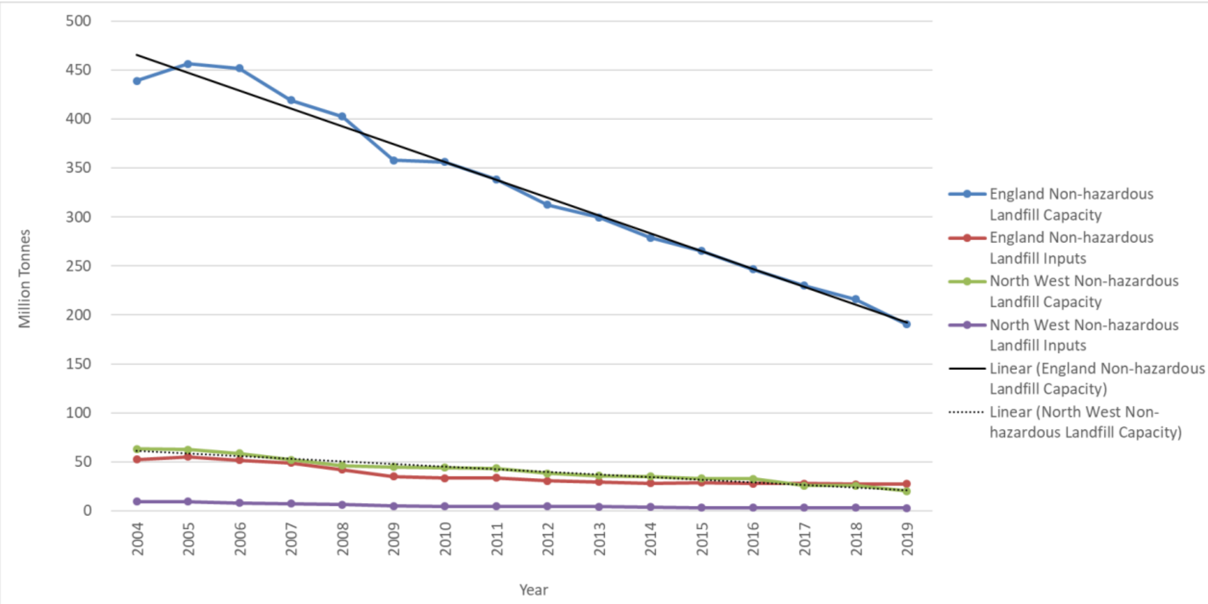
3.4 Non-hazardous waste management infrastructure

3.4.1 Data published by the Environment Agency between 2004 and 2019[13], set out in Figure 2, shows a downward trend of non-hazardous waste landfill capacity in England (indicated by the linear trend line) with about 439 million tonnes in 2004 declining to approximately 191 million tonnes in 2019 (approximately 57% reduction). Over the same period, the non-hazardous waste input rates have decreased even more steeply from 53 million tonnes to 28 million tonnes (approximately 48% reduction).

3.4.2 This downward trend is mainly driven by EU and UK sustainable waste management policy promoting the reduction and reuse of waste, increasing recycling and energy recovery and thereby reducing the quantity of biodegradable municipal waste being disposed of to landfill.

3.4.3 There has been a significant increase in the provision of alternative waste treatment infrastructure (e.g. materials recovery facilities, composting and anaerobic digestion plants and waste to energy facilities) to enable the diversion of waste away from landfill.

Figure 2: Non-hazardous landfill capacity and inputs in England/North West region (2004 to 2019)



[13] Environment Agency (2019), *Waste Management 2019 in England: Data Tables.* Available online at: https://data.gov.uk/dataset/d409b2ba-796c-4436-82c7-eb1831a9ef25/2019-waste-data-interrogator.

3.5 Non-hazardous landfill significance criteria

3.5.1 The significance criteria in Table 3 have been developed for non-hazardous waste landfill as part of the EIA SMR for the Proposed Scheme. They are relevant for non-hazardous waste, which will arise from the construction and operation of the Proposed Scheme.

Table 3: Non-hazardous landfill significance criteria

Degree of significance	Non-hazardous landfill criteria
Major adverse	Net increase in waste arisings relative to the future baseline without the Proposed Scheme leading to a severe national and regional-scale reduction in landfill void space capacity for non-hazardous waste. Need for additional large-scale waste treatment and/or disposal capacity of greater than 250,000 tonnes per annum. Effect may be judged to be of importance in the regional planning context and, therefore, of potential concern to a project depending upon the importance attached to the issue in decision-making.
Moderate adverse	Net increase in waste arisings relative to the future baseline without the Proposed Scheme leading to regional-scale reduction in landfill void space capacity for non-hazardous waste. Need for additional medium-scale waste treatment and/or disposal capacity of between 50,000 to 250,000 tonnes per annum. Effect may be judged to be important in the local planning context, e.g. where effects are permanent or long-term and the effect on local waste treatment and disposal infrastructure is such that additional capacity may be required.
Minor adverse	Net increase in waste arisings relative to the future baseline without the Proposed Scheme leading to local-scale reduction in landfill void space capacity for non-hazardous waste. Need for additional small scale waste treatment and/or disposal capacity of up to 50,000 tonnes per annum. Effect is of low importance in the decision-making process but may be of relevance to the detailed design and mitigation of a project.
Negligible	No significant increase in waste arisings relative to the future baseline without the Proposed Scheme or reduction in landfill void space capacity for non-hazardous waste. No appreciable adverse or beneficial effects.
Beneficial	Net reduction in waste arisings and diversion of waste from landfill relative to the future baseline without the Proposed Scheme resulting in an environmental improvement. Positive effect on waste arisings overall and available capacity of waste treatment and disposal infrastructure.

3.5.2 For minor adverse environmental effects, the upper threshold value has been set as 50,000 tonnes per annum. This threshold value has been selected with reference to the DCLG Planning Practice Guidance: environmental impact assessment. The Indicative screening thresholds Annex, containing information on the indicative screening thresholds and criteria for identification of Schedule 2 development requiring EIA and indicative values for determining significant effects, states that an EIA for installations for the disposal of waste is more likely to be required where new capacity is created to hold more than 50,000 tonnes per year.

3.5.3 The threshold values for moderate and major adverse environmental effects have been based on professional judgement. These are extrapolations of the threshold value for minor adverse environmental effects, based on an incremental increase of the total non-hazardous waste quantity to be disposed of by applying a factor of up to five to define the moderate adverse environmental effects upper threshold value (i.e. 50,000 to 250,000 tonnes per annum), and by applying a factor of five to define the major adverse environmental effects threshold value (i.e. greater than 250,000 tonnes per annum).

3.5.4 The disposal of 250,000 tonnes of non-hazardous waste represents approximately 1.22% of the total non-hazardous landfill capacity in the North West region, and approximately 0.13% of non-hazardous landfill capacity in England based on the 2019 non-hazardous landfill capacity data from the Environment Agency[14]. Non-hazardous waste generated by the Proposed Scheme will arise during the thirteen-year construction period (2025 to 2038), and also during the operational period starting in 2039.

3.5.5 Construction of the Proposed Scheme would start with enabling works followed by the earthworks such as tunnelling etc. Any non-hazardous waste generated during the construction period of the Proposed Scheme would not occur all in a single year, which will reduce the pressure on non-hazardous landfill capacity.

[14] Environment Agency (2019), *Waste Management 2019 in England: Data Tables.* Available online at: https://data.gov.uk/dataset/d409b2ba-796c-4436-82c7-eb1831a9ef25/2019-waste-data-interrogator.

4 Rationale for hazardous landfill significance criteria

4.1 General

4.1.1 This section of the technical note sets out the rationale for the development of the significance criteria for the disposal of hazardous waste to be used in the assessment of the significance of environmental effects associated with the disposal of hazardous waste arising from the Proposed Scheme.

4.1.2 In determining the quantity of hazardous waste, the designers of the Proposed Scheme have considered both the treatment of the hazardous waste on and off-site to reduce its hazardousness and, the potential for moving waste management up the waste hierarchy.

4.1.3 Hazardous waste, covered by this technical note, comprises contaminated soils (i.e. unacceptable material Class U2)[15], which cannot be remediated on- or off-site, and therefore are unacceptable for reuse within the engineering or environmental mitigation earthworks of the Proposed Scheme. It also covers hazardous waste generated from demolition works associated with the construction of the Proposed Scheme. However, it does not include, for example, radioactive contaminated land containing dangerous substances etc., which would be disposed of at an appropriately authorised facility.

4.2 Hazardous waste legislative guidance

4.2.1 The WFD provides a European-wide definition of hazardous waste. Hazardous waste is defined as a waste possessing one or more of the 15 hazardous properties set out in Annex III of the WFD.

4.2.2 The WFD also classifies and identifies wastes in the EWC, which are considered to be hazardous because of the hazardous properties set out in Annex III of the WFD.

4.2.3 The Hazardous Waste (England and Wales) Regulations 2005 (as amended)[16] set out the regime for the control and tracking of the movement of hazardous waste for the purpose of implementing the EU Hazardous Waste Directive 91/689/EC[17].

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[15] Department for Transport (2009), *Highways Agency, Manual of Contract Documents for Highway Works, Volume 1 – Specification for Highway Works, Series 600 Earthworks*. Available online at: http://www.standardsforhighways.co.uk/ha/standards/mchw/vol1/pdfs/600.pdf

[16] *The Hazardous Waste (England and Wales) Regulations 2005.* (SI 2005 No. 894), Her Majesty's Stationery Office, London.

[17] *Directive 91/689/EEC on hazardous waste 1991*. Strasbourg, European Parliament and European Council.

4.2.4 The Environment Agency Technical Guidance WM3 'Waste Classification: Guidance on the Classification and Assessment of Waste'[18], provides a definition for hazardous waste as per the WFD. The technical guidance also provides a waste assessment methodology and guidance on waste classification using the European List of Waste (Commission Decision 2000/532/EC)[19].

4.3 National Policy Statement for hazardous waste

4.3.1 The Department for Environment, Food and Rural Affairs (Defra) National Policy Statement (NPS) for Hazardous Waste[20] provides planning policy in relation to nationally significant hazardous waste infrastructure. The capacity threshold[21] stated in the NPS for hazardous waste landfill is 100,000 tonnes per annum, which in turn reflects the threshold set out in s.30 of the Planning Act 2008[22]. This threshold is based on total weight of waste and not just on the weight of any hazardous components.

4.4 Other major infrastructure projects

4.4.1 As stated in Section 2 of this technical note the London 2012 Olympic Park is constructed on land previously used by a variety of industries, which left a legacy of soil and groundwater contamination. The ODA used in-situ and ex-situ soil cleaning techniques to enable the reuse of 80% of contaminated soil, thereby reducing the quantity of hazardous waste that required landfill disposal.

4.5 Hazardous waste management infrastructure

4.5.1 In 2019, a total of 5,542,581 tonnes of hazardous waste was sent for treatment/disposal in England of which 868,029 tonnes was landfilled (i.e. 16%). Of this total, 323,368 tonnes (i.e. 37%) comprised construction and demolition waste (including asbestos and excavated soils

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[18] Environment Agency (2015), *Waste Classification - Guidance on the classification and assessment of waste - Technical Guidance.* Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427077/LIT_10121.pdf.

[19] European Commission (2000), European List of Waste (Commission Decision 2000/532/EC); http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000D0532:20020101:EN:PDF; Accessed 14 June 2017.

[20] Department for Environment, Food and Rural Affairs (2013), *National Policy Statement for Hazardous Waste: A Framework Document for Planning Decisions on Nationally Significant Hazardous Waste Infrastructure.* Available online at: https://www.gov.uk/government/publications/hazardous-waste-national-policy-statement

[21] This is the capacity threshold at which the construction of new hazardous waste landfill disposal capacity becomes nationally significant.

[22] *Planning Act 2008* (c.29). Her Majesty's Stationery Office, London. Available online at: https://www.legislation.gov.uk/ukpga/2008/29/pdfs/ukpga_20080029_en.pdf.

from contaminated sites). Environment Agency hazardous waste data for England for the period 2006 to 2019 is shown in Table 4.

4.5.2 The European List of Waste (Commission Decision 2000/532/EC) includes Chapter 17 'Construction and Demolition Waste (including excavated soils from contaminated sites)'. The nature of the Proposed Scheme suggests that the majority of hazardous waste for disposal will be construction and demolition waste, and excavated soils from contaminated sites.

Table 4: Construction and demolition waste (including excavated soils from contaminated sites) to hazardous landfill for England[23]

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Million Tonnes	0.64	0.64	0.77	0.37	0.33	0.73	0.52	0.35	0.51	0.53	0.37	0.38	0.36	0.32
As % of total hazardous waste inputs	89%	114%[24]	84%	68%	62%	91%	67%	51%	78%	69%	68%	72%	61%	36%

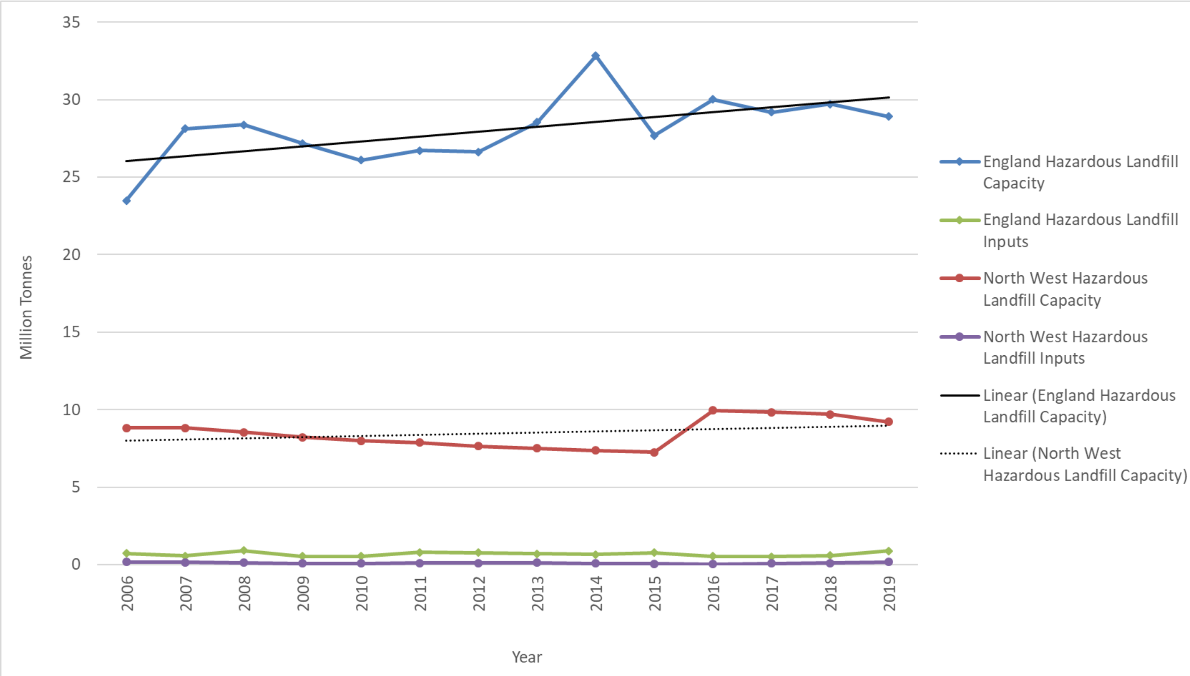
4.5.3 There are a number of off-site soil treatment centres in England for the treatment of contaminated soils to enable subsequent reuse. There are also on-site treatment technologies available depending on the nature of the soil contamination.

4.5.4 Data published by the Environment Agency for the period 2006 to 2019, set out in Figure 3, shows a slightly upward trend of hazardous waste landfill capacity in England (indicated by the linear trend line) with about 23 million tonnes in 2006 increasing to almost 29 million tonnes in 2019.

[23] Environment Agency (2019), *Waste Management 2019 in England: Data Tables.* Available online at: https://data.gov.uk/dataset/d409b2ba-796c-4436-82c7-eb1831a9ef25/2019-waste-data-interrogator.

[24] Assumes difference sent to non-hazardous SNRHW landfill – see Section 2.4.

Figure 3: Hazardous landfill capacity and inputs in England/North West region (2006 to 2019)



4.5.5 The hazardous waste landfill capacity data for the North West region indicates an overall slight upward trend (indicated by the linear trend line) from just over 8.8 million tonnes in 2006 to just over 9.2 million tonnes in 2019 (see Figure 3).

4.6 Hazardous landfill significance criteria

4.6.1 The significance criteria in Table 5 have been developed for hazardous waste landfill as part of the EIA SMR for the Proposed Scheme. They are relevant for hazardous waste, which will arise from the construction of the Proposed Scheme associated with demolition, and the excavation of contaminated land.

Table 5: Hazardous landfill significance criteria

Degree of significance	Hazardous landfill criteria
Major adverse	Net increase in waste arisings relative to the future baseline leading to a severe national and regional-scale reduction in hazardous waste landfill void space capacity. Need for additional large-scale hazardous waste disposal capacity of greater than 100,000 tonnes per annum[25]. Effect may be judged to be of importance in the regional planning context and, therefore, of potential concern to a project depending upon the importance attached to the issue in the decision-making process.

[25] Figure is threshold value given in s.30 Planning Act 2008 and referenced in National Policy Statement for Hazardous Waste.

Degree of significance	Hazardous landfill criteria
Moderate adverse	Net increase in waste arisings relative to the future baseline leading to regional-scale reduction in hazardous waste landfill void space capacity or need for additional medium-scale hazardous waste disposal capacity of between 20,000 to 100,000 tonnes per annum. Effect may be judged to be important in the local planning context, e.g. where effects are permanent or long-term and the effect on local waste treatment and disposal infrastructure is such that additional capacity may be required.
Minor adverse	Net increase in waste arisings relative to the future baseline leading to local-scale reduction in hazardous waste landfill void space capacity or need for additional small scale hazardous waste disposal capacity of up 20,000 tonnes per annum. Effect is of low importance in the decision-making process but may be of relevance to the detailed design and mitigation of a project.
Negligible	No significant increase in waste arisings relative to the future baseline or reduction in landfill void space capacity. No appreciable adverse or beneficial effects.
Beneficial	Net reduction in hazardous waste arisings and diversion of waste from landfill relative to the future baseline resulting in an environmental improvement. Positive effect on waste arisings overall and available capacity of hazardous waste treatment and disposal infrastructure.

4.6.2 The threshold value of 100,000 tonnes per annum has been chosen for major adverse environmental effects based on the nationally significant hazardous waste infrastructure threshold given in the NPS for Hazardous Waste.

4.6.3 The disposal of 100,000 tonnes of hazardous waste would represent about 0.3% of the hazardous landfill capacity in England and about 1.1% of the North West regional capacity, based on data published by the Environment Agency for 2019[26].

4.6.4 The threshold values for minor and moderate adverse environmental effects have been based on professional judgement. These are extrapolations of the threshold value for major adverse environmental effects based on an incremental decrease of the total hazardous waste quantity to be disposed of using a reduction factor of up to five to define the upper threshold value for moderate environmental adverse effects of 100,000 tonnes per annum, and a reduction of five to define the upper threshold value for minor environmental adverse effects of 20,000 tonnes per annum.

4.6.5 The NPS for Hazardous Waste includes a nationally significant infrastructure threshold for treatment capacity of hazardous waste, of 30,000 tonnes per annum. The extrapolation approach is used, not least to be consistent with the other landfill types.

4.6.6 Landfill capacity classified for non-hazardous waste may be used to dispose of stable non-reactive hazardous waste (SNRHW) providing such disposal does not occur in the same landfill cell as non-hazardous waste. In addition, the SNRHW must exhibit leaching behaviour equivalent to non-hazardous waste. In practice, this restricts the disposal of hazardous wastes to non-hazardous landfill to material such as asbestos waste (e.g. asbestos cement board). Environment Agency landfill data does not quantify the amounts of hazardous waste

[26] Environment Agency (2019), Waste Management 2019 in England: Data Tables. Available online at: https://data.gov.uk/dataset/d409b2ba-796c-4436-82c7-eb1831a9ef25/2019-waste-data-interrogator.

sent to non-hazardous SNRHW landfill but does state it is usually a small part of the overall capacity of the site.

4.6.7 The Proposed Scheme would be constructed over a period of thirteen years (i.e. 2025 to 2038) starting with enabling works followed by the earthworks such as tunnelling etc. Any hazardous waste generated by the Proposed Scheme would not occur all in a single year, which will reduce the pressure on hazardous landfill capacity.

Appendix A: EIA Guidance

The DCLG, Planning Practice Guidance: Environmental Impact Assessment provides the indicative screening criteria and thresholds set out in Table A 1, for installations for the disposal of non-hazardous waste and inert waste.

Table A 1: Thresholds and Criteria for the identification of Schedule 2 development requiring Environmental Impact Assessment and indicative values for determining significant effects

Development type	Schedule 2 criteria and thresholds	Indicative criteria and threshold	Key issues to consider
(b) Installations for the disposal of waste (unless included in Schedule 1)	(i) The disposal is by incineration; or (ii) the area of the development exceeds 0.5 hectare; or (iii) the installation is to be sited within 100 metres of any controlled waters.	Installations (including landfill sites) for the deposit, recovery and/or disposal of household, industrial and/or commercial wastes where new capacity is created to hold more than 50,000 tonnes per year, or to hold waste on a site of 10 hectares or more. Sites taking smaller quantities of these wastes, sites seeking only to accept inert wastes (demolition rubble etc.) or Civic Amenity sites, are unlikely to require Environmental Impact Assessment.	Scale of the development and the nature of the potential impact in terms of discharges, emissions or odour.

Annex M – Technical notes: Water resources and flood risk

The following technical notes are contained in this annex:

- Water resources and flood risk – Water Framework Directive (WFD) compliance assessment process;
- Water resources and flood risk – Groundwater assessment method;
- Water resources and flood risk – Surface water quality assessment and spillage; and
- Water resources and flood risk – Flood risk.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Water resources and flood risk – Water Framework Directive (WFD) compliance assessment process

Contents

1 Introduction

1.1.1 This technical note has been prepared as guidance for the assessment of compliance with European Union Water Framework Directive (WFD) legislation[1]. This legislation was transcribed into law in England and Wales and is currently represented as the Water Resources (Water Framework Directive) (England and Wales) Regulations (2017)[2]. This technical note should be read in conjunction with the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR). It is intended as a guide to ensure a consistent approach is adopted across the Proposed Scheme. It is not an exhaustive and prescriptive methodology.

1.1.2 The WFD shall be considered from pre-hybrid Bill stage through to final detailed design and construction.

1.1.3 A WFD Compliance Assessment (referred to as a 'WFD Assessment') is required for the Proposed Scheme as agreed with the Environment Agency. This is to be prepared on a route-wide basis in general accordance with this guidance.

1.1.4 There is no established methodology for assessing compliance with WFD legislation. The WFD Assessment will be based largely on internal Environment Agency guidance[3], the prior experience of HS2 Ltd on Phase One and Phase 2a and professional judgement. The approach applied is also in general accordance with the advisory note provided by the Planning Inspectorate in relation to the requirements of the WFD as applicable to large infrastructure projects[4].

1.1.5 During Phase One and Phase 2a, workshops were held with the Environment Agency to agree the scope and approach to the WFD Assessment. This considered the latest guidance, including draft or unpublished internal Environment Agency guidance. The approach for the Proposed Scheme is consistent with the approaches applied on the previous phases. HS2 Ltd will continue to work with the Environment Agency on all phases, through outline and detailed design, construction and operation.

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[1] Water Framework Directive, *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Strasbourg, European Parliament and European Council.

2 Department of Environment, Food and Rural Affairs (2017), *Water Resources (Water Framework Directive) (England and Wales) Regulations (2017).*

[3] Environment Agency (2010), *Assessing new modifications for compliance with WFD: detailed supplementary guidance.*

[4] Planning Inspectorate (2017), *Advice Note 18, The Water Framework Directive.* Available online at: https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2017/06/advice_note_18.pdf.

1.1.6 The WFD classification data that will be assessed is taken from the Environment Agency Cycle 2 River Basin Management Plan (RBMP) annexes, published in 2015[5]. A subsequent update in 2019[6] to the data published in these RBMPs will also be used to inform the assessment.

1.1.7 Where baseline data are limited or unavailable, professional judgement will be used in the assessment and a precautionary approach will be adopted.

1.1.8 The WFD Assessments prepared for the Proposed Scheme are 'living' documents, which will be updated periodically to reflect the latest iteration of the design and assessment process.

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[5] Environment Agency (2016), *River basin management plans: 2015*. Available at: https://www.gov.uk/government/collections/river-basin-management-plans-2015.

[6] Environment Agency (2020), *Catchment Data Explorer*. Available online at: https://environment.data.gov.uk/catchment-planning/.

2 Overview of the WFD

2.1 Aims

2.1.1 The WFD aims to protect and enhance the quality of the water environment across all European Union (EU) Member States. It takes a holistic approach to the sustainable management of water by considering the interactions between surface water, groundwater and water-dependent ecosystems.

2.1.2 Under the WFD, 'water bodies' are the basic management units and are defined as all or part of a river system or aquifer. These water bodies form part of a larger 'River Basin District' (RBD), for which 'River Basin Management Plans' (RBMP) are developed by EU Member States and environmental objectives are set. These RBMP are produced every six years, in accordance with the river basin management planning cycle. The latest RBMP were produced in 2015, as an update to the first plans published in 2009. The plans set out the current status and status objectives of each water body, together with the pressures affecting the water environment and a programme of measures and actions needed to achieve the objectives.

2.1.3 The WFD requires all EU Member States to classify the current condition or 'status or potential' of surface water and groundwater bodies and to set a series of objectives for maintaining or improving conditions so that water bodies maintain or reach 'good status or potential'.

2.1.4 The WFD was transposed into law in England and Wales via the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (herein referred to as the WFD Regulations), with subsequent amendments in 2015, 2016, and 2017. As the WFD is fully transposed into UK law, it remains in place following Britain's exit from the EU in January 2021.

2.2 WFD requirements for new developments

2.2.1 To ensure compliance with the WFD, decision makers must consider whether proposals for new developments have the potential to:

- cause a deterioration of a water body from its current status or potential;
- prevent future attainment of good status or potential where not already achieved;
- impact on protected or priority species and habitats; and/or
- provide opportunities to improve the water environment.

2.2.2 A ruling by the European Union Court of Justice on 1 July 2015[7] has significant implications for projects that may impact water bodies, namely:

- consent for development must not be granted by an authorising authority - unless a derogation is granted - where the project may cause a deterioration in the status of a body of surface water or where it jeopardises the attainment of good ecological surface water status or of good ecological potential and good surface water chemical status by the date laid down in the WFD;
- that "deterioration of the status" of the relevant body of surface water includes a fall by one class of any element of the "quality elements" within the meaning of Annex V of the WFD even if the fall does not result in a fall of the classification of the body of surface water as a whole; and
- if the quality element is already in the lowest class, any deterioration of that element represents deterioration of status within the meaning of Article 4(1)(a)(i).

2.2.3 In the event that a proposed development does not fully mitigate the risks of deterioration occurring, or it prevents future attainment of good status or potential, then evidence would need to be provided to satisfy all the requirements of Regulation 19 of the WFD Regulations in order to be compliant, namely that:

- all practicable steps have been taken to mitigate the adverse impact on the status of the water body;
- the reasons for the modifications or alterations are specifically set out and explained in the RBMP;
- the reasons for the modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the WFD objectives are outweighed by the benefits of the new modifications or alterations to (among other things) sustainable development; and
- the beneficial objectives served by the modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

2.2.4 Thus with regard to the Proposed Scheme, if the hybrid Bill design and Environmental Statement (ES) cannot demonstrate that there will be no deterioration, then a derogation will need to be prepared under Regulation 19 to ensure that the Proposed Scheme is compliant under the WFD legislation and the Bill can proceed through Parliament. Further information that would be prepared through the design process may alleviate the need for a derogation on particular water bodies but will have to be prepared to ensure compliance can be attained.

[7] Case 461/13 Bund für – Umwelt Und Naturschutz Deutschland v Bundesrepublik Deutschland ("the Bund case") concerning the interpretation of Article 4(1)(a)(i) to (iii) of the Water Framework Directive 2000/60/EC ("WFD").

3 Determination of WFD status

3.1 Introduction

3.1.1 Surface water bodies and groundwater bodies are defined within WFD legislation. There are three types of surface water body, as follows:

- natural water bodies;
- heavily modified water bodies (HMWBs);
- artificial water bodies (AWBs).

3.1.2 The overall status of natural surface water bodies is determined on the basis of their ecological status and chemical status. The overall status of heavily modified and artificial water bodies is classified based on their ecological potential and chemical status. The overall status of groundwater bodies is determined on the basis of their quantitative status and chemical status.

3.1.3 Groundwater bodies are defined within WFD legislation as Groundwater Management Units (GWMU) and Water Resource Management Units (WRMU) and their status is determined on the basis of quantitative and chemical sub-elements.

3.1.4 The means by which these determinations are made for both surface water and groundwater bodies is described in this section.

3.2 Determination of the status of natural surface water bodies

Ecological status

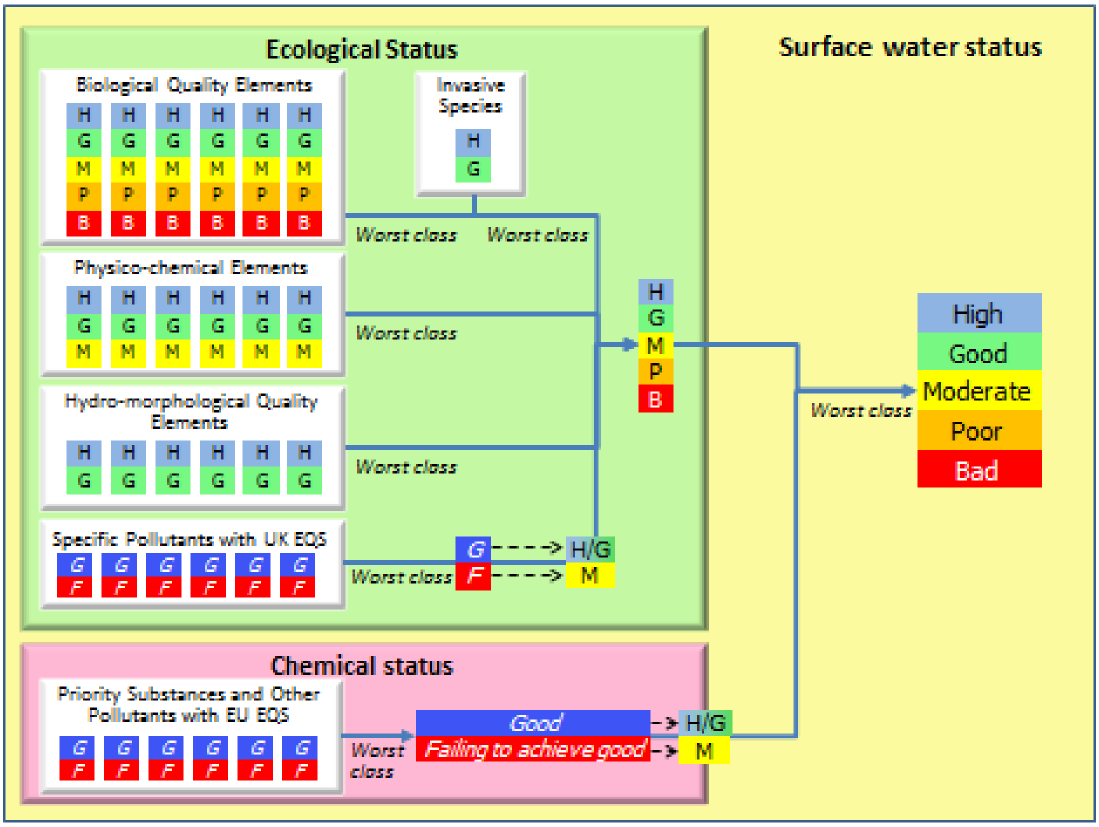
3.2.1 Ecological status is defined by the overall quality of the structure and functioning of aquatic ecosystems associated with surface waters, i.e. the condition of the watercourse. This is assigned on a scale of high, good, moderate, poor or bad, and on the basis of four classification elements or 'tests', as follows:

- biological - this test is designed to assess the status indicated by a biological quality element such as fish, invertebrates, macrophytes or phytobenthos (diatoms). The biological quality elements can influence an overall water body status from bad through to high. It is also important to note that the presence of invasive species prevents a water body from achieving high status when all other elements attain high;
- physico-chemical - this test is designed to assess the status indicated by physico-chemical quality elements such as dissolved oxygen, phosphorus and ammonia, against environmental standards. The physico-chemical quality elements can only influence an overall water body status from moderate through to high;

- specific pollutants - this test is designed to assess compliance with environmental standards for concentrations of specific pollutants, such as zinc, cypermethrin or arsenic. As with the physico-chemical test, the specific pollutant assessment can only influence an overall water body status from moderate through to high; and
- hydromorphology - for natural surface water bodies this test[8] is undertaken by the Environment Agency during classification when the biological and physico-chemical tests indicate that a water body may be of high status. It specifically assesses hydromorphological quality elements such as water flow, sediment composition and movement, continuity, and structure of the habitat against reference or 'largely undisturbed' conditions. If the hydromorphological quality elements do not support high ecological status, then the status of the water body is limited to good overall status. Hydromorphological assessments are used to determine 'high' overall ecological status only, and are not be used to drive a water body status class below good. The 'does not support good' classification should be reported for the purposes of identifying water bodies which fail the flow test.

3.2.2 The worst case classification is assigned as the overall surface water body status, in a 'one-out all-out' system. This system is summarised in Figure 1.

Figure 1: WFD classification elements for surface water body status



[8] Environment Agency (2015), *Rules for assessing Surface Water Body Status and Potential, Decision document for 2015 new building block (cycle 2) Water Framework Directive classifications (version 2.0)*.

Source: Environment Agency, (2015), *Rules for Assessing Surface Water Body Status and Potential*.

Chemical status

3.2.3 Chemical status is defined by compliance with environmental quality standards (EQS) for chemicals that are priority substances and/or priority hazardous substances, in accordance with the Environmental Quality Standards Directive (2008/105/EC)[9], and as amended by the Priority Substances Directive (2013/39/EU)[10]. These Directives have been transposed into UK Legislation via the 2018 Environmental Permitting Regulations[11] and the WFD Regulations, supported by the WFD (Standards and Classification) Directions (England and Wales) 2015[12]. Chemical status is assigned on a scale of good or fail.

3.2.4 The Priority Substances Directive (2013/39/EU) comprised amendments to the list of priority substances to be monitored via: the identification of new substances; the revision of the EQS for some existing substances; and setting biota EQS for some existing and newly identified priority substances. These amendments, put into effect from December 2018, resulted in the chemical status of all surface water bodies in England as failing within the 2019 classifications.

3.3 Determination of ecological potential for heavily modified (and artificial) water bodies

3.3.1 Ecological potential is assigned to AWB (such as reservoirs and canals), or natural water bodies which, as a result of physical alterations by human activity, are substantially changed in character. The latter are termed HMWB. The term 'ecological potential' is used to classify AWBs and HMWBs as it may be impossible for these water bodies to achieve good ecological status (GES) because of their creation or modification for a specific use, such as navigation, water supply or flood protection. The ecological potential of an AWB or HMWB represents the degree to which the quality of the water body approaches the optimum condition it could achieve given its artificial or heavily modified state.

3.3.2 AWB and HMWB are subject to an additional set of rules that need to be implemented prior to running the one-out-all-out process. These rules determine which biological quality elements should be used in the water body ecological potential classification. Under normal

[9] *Directive 2008/105/EC of the European Parliament and of the Council of 16 December on environmental quality standards in the field of water policy*. Strasbourg, European Parliament and European Council.

[10] *Directive 2013/39/EU of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy.* Strasbourg, European Parliament and European Council.

[11] *The Environmental Permitting (England and Wales) (Amendment) Regulations 2018.* Her Majesty's Stationary Office, London.

[12] *The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.*

circumstances, AWB and HMWB are classified according to an assessment of mitigation measures, which defines good ecological potential (GEP) in water bodies where all applicable mitigation is in place, and moderate ecological potential in water bodies where some or all relevant mitigation is missing. However, to prevent AWB and HMWB being incorrectly classified as good potential in situations where all mitigation is in place, but other pressures are causing an impact (e.g. nutrient enrichment or pollution from toxic substances), the methodology adopted in the UK additionally considers biological indicators providing they are not sensitive to the heavily modified nature of the water body.

3.3.3 AWB and HMWB hydromorphological elements are assessed using a three-stage process, firstly looking at flow, then mitigation measures and then biological quality elements.

3.3.4 Flow conditions are assessed initially on a fail or pass basis to determine which of the biological and physico-chemical quality elements should be used in the classification of ecological potential.

3.3.5 Where the flow conditions are unaffected by the physical modification (flow conditions pass), the water body potential is determined by the worst of either the mitigation measures assessment, or any element that is not sensitive to the modified nature of the water body.

3.3.6 Where the flow conditions are significantly impacted by the physical modification (flow conditions fail), the water body potential is determined by the worst of any of the mitigation measures assessments or the assessment of biological quality elements, physico-chemical quality elements or specific pollutants.

3.3.7 Where a water body is designated as artificial or heavily modified for water resources usage, either solely or jointly with other uses, the flow condition is assumed to be good (pass).

3.4 Determination of the status of groundwater bodies

3.4.1 Under the WFD, groundwater body status is classified on the basis of quantitative status and chemical status. The groundwater bodies are separated into GWMU and WRMU. GWMU are sub-divisions of the groundwater to aid the resource assessment process. WRMU are sub-divisions according to the water resource availability and the management of water.

Quantitative status

3.4.2 Quantitative status is defined by the quantity of groundwater available as base flow to watercourses and water-dependent ecosystems and as 'resource' available for use as drinking water and other consumptive purposes. It is assigned on a scale of good or poor, and on the basis of four classification elements or 'tests' as follows:

- saline or other intrusions - this test is designed to identify groundwater bodies where the intrusion of poor quality water, such as saline water or water of different chemical composition, as a result of groundwater abstraction is leading to sustained upward trends in pollutant concentrations or significant impacts on one or more groundwater abstractions;

- surface water - this test is designed to identify groundwater bodies where groundwater abstraction is leading to a significant diminution of the ecological status of associated surface water bodies;
- Groundwater Dependent Terrestrial Ecosystems (GWDTE) - this test is designed to identify groundwater bodies where groundwater abstraction is leading to significant damage[13] to associated GWDTE; and
- water balance - this test is designed to identify groundwater bodies where groundwater abstraction exceeds the 'available groundwater resource', defined as the rate of overall recharge to the groundwater body itself less the rate of flow required to meet the ecological needs of associated surface water bodies and GWDTE.

Chemical status

3.4.3 Chemical status is defined by the concentrations of a range of key pollutants, by the quality of groundwater feeding into watercourses and water-dependent ecosystems and by the quality of groundwater available for drinking water purposes. This is assigned on a scale of good or poor, and on the basis of five classifications elements or 'tests', as follows:

- saline or other intrusions – this test is designed to identify groundwater bodies where the intrusion of poor quality water, such as saline water or water of different chemical composition, as a result of groundwater abstraction is leading to sustained upward trends in pollutant concentrations or significant impact on one or more groundwater abstractions;
- surface water – this test is designed to identify groundwater bodies where groundwater is leading to a significant diminution of the chemical status of associated surface water bodies;
- GWDTE – this test is designed to identify groundwater bodies where groundwater is leading to significant damage[14] to associated GWDTE;
- Drinking Water Protected Areas (DrWPA) – this test is designed to identify groundwater bodies failing to meet the DrWPA objectives defined in Regulation 8 of the WFD Regulations or at risk of failing in the future. The aim is no deterioration in quality of waters for human consumption; and
- general quality assessment – this test is designed to identify groundwater bodies where widespread deterioration in quality has, or will, compromise the strategic use of groundwater. The aim is no significant impairment of human use of groundwater and no significant environmental risk from pollutants across a groundwater body. Status is

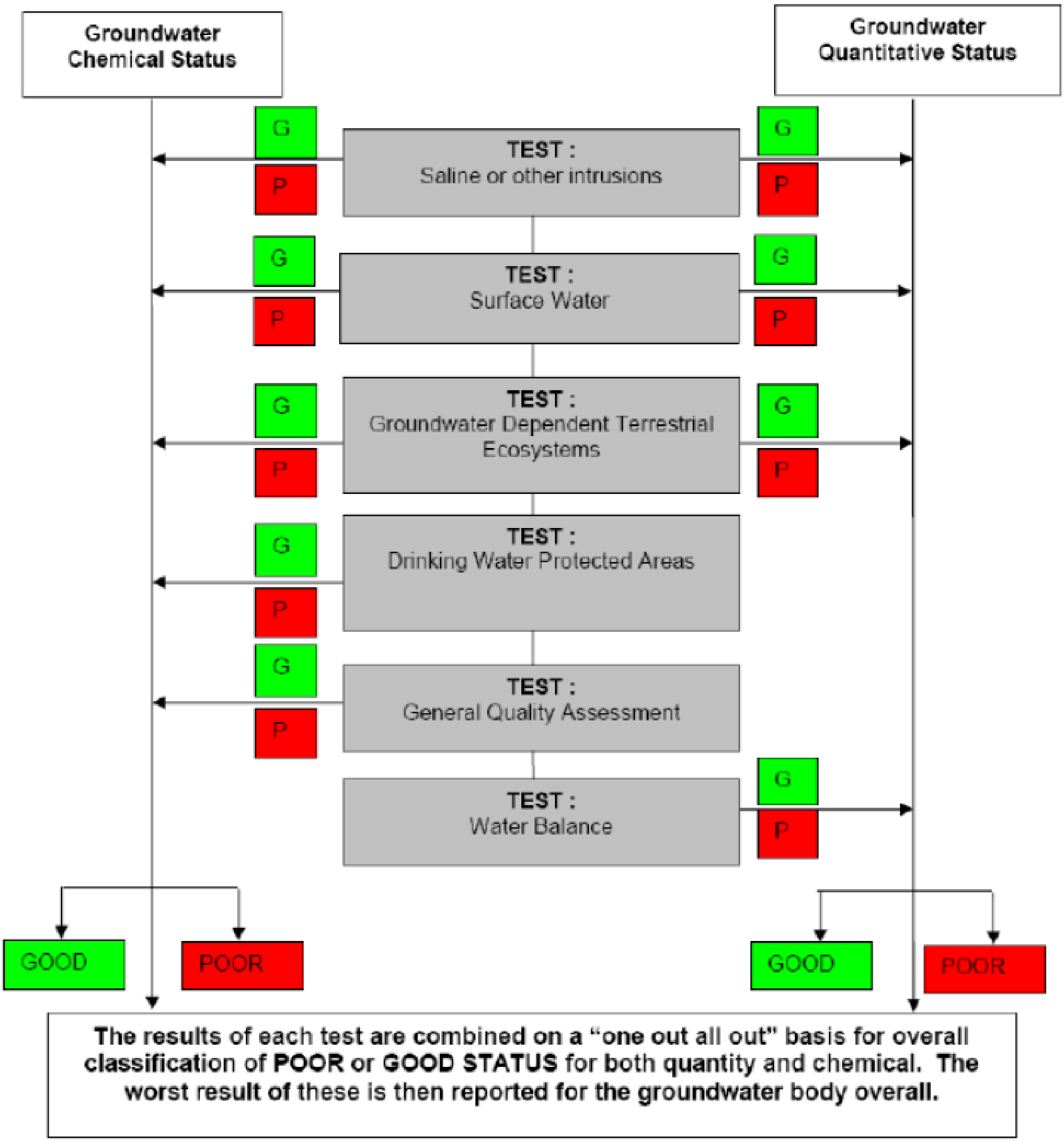
[13] As described in UKTAG (2012), *Paper 11b (ii) Groundwater Quantitative Classification for the purpose of the Water Framework Directive and the Groundwater Directive*.

[14] As described in UKTAG (2012), *Paper 11b(i) Groundwater Chemical Classification for the purpose of the Water Framework Directive and the Groundwater Directive*.

assessed primarily using data collected from the Environment Agency monitoring network; therefore, the scale of assessment means that groundwater status is mainly influenced by larger scale effects such as significant abstraction or widespread diffuse pollution.

3.4.4 The worst case classification is, as with surface water bodies, assigned as the overall groundwater body status, in a 'one-out all-out' system. This system is summarised below in Figure 2.

Figure 2: WFD classification elements for groundwater body status



Source: Environment Agency Groundwater Quantitative Status Assessment (Classification) Method Statement

4 Scope of assessment

4.1 Spatial and temporal scope

4.1.1 The spatial scope of the assessment includes all WFD designated surface water and groundwater bodies potentially affected by the Proposed Scheme.

4.1.2 The assessment will be undertaken at the water body scale (as designated under the WFD). For surface water bodies, the assessment considers all tributary watercourses that are affected by the Proposed Scheme. The assessment of impacts on fish will also include watercourses which are upstream tributaries of watercourses directly affected by the Proposed Scheme. This is in recognition of the migratory habits of fish and the potential presence of spawning habitats in the tributaries.

4.1.3 The assessment will include any interfaces with Phase One and Phase 2a of the Proposed Scheme, with regards to potential effects to surface water and groundwater bodies that extend across the study areas of Phase 2a and the Proposed Scheme.

4.1.4 Temporary impacts are not considered to result in deterioration in WFD status of the water body, if the water body:

- is only impacted for a short time period;
- recovers within a short time period; and/or
- recovers without the need for any restoration measures.

4.1.5 Accordingly, temporary impacts to water bodies associated with the construction phase of the Proposed Scheme are only included within the WFD Assessment where there is the potential for these to affect WFD status. The duration of the effect on WFD status is therefore considered, as opposed to the duration of the proposed activity.

4.2 Technical scope

Surface water

4.2.1 All ecological status sub-elements, including biological, physico-chemical, specific pollutants, or hydromorphological quality elements, have been included in the scope of the assessment.

4.2.2 Chemical status sub-elements, including priority substances, priority hazardous substances and other pollutants, have been included in the scope out of the assessment.

Groundwater

4.2.3 No quantitative status or chemical status sub-elements have been scoped out of the assessment.

4.3 Assumptions

4.3.1 Watercourses that are crossed by the Proposed Scheme which are not officially designated as WFD water bodies by the Environment Agency will be included in the assessment. It will be assumed that these water bodies have the same status objectives as the designated water body into which they flow. However, the measures proposed to mitigate any adverse impacts on these water bodies will aim to be appropriate to their local context.

4.3.2 Regulations 13 and 14 of the WFD Regulations include requirements to implement measures necessary to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater. The Groundwater (Water Framework Directive) (England) Direction 2016[15] complements the WFD Regulations and includes a requirement for measures to prevent or limit inputs of pollutants into groundwater so that WFD environmental objectives can be achieved.

4.3.3 Much of the mitigation incorporated into the design of the Proposed Scheme is aligned to the ‘prevent and limit’ objective. Compliance with this will not be explicitly assessed as part of the water body status assessment; however, it will be taken into account during the assessment of the General Quality Assessment WFD element, which considers the potential impacts of the Proposed Scheme on groundwater quality as a whole.

[15] Department of Environment, Food and Rural Affairs (2016), *Groundwater (Water Framework Directive) (England) Direction 2016.* Available online at: https://www.gov.uk/government/publications/the-groundwater-water-framework-directive-england-direction-2016.

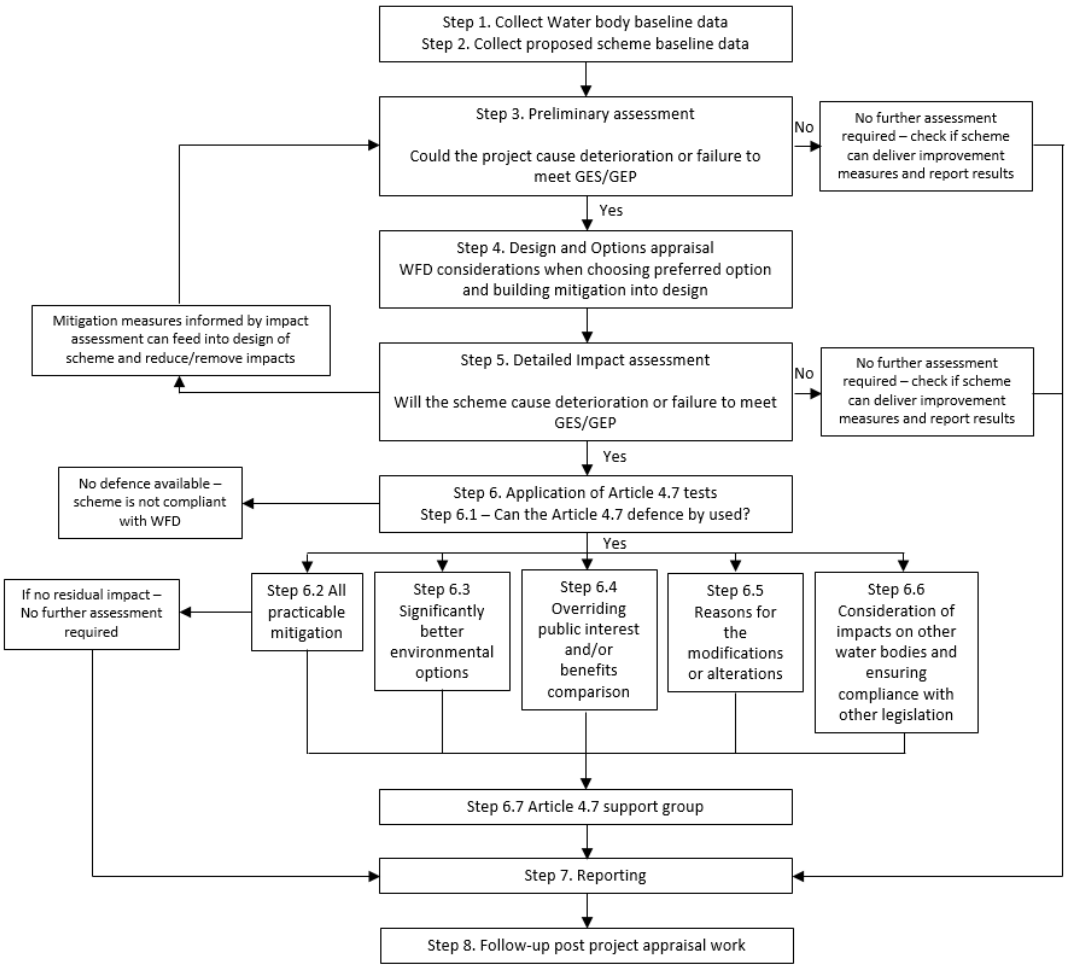
5 Process overview

5.1.1 The WFD assessment will be undertaken as a stepped process, which can be summarised in the following steps:

- **Step 1:** Collect water body baseline data;
- **Step 2:** Collect Proposed Scheme baseline data;
- **Step 3:** Preliminary assessment;
- **Step 4:** Design options appraisal and selection of preferred option;
- **Step 5:** Detailed impact assessment;
- **Step 6:** Application of Regulation 19 tests where applicable;
- **Step 7:** Reporting; and
- **Step 8:** Follow-up post-project appraisal work.

5.1.2 This process is illustrated in Figure 3.

Figure 3: Steps in the WFD assessment process



5.1.3 The assessment process is described in further detail in Appendix A of this technical note. There is no established methodology for assessing compliance with WFD legislation. The applied assessment process shown in Figure 3 has been agreed with the Environment Agency. This is based on available Environment Agency guidance, the prior experience of HS2 Ltd on Phase One and Phase 2a, and professional judgement.

5.1.4 The assessment approach is also in general alignment with the advisory note provided by the Planning Inspectorate[4]. Table 1 provides a summary of the assessment steps outlined by the advisory note, and the alignment with the corresponding process steps and key tasks applied by HS2 Ltd (as illustrated in Figure 3).

Table 1: Summary of WFD Assessment process steps outlined by 2017 Planning Inspectorate advisory note and alignment with assessment approach applied by HS2 Ltd

Planning Inspectorate Advisory Note – WFD Assessment Steps[4]	Corresponding WFD Assessment Steps applied by HS2 Ltd	Key tasks
Step 1: Screening	Step 1 & 2: Baseline Assessment (Water Body & scheme)	• Identify relevant water bodies (and watercourses) and their baseline status/condition. • Identify relevant components and 'zone of influence' of Proposed Scheme. • Share findings with Environment Agency and agree on conclusions.
Step 2: Scoping	Step 3: Preliminary Assessment	• Identify relevant impacts of Proposed Scheme and associated likely effects on WFD status elements of relevant water bodies. Identify those quality elements at risk from Proposed Scheme impacts, to be carried forward for detailed impact assessment. • Identify relevant existing pressures and programme of measures of relevant water bodies and associated likely effects from Proposed Scheme. Identify pressures and measures at risk from Proposed Scheme, to be carried forward for detailed impact assessment. • Share findings with Environment Agency and agree on conclusions.
Step 3: Detailed Impact Assessment	Step 5: Detailed Impact Assessment	• Describe methodology used to determine and quantify scale of WFD impacts on quality element status and associated risk of deterioration. • Assessment of effects of Proposed Scheme on status of quality elements of relevant water bodies,

Planning Inspectorate Advisory Note – WFD Assessment Steps[4]	Corresponding WFD Assessment Steps applied by HS2 Ltd	Key tasks
		and associated risk of deterioration. • Identification of any mitigation requirements and residual effects and risk of deterioration of status. • Conclusion on compliance of Proposed Scheme and any resultant Regulation 19 test requirements. • Identification of any enhancements delivered by the Proposed Scheme.

5.1.5 The WFD Assessment will be undertaken in liaison with the Environment Agency. This will involve undertaking a series of surface water and groundwater workshops to outline and agree upon the findings of the baseline assessment stage, as well as the provision of draft preliminary assessment and detailed impact assessment results for review by relevant Environment Agency area staff.

5.1.6 A detailed audit trail will be compiled to accompany the route-wide WFD Assessment report. This will catalogue all relevant water body and scheme baseline information, desk study and field survey findings, and the identification of all relevant Proposed Scheme components, impact types, and WFD quality elements requiring detailed impact assessment. The audit trail will also capture any enhancements embedded within the Proposed Scheme design, as well as any additional enhancement opportunities identified during the assessment process and in consultation with the Environment Agency and key stakeholders.

6 Reporting

6.1.1 The WFD Assessment will be a stand-alone route-wide report for each phase of the Proposed Scheme. The structure of the report will reflect the process outlined in Section 5, with detailed content as per Appendix A of this technical note.

6.1.2 The WFD Assessment will inform the content of the ES, as follows:

- where a non-compliance is identified as part of the WFD Assessment, it will be reported as a significant effect within the ES; and
- the WFD Assessment will identify additional mitigation requirements relating to effects on specific WFD quality elements of the relevant water bodies in order to prevent non-compliance with WFD objectives. The WFD Assessment will also inform the mitigation proposed in the ES.

Appendix A: Assessment process

1 Introduction

1.1.1 This appendix summarises the key steps involved in undertaking the WFD Assessment (as described in Section 5 of this technical note). This includes an overview of the scope, methodology and data requirements of each step.

2 Establishment of water body baseline

2.1 Overview

2.1.1 The baseline condition of the surface water and groundwater bodies potentially affected by the Proposed Scheme will be identified via a combination of desk-top assessment and, where possible (subject to access constraints), field surveys. This will include the assessment of the baseline ecological, hydromorphological, physico-chemical and hydrogeological condition of the water bodies affected.

2.2 Desk study

2.2.1 A desk-top exercise will be undertaken to collate and review readily available baseline environmental information and environmental, asset and operations data obtained from relevant stakeholders, such as the Environment Agency, Natural England and relevant water companies.

2.2.2 The WFD status and status objectives information for the relevant WFD water bodies will be derived based on Environment Agency data (Cycle 2 Water Body Status Classification data originally published in 2015, and updated in 2019[16,17]). These data are considered to provide the current best estimate of status and are the formal baseline against which the Environment Agency will assess compliance with the 'no deterioration' objective in 2020.

2.2.3 Available Environment Agency WFD monitoring data for the relevant WFD water bodies will be collated and reviewed in order to develop further understanding of the baseline condition of the water bodies and to inform the scoping of any additional baseline

[16] Environment Agency (2015a), *River Basin Management Plan Humber river basin district*. Available online at: https://www.gov.uk/government/collections/river-basin-management-plans-2015#humber-river-basin-district-rbmp:-2015.

[17] Environment Agency (2015b), *River Basin Management Plan North West river basin district.* Available online at: https://www.gov.uk/government/collections/river-basin-management-plans-2015#north-west-river-basin-district-rbmp:-2015.

monitoring surveys at key sites where existing monitoring data is limited/ absent (see Section 2.3 of this appendix for further details).

2.2.4 The baseline condition of the relevant water bodies will be further established using available datasets, such as (but not limited to) the following:

- Ordnance Survey (OS) mapping;
- historical OS mapping;
- aerial photography;
- LiDAR data (Environment Agency);
- digital river network (Environment Agency);
- river gauge data (National River Flow Archive (NRFA));
- river catchment characteristics (Flood Estimation Handbook (FEH));
- bedrock and superficial geology mapping (British Geological Survey (BGS));
- licensed and unlicensed groundwater abstractions information (not all unlicensed abstractions have to be recorded[18]);
- borehole water level and water quality monitoring data (Environment Agency); and
- statutory environmental designation information (Natural England).

Surface water (watercourses)

2.2.5 The assessment of the baseline condition of the relevant WFD surface water bodies will involve the identification and characterisation of all watercourses affected by the Proposed Scheme within each of the water body catchment areas. This will include detailing watercourse locations, lengths, catchment areas and general catchment characteristics (e.g. land use, geology, presence of environmental designations, etc.).

2.2.6 The baseline assessment will also include analysis of the low-flow (baseflow) characteristics of each of the affected watercourses. Low flows provide an area of continuously wetted habitat that helps to maintain ecological productivity with regard to populations of aquatic plants and animals[19]. For fish, this includes sufficient flow and sufficient water depth to facilitate spawning and egg and juvenile growth. In addition, the low-flow regime is important for maintaining physico-chemical water quality, including suitable water temperatures and dissolved oxygen concentrations.

2.2.7 Q95 flow value estimates (denoting the flow that is exceeded 95% of the time i.e. low flows) will be derived at the location where the Proposed Scheme intercepts the watercourse. On watercourses that are crossed by multiple Proposed Scheme components, the furthest

[18] *Private Water Supplies (England) Regulations 2016* (SI 2016 No. 618). London, Her Majesty's Stationary Office.
[19] UKTAG (2013), *River flow for good ecological potential, final recommendations, version 1.0.*

downstream point shall be used for the flow estimate calculation in order to ensure a conservative approach.

2.2.8 The watercourse catchment extent and area data used for deriving Q95 flow value estimates are attained using the FEH Web Service[20]. In cases where the catchment area of the watercourse is too small to be recognised by the FEH Web Service (generally catchments less than 0.5km^2), catchment extents will be manually digitised using Geographical Information System (GIS) software based on OS mapping contours and available LiDAR data. The catchment extents are inputted into LowFlows 2™ (2010)[21] software in GIS format, which uses hydrological estimation methods to predict flows within ungauged catchments. These methods have been developed by the Centre for Ecology and Hydrology (CEH) and the Environment Agency and provide annual and monthly flow duration statistics for the natural flow regime, including an estimate of Q95.

2.2.9 WFD biological status information and Environment Agency biological monitoring data (where available) will be utilised to assess the baseline biological condition of the surface water bodies and watercourses affected by the Proposed Scheme. Where available, additional existing data will also be utilised, including River Habitat Survey (RHS) and River Corridor Survey (RCS) data. The data from these surveys is not directly relevant to the WFD status assessment process, but may provide some indication of macrophyte cover and contextual information on habitat quality and the potential influence of other pressures within the catchment (such as damage to channel habitats from grazing, existing structures, shading etc.). They also contain information on the principal plant species present and their extent.

2.2.10 WFD physico-chemical and chemical status information and Environment Agency water quality monitoring data (where available) will be utilised to assess the baseline water quality condition of the surface water bodies and watercourses affected by the Proposed Scheme. Where required, data on surface water discharge consents and dilution or mass balance calculations for specific water bodies will be taken from the water resource appendices (contained in Volume 5 of the ES).

Groundwater

2.2.11 The assessment of the baseline condition of the relevant WFD groundwater bodies and associated groundwater dependent features (GWDTE, springs, etc.) will be based on information obtained from BGS and Environment Agency mapping.

2.2.12 There is typically limited site-specific groundwater level or quality data available. Groundwater data is generally obtained from boreholes. Although there are some boreholes

[20] Centre for Ecology and Hydrology (2017), *FEH Web Service*. Available online at: https://fehweb.ceh.ac.uk.

[21] LowFlows 2™ (2010), *Wallingford*: Wallingford HydroSolutions Limited.

along the route, none have been drilled for the Proposed Scheme. Where no baseline data is available, the groundwater body baseline assessment will apply a precautionary approach.

2.2.13 GWDTE will be identified from published databases of designated statutory and non-statutory sites in the study area as well as water-dependent ecological features identified in the ES. Spring features will be identified from issues labelled on the OS maps. Expert judgement will be used to identify GWDTE located beyond a 1km buffer from the route that may potentially be affected by the Propose Scheme.

2.2.14 Licensed and unlicensed groundwater abstractions details will be obtained from the Environment Agency and/or local authority, respectively.

2.3 Field survey

2.3.1 To supplement the desk study, baseline field surveys will be undertaken of the watercourses affected by the Proposed Scheme. These surveys will comprise reconnaissance site visits, followed by simplified RCS and fluvial geomorphological assessment surveys (dependent on accessibility and the nature of the sites being assessed).

2.3.2 Groundwater surveys will also be undertaken, involving: the identification and characterisation of groundwater features and potential groundwater-surface water interactions; the estimate of spring flows and measurement of basic groundwater quality parameters (e.g. water temperature, pH, etc.); and the recording of abstraction details.

2.3.3 Further details of the approach and methodology applied for surface water and groundwater baseline field survey are provided in the following sections.

Surface water

2.3.4 The surface water baseline field surveys will be undertaken by a minimum of one Fluvial Geomorphologist and one Aquatic Ecologist. These surveys will be undertaken following prescribed HS2 Ltd methodology for WFD data collection, involving the collection of detailed (quantitative) ecological and fluvial geomorphological information for reaches of a watercourse upstream and downstream of each route intersect (where access is possible).

2.3.5 The surface water baseline field surveys will involve two levels of assessment, depending on accessibility and the nature of the watercourse at each site. Each site will be subject to an initial reconnaissance survey. This process will involve the collection of reach-scale observations about the fluvial geomorphological characteristics and aquatic habitat potential of the watercourse at the site. These reconnaissance site visits will inform where more detailed surveys are required.

Reconnaissance survey

2.3.6 Reconnaissance surveys will comprise observational walkovers, undertaken by a minimum of one Fluvial Geomorphologist and one Aquatic Ecologist. This will include capture of geo-referenced photographs along the survey extent. Walkovers will aim to cover a minimum 200m reach (100m upstream and downstream of the route intersect with the watercourse), where access allows.

2.3.7 Data will be collected during the reconnaissance surveys using agreed survey proforma to provide a reach-scale fluvial geomorphological and aquatic habitat potential characterisation of the watercourse at the intersect site. The proforma will include a photograph log and be supplemented with GIS data layers highlighting the survey extents at each site and the location of survey photographs.

2.3.8 The watercourse characterisations developed from the reconnaissance surveys will be used to inform baseline definition within the WFD Assessment and the screening of requirements for further detailed fluvial geomorphological assessment survey and, where deemed necessary in relation to the availability of existing Environment Agency data, baseline WFD biological quality element surveys.

Fluvial Geomorphological Assessment surveys

2.3.9 Where reconnaissance surveys identify a requirement to collect further hydromorphological information at the site, a detailed fluvial geomorphological assessment survey of the watercourse will be undertaken.

2.3.10 Where access allows, fluvial geomorphological surveys will be undertaken along a minimum 200m reach (100m upstream and downstream of the route intersect with the watercourse) and, where possible, extended up to 2km upstream and downstream.

2.3.11 Watercourses will be broken into 'geomorphological reaches' based upon the dominant geomorphological characteristics and controls present along the channel. Geomorphological reaches are therefore distinguished based on key indicators of morphological change, including changes in bed and bank material, channel gradient, dominant processes, riparian character etc. as well as key controls on the system. Information concerning dominant flow types, erosion and depositional processes and forms, channel dimensions and bank composition will be collected for each geomorphological reach.

2.3.12 The characterisation of the watercourses into separate aquatic biotope (habitat) sub-reaches will also be undertaken. These sub-reaches are defined based on identification of different dominant flow types (e.g. riffles, runs, pools, etc.); which are important to the varied behavioural characteristics and habitat requirements of key target aquatic species at different stages of their life-cycles. Flow types are predominantly identified based on channel morphology and through observations of water depth and velocity.

2.3.13 The surveys will also include capture of geo-referenced photographs of the river channel, riparian zone and surrounding floodplain along the survey extent.

2.3.14 The survey data will be collected in alignment with agreed HS2 Ltd survey specifications and will be digitised and geo-referenced using ArcGIS software. Key datasets that will be collected during the survey included the following:

- geomorphological reach – broad characterisation and summary of key characteristics and dominant processes;
- flow types – including: waterfall, cascade, chute, run, boil, riffle, glide, pool, ponded, backwater, marginal deadwater, undefinable micro-scale variation and dry channel;
- depositional features – including: bars (side bar, mid-channel bar, point bar, mature island), significant silty/sandy margins, berms and recent floodplain/bank-top deposits;
- bank erosion – including: fluvial, geotechnical, sub-aerial, eroding cliff, tree scour, poaching, burrowing, and footpath;
- sediment input sources – including: tributary, hill-slope coupling, runoff from track, runoff from gate, and wider catchment sediment pathways;
- in-stream structures – including: weirs, dams, culverts, sluices, bridges, pipe crossings, fords, flow deflectors and large woody debris dams);
- evidence of sediment management, bank modifications and channel modifications – including: realignments, bank protection, embankments, set-back embankments and dredging/sediment removal);
- channel shading – estimated % of tree canopy/structure cover;
- riparian vegetation typology;
- invasive species (flora) – including: Giant Hogweed, Japanese Knotweed, Himalayan Balsam and Rhododendron;
- estimated bank-full width and depth cross-sections;
- estimated wetted channel width and depth cross-sections; and
- photographs.

Simplified River Corridor Surveys

2.3.15 Where reconnaissance surveys identify a requirement to collect further aquatic ecology information simplified RCS will be undertaken. These surveys will involve the ecological mapping of the watercourse at the intersect site, highlighting key channel features and habitat characteristics. This will include the assessment of the suitability of aquatic habitat for supporting WFD biological quality elements within the affected watercourse at the location of the Proposed Scheme and upstream.

2.3.16 The survey data will be collected using agreed survey proforma and base maps. The surveys will involve the capture of geo-referenced photographs of key features identified along the survey extent. Proforma will be supplemented with GIS data layers highlighting the survey extents at each site and the location of survey photographs.

2.3.17 Aquatic ecological surveys will also be used to inform the scoping of requirements for any additional, targeted WFD biological baseline monitoring (including fish surveys, aquatic invertebrate and phytobenthos sampling, and macrophyte surveys) on watercourses affected by the Proposed Scheme. This is described further in the next sub-section.

Biological Quality Element surveys

2.3.18 Where no Environment Agency baseline monitoring data is available for a WFD surface water body affected by the Proposed Scheme, and desk study and/or field survey information suggests aquatic habitat potential at the location of the Proposed Scheme, WFD biological quality element surveys will be undertaken to inform the WFD Assessment and the ES. Biological quality element surveys will be undertaken using a methodology compliant with Environment Agency WFD standard practices and will include (where appropriate and access allows):

- fish[22];
- macroinvertebrates[23];
- macrophytes[24]; and
- phytobenthos (diatoms) [25].

2.3.19 The biological quality elements survey data will be collected using agreed survey proforma.

Fish

2.3.20 The fish baseline survey data will provide species diversity and abundance information and include reference to species protected under the Salmon and Freshwater Fisheries Act 1975[26] and EU Freshwater Fish Directive (FFD)[27]. The operative provision of the Freshwater Fish Directive has been taken over into the WFD, allowing the FFD to be repealed.

Macroinvertebrates

2.3.21 The macroinvertebrate baseline survey data is used to produce biological indices, including Whalley Hawkes Paisley Trigg (WHPT), Average Score Per Taxon (ASPT), Lotic-invertebrate Index for Flow Evaluation (LIFE), and classification scores using the River Invertebrate Classification Tool (RICT).

[22] British Standards Institution (2003*), EN 14011: 2003 Water Quality Sampling of Fish with Electricity.*

[23] Environment Agency (2009), *Freshwater macro-invertebrate sampling in rivers*, Operational instruction 018_08; see also UKTAG, (2014), *River Assessment Method, Benthic Invertebrate Fauna, Invertebrates (General Degradation): Whalley, Hawkes, Paisley & Trigg (WHPT) metric in River Invertebrate Classification Tool (RICT).*

[24] UKTAG (2014), *River Assessment Method, Macrophytes and Phytobenthos, Macrophytes* (River LEAFPACS2).

[25] UKTAG (2014), *River Assessment Method, Macrophytes and Phytobenthos, Phytobenthos – Diatoms for Assessing River and Lake Ecological Quality* (River DARLEQ2).

[26] *Salmon and Freshwater Fisheries Act 1975.* London, Her Majesty's Stationery Office.

[27] *Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life*. Strasbourg, European Parliament and European Council.

Macrophytes

2.3.22 The macrophyte baseline survey data is used to produce biological indices, including River Macrophyte Nutrient Index (RMNI), River Macrophyte Hydraulic Index (RMHI), number of macrophytes taxa (NTAXA), number of functional groups (NFG), and cover of green filamentous algae (ALG), and River LEAFPACS2 tool scores.

Phytobenthos (diatoms)

2.3.23 The phytobenthos baseline survey data is used to produce biological indices, including the Trophic Diatom Index (TDI), and Diatoms for Assessing River and Lake Ecological Quality (DARLEQ2) tool scores.

Groundwater

2.3.24 The groundwater body baseline surveys will be undertaken by a minimum of one Hydrogeologist and one Aquatic Ecologist. These surveys will be undertaken following prescribed HS2 Ltd methodology for WFD data collection, and using a standard proforma agreed with the Environment Agency.

2.3.25 The groundwater surveys will involve two levels of assessment, depending on accessibility and the nature of the groundwater feature at each site. Each site will be subject to an initial survey. This process will involve the collection of general observations and will inform where more detailed hydrogeological audits of any groundwater features are required.

2.3.26 The groundwater body baseline surveys will involve two different approaches, depending on the groundwater features surveyed.

2.3.27 For natural groundwater features, including springs and GWDTE, groundwater baseline surveys will involve walkover surveys of the groundwater feature and the surrounding site. This process will involve the recording of general observations about the hydrogeological and aquatic ecological condition of the site.

2.3.28 For licensed and unlicensed abstraction sites, walkover surveys will be undertaken to collect details about the abstraction (including, where possible, undertaking discussions with the owner).

2.3.29 These approaches are described in further detail in the following sections.

Springs and GWDTE walkover surveys

2.3.30 Baseline walkover surveys for potential springs and GWDTE will involve the collection of hydrogeological and ecological information for key groundwater features in the vicinity of the Proposed Scheme (typically within 1km and where access allows). This will include an assessment of groundwater-surface water interactions and field estimates of spring flows and basic groundwater quality (e.g. water temperature, pH, and electrical conductivity).

2.3.31 Key hydrogeological information and datasets to be collected during the survey include the following:

- nature of water feature;
- water quality – including: appearance, pH, electrical conductivity and temperature;
- flow estimate;
- hydraulic connectivity to other water features;
- dependency of wetland ecology on groundwater;
- future monitoring recommendations – including: water level monitoring and flow monitoring; and
- photographs of all water features assessed.

2.3.32 Key ecological information and datasets to be collected during the survey include the following:

- groundwater-dependant habitat extent, composition and structure;
- vegetation composition – including: positive indicator species; indicators of negative change (undesirable non-woody plant species) and indicators of negative change (undesirable woody plant species);
- indicators of local distinctiveness;
- future monitoring recommendations; and
- photographs of all water features assessed.

2.3.33 The need for further hydrogeological surveys will be identified, including the determination of suitable locations for long-term monitoring installations such as staff gauges, transducers or weirs.

2.3.34 The ecologist will also highlight any ecological issues that were apparent during the walkover, and scope any further ecological survey requirements.

Licensed and unlicensed groundwater abstraction walkover surveys

2.3.35 Baseline walkover surveys for licensed and unlicensed abstractions will involve the collection of relevant hydrogeological information (where access allows). Key information collected during the survey include the following:

- licence information (for licensed abstractions only) – including: licence holder, licence number and licensed quantity;
- abstraction type e.g. borehole, well, spring;
- well details – including: location, diameter, depth to base and datum;
- use;
- groundwater level information – including: aquifer, rest water level and pumped water level;

- pump type; and
- photographs of all features assessed.

2.4 Screening of watercourses

2.4.1 Following baseline desk study and reconnaissance field surveys, all watercourses affected by the Proposed Scheme will be categorised based on a range of criteria relating to the estimated baseflow, geomorphological condition, and aquatic habitat potential at the location of the Proposed Scheme. These categories are summarised in Table 2. The categories have been aligned with the water resource receptor value classes described in the EIA SMR[2] (see Section 21).

2.4.2 These categories will be used to inform the screening in or out of watercourses for further WFD impact and mitigation assessment. This screening assessment will be undertaken in consultation with the Environment Agency.

2.4.3 Mitigation included in the design will be derived as part of the design and construction methodology of the Proposed Scheme will be applied at all watercourses, regardless of their screening outcome.

Table 2: Categories used to support screening of watercourse sites in/out of detailed WFD impact and mitigation assessment

Cat.	Description	Criteria	EIA Receptor Value	Screening Outcome
1	No defined channel present at site	• No evidence of presence of surface water feature (no defined channel present or evidence of historical channel but is now in filled)	N/a	Screened out of WFD compliance assessment
2	Channel with no baseflow*/Minor Tributary	• Ordinary watercourse • Minor tributary (within WFD water body catchment). Artificially created drainage channel or small natural headwater or ephemeral channel. • Channel with little or no baseflow. Absence of flowing water for majority of year/limited connection to water table (potential to dry out). Shallow, ponded water present at times. • No regular fluvial geomorphological processes or features present. • Low potential to support freshwater fish, macroinvertebrate, and/or macrophyte communities. • Riparian zone typically impacted by land use/regular vegetation management.	Low	Screened out of WFD compliance detailed impact and mitigation assessment

Cat.	Description	Criteria	EIA Receptor Value	Screening Outcome
		• Low overall aquatic habitat and hydromorphological value.		
3	Channel with limited baseflow**/Moderate Tributary	• Ordinary watercourse • Moderate tributary (within WFD water body catchment). Artificially created drainage channel or small natural channel. • Channel with limited baseflow. Typically shallow low flows. • Non-definable morphological flow types, except in localised and isolated reaches. • Limited and discrete active fluvial geomorphological processes and features. • Limited potential to support freshwater fish, macroinvertebrate, and/or macrophyte communities. • Riparian zone may be impacted by land use/regular vegetation management in some cases. • Moderate overall aquatic habitat and hydromorphological value.	Moderate	Screened in for WFD compliance detailed impact and mitigation assessment
4a	"Modified' channel with permanent baseflow***/Primary Watercourse	• Main River or a significant Ordinary Watercourse. • WFD water body main river line.	High or Very High	Screened in for detailed WFD impact and mitigation assessment

Cat.	Description	Criteria	EIA Receptor Value	Screening Outcome
		• Modified natural channel with permanent baseflow. Likely designated as HMWB under WFD. • Definable flow types (but diversity impacted by modifications). • Active fluvial geomorphological processes and features (but functionality and diversity impacted by modifications). • Potential to support some freshwater fish, macroinvertebrate, and/or macrophyte communities (but habitat value impacted by modifications). • Riparian zone typically impacted by land use/regular vegetation management. • Aquatic habitat and hydromorphological potential (but currently restricted by modifications).		
4b	"Functioning' channel with permanent baseflow***/Primary Watercourse	• Main River or a significant Ordinary Watercourse. • WFD water body main river line. • Natural channel with permanent baseflow. • Definable flow types.	High or Very High	Screened in for detailed WFD impact and mitigation assessment

Cat.	Description	Criteria	EIA Receptor Value	Screening Outcome
		• Active fluvial geomorphological processes and features. • Potential to support some freshwater fish, macroinvertebrate, and/or macrophyte communities. • Riparian zone may be impacted by land use/regular vegetation management in some cases. • Good overall aquatic habitat and hydromorphological value.		
5	Canal	• Canal. Designated AWB under WFD.	High or Very High	Screened in for detailed WFD impact and mitigation assessment

* Sites typically assessed has having Q95 flow ≤0.002m^3/s

** Sites typically assessed has having Q95 flow >0.002m^3/s to ≤0.01m^3/s

*** Sites typically assessed has having Q95 flow >0.01m^3/s

3 Establishment of Proposed Scheme baseline

3.1 Overview

3.1.1 The baseline assessment will establish the key components of the Proposed Scheme design and their likely impacts to surface water and groundwater bodies. This will, in turn, be used to inform the subsequent preliminary assessment.

3.2 Proposed Scheme components

3.2.1 The CT-06 map series (which are presented in the ES) is the primary source of Proposed Scheme design information.

3.2.2 The assessment will include all Proposed Scheme components associated with the Proposed Scheme, which have the potential to permanently affect surface water and groundwater bodies, and therefore have the potential to impact on WFD status.

3.2.3 Proposed Scheme components will be detailed individually, with the exception of where certain Proposed Scheme components are combined as part of the proposed features (e.g. river diverted with associated removal of an existing culvert).

3.2.4 Establishment of the Proposed Scheme baseline will include the identification of all relevant mitigation included in the design within the Proposed Scheme design and construction methodology (see Section 5 of this appendix for further details).

3.3 Initial identification of potential impacts

3.3.1 The range of generic, direct impacts likely to be associated with the typical Proposed Scheme components are summarised in Table 3 and Table 4 for surface water and for groundwater, respectively.

3.3.2 The impact of other structures (such as earth bunds, material storage areas, temporary haulage routes, etc.) on water bodies within or adjacent to the route are also considered, where the associated impacts are expected to extend beyond three years (as described in the sections above).

Table 3: Identified impacts of Proposed Scheme components on surface water bodies

	Impact considered							
Proposed Scheme component	**Footprint**	**Shading**	**Drainage (changes in water quantity or quality due to discharge of surface water runoff to surface water body)**	**Changes to water body hydromorphology leading to changes in river processes and habitats upstream and downstream**	**Changes in flow velocity and volume due to dewatering**	**Changes in water quality due to discharge of groundwater to surface water body**	**Creation of new habitats**	**Settlement of ground leading to enhancement of fractures and increased vertical permeability where applicable**
Viaduct	✓	✓	✓	✓	X	X	X	X
Viaduct with footings in water body	✓	✓	✓	✓	X	X	X	X
Underbridge	X	✓	✓	X	X	X	X	X
Clear span bridge	X	✓	✓	X	X	X	X	X
Bridge with footings in water body	✓	✓	✓	✓	X	X	X	X
Aqueduct	✓	X	✓	✓	X	X	X	X
Culvert	✓	✓	✓	✓	X	X	X	X
Access road culvert	✓	✓	✓	✓	X	X	X	X
Highway realignment culvert	✓	✓	✓	✓	X	X	X	X
Drop inlet culvert	✓	✓	✓	✓	X	X	X	X
Extension of existing culvert	✓	✓	✓	✓	X	X	X	X
Daylighting of existing culvert	✓	✓	✓	✓	X	X	✓	X
Inverted Siphon	✓	✓	✓	✓	X	X	X	X
Highway drainage outfall	X	X	✓	✓	X	X	X	X
Diversion	✓	X	X	✓	X	X	X	X

	Impact considered							
Realignment	✓	X	X	✓	X	X	X	X
Flood embankment	✓	X	✓	✓	X	X	X	X
Embankment with sub-surface reinforcement	✓	X	X	✓	✓	✓	X	X
Retaining wall	✓	X	X	✓	✓	✓	X	X
Cutting	✓	X	✓	✓	✓	✓	X	X
Cutting with retaining structure	✓	X	✓	✓	✓	✓	X	X
Cut and cover tunnels	✓	X	✓	✓	✓	✓	X	X
Cut and cover tunnel with retaining structure	✓	X	✓	✓	✓	✓	X	X
Tunnel Portal	✓	X	✓	✓	✓	✓	X	X
Bored tunnel	✓	X	X	X	✓	✓	X	✓
Ground stabilisation	✓	X	X	✓	✓	✓	X	X
Station	✓	X	✓	X	X	X	X	X
Infrastructure maintenance base rail (IMB-R)	✓	X	✓	X	X	X	X	X
Rolling stock depot (RSD)	✓	X	✓	X	X	X	X	X
Borrow pit	✓	X	✓	✓	✓	✓	X	X

Table 4: Identified impacts of Proposed Scheme components on groundwater bodies

	Impact considered			
Proposed Scheme component	Lowering of groundwater levels and reduction in groundwater contributions to surface water bodies, GWDTE or groundwater abstractions by temporary dewatering/permanent groundwater control	Disturbing or mobilising existing poor quality groundwater by temporary dewatering or depressurisation and permanent groundwater control	Damming of groundwater flow and reduction in groundwater contributions	Creating or altering of pathways along which existing poor quality groundwater can migrate
Ground level components	X	X	X	X
Embankment	X	X	X	X
Embankment with subsurface reinforcement	✓	✓	✓	✓
Cutting	✓	✓	X	X
Retaining walls	✓	✓	✓	✓
Cutting with retaining structure	✓	✓	✓	✓
Stations/Depots	✓	✓	✓	✓
Bored tunnel	X	X	✓	✓
Tunnel portal	✓	✓	✓	✓
Vent shaft	✓	✓	✓	✓
Cut and cover tunnel	✓	✓	X	X
Cut and cover tunnel with retaining structure	✓	✓	✓	✓
Viaduct foundations	X	X	✓	✓
Overbridge foundations	X	X	✓	✓
Bridge foundations	X	X	✓	✓
Borrow pit	✓	✓	✓	✓
Ground stabilisation	X	X	✓	✓

4 Preliminary assessment

4.1 Overview

4.1.1 The objective of the preliminary assessment is to (following consideration of mitigation included in the design) establish the relevant impacts of the various Proposed Scheme components and the associated likely effects on the WFD status elements of the relevant surface water and groundwater bodies. Effects are considered with regard to the risk of the Proposed Scheme causing a deterioration in current status and/or a failure to achieve status objectives. Only those Proposed Scheme components that could result in deterioration or failures of this kind should then be taken forward for more detailed assessment.

4.1.2 The preliminary assessment therefore comprises two key parts, as follows:

- consideration of the likely effects of Proposed Scheme components on the current WFD status, including:
  - the scoping of the generic impacts of all identified Proposed Scheme components against the proposed mitigation included in the design, in order to identify residual impacts with the potential to affect WFD status; and
  - the identification of the relevant surface water and groundwater WFD status elements potentially affected by the residual impacts of each Proposed Scheme component.
- consideration of the likely effects of Proposed Scheme components on status objectives, including:
  - the scoping of all identified Proposed Scheme components against Environment Agency RBMP Cycle 2 surface water and groundwater body 'reasons for not achieving good' (RNAG) and 'programme of measures' (PoM) datasets, in order to identify where the Proposed Scheme poses a potential risk of worsening existing pressures responsible for status failures and/or adversely affecting or preventing the implementation of measures identified to address existing status failures; and
  - the scoping of all identified Proposed Scheme components against Environment Agency HMWB and AWB 'mitigation measure assessments' (MMA), in order to identify where the Proposed Scheme poses a potential risk of inhibiting the implementation of measures derived to mitigate the impacts of existing physical modifications and operational regimes to support the achievement of good ecological potential objectives.

4.1.3 These two parts of the preliminary assessment are described in further detail in the following sections.

4.2 Consideration of likely effects on current status

4.2.1 This part of the preliminary assessment stage relates to the 'no deterioration of current status' aspect of WFD compliance objectives.

4.2.2 The generic impacts of the various Proposed Scheme components identified during the baseline assessment stage will be scoped against the mitigation included in the design in order to identify residual impacts.

4.2.3 Both beneficial and adverse potential impacts of Proposed Scheme components will be considered. For instance, beneficial impacts for biological and hydromorphological quality elements are likely to arise primarily from river diversions and or realignments, which will be designed to incorporate buffer strips for potential riparian habitat improvements as well as channel morphological improvements where appropriate and reasonably practicable (e.g. the creation of aquatic habitat features such as pools, riffles, runs and marginal berms).

4.2.4 The likely effects of Proposed Scheme component impacts on the WFD status elements of relevant WFD surface water and groundwater bodies will then be identified. This includes identifying the anticipated nature (i.e. beneficial or adverse) and magnitude of the effect, utilising a traffic light rating system agreed with the Environment Agency (see Section 6 of this technical note for further details). As a result, the preliminary assessment identifies those WFD status elements requiring detailed impact assessment for each component.

4.2.5 For surface water bodies, the likely effects of Proposed Scheme components will be identified for each of the relevant surface water body WFD status elements, as follows:

- biological effects – considered in terms of likely change in composition and abundance of phytobenthos, macrophytes and macroinvertebrate communities and for fish on composition, abundance and age structure;
- physico-chemical effects – considered in terms of likely changes in the chemical composition of phosphate and ammonia and for physical changes which cause variations in dissolved oxygen and temperature;
- specific pollutant effects – considered in terms of likely changes in the chemical composition of specific pollutants (e.g. copper, triclosan, zinc, etc.); and
- hydromorphological effects – considered in terms of likely changes in the quantity and dynamics of flow, river continuity (including restrictions such as sluices and weirs), river depth and width variation, structure and substrate and structure of the riparian zone.

4.2.6 For groundwater bodies, the likely effects of Proposed Scheme components will be identified for each of the relevant groundwater body WFD status elements, as follows:

- quantitative effects – be considered in terms of the likely changes in groundwater levels, groundwater flows and the hydraulic regime, spring flows and rates of baseflow to surface waters; and
- chemical effects - considered in terms of the likely changes in chemical water quality.

4.3 Consideration of likely effects on status objectives

4.3.1 This part of the preliminary assessment stage relates to the 'no prevention of status objectives' aspect of WFD compliance objectives. The assessment includes only those water bodies affected by the Proposed Scheme that are currently failing to meet their good ecological status/potential or good quantitative status objectives (with regards to surface water and groundwater bodies, respectively).

4.3.2 Each of the Proposed Scheme components identified during the baseline assessment stage will be scoped against the WFD status elements of the relevant water bodies that are currently failing their good status objective under WFD. This includes the surface water management issues (SWMIs), activities and business sectors associated with each failure, as well as any measures derived to address failures (as defined within the Environment Agency RBMP Cycle 2 RNAG and PoM datasets, respectively).

4.3.3 In addition, the Proposed Scheme components will be scoped against all mitigation measures identified by the Environment Agency for any AWBs or HMWBs affected by the Proposed Scheme. These measures are required to be implemented in order for these water bodies to achieve their good ecological potential objectives (see main report, Section 3.3 of this technical note for details).

4.3.4 The preliminary assessment will consider whether the Proposed Scheme will worsen known cause of failures and/or prevent defined measures from being implemented effectively, for each of the relevant water bodies. A precautionary approach is taken, whereby any identification of a potential adverse effect is used to highlight the potential for the Proposed Scheme to prevent the status objective of the relevant water body from being obtained. Accordingly, the relevant cause of failure or measure is taken forward for more detailed assessment. Where no AWB or HMWB mitigation measures have been identified by the Environment Agency for a water body, it will be assumed that no further detailed assessment is required at this stage.

4.3.5 Where the RBMP measures refer to proposed future changes in regulation, research and development projects and awareness-raising campaigns, it will be assumed that such measures are insensitive to impact by the Proposed Scheme.

5 Design and options appraisal

5.1 Overview

5.1.1 The objectives of this step are to identify the options available that are most compatible with achieving WFD objectives and to develop the design of mitigation to reduce the risk of the Proposed Scheme causing a deterioration in the status of any one of the quality elements used to determine water body status.

5.1.2 An iterative design approach will be adopted, with WFD specialists involved with both:

- identifying which options are best aligned with WFD objectives, so that these considerations have appropriate weighting, relative to wider environmental issues such as heritage and community impact; and
- developing the design of the preferred option to help to mitigate the potentially adverse impacts on WFD water bodies.

5.1.3 Consequently, mitigation is embedded into the design and construction methodology of the Proposed Scheme, allowing the WFD detailed impact assessment to focus on any additional mitigation required (as described in Section 6 of this technical note).

5.2 Rationale

5.2.1 The Proposed Scheme will seek to avoid direct or indirect harm to landscape, water and ecological resources, to mitigate adverse impacts where necessary, and to enhance such resources where reasonably practicable.

5.2.2 Where potentially significant adverse environmental effects have been identified during the assessment process, developing appropriate mitigation will be an iterative part of the Proposed Scheme development following the hierarchy below:

- avoidance – incorporate measures to avoid the effect, for example, alternative design options or modifying the Proposed Scheme programme to avoid environmentally sensitive periods;
- reduction – incorporate measures to lessen the effect, for example, fencing off sensitive areas during construction and implementing a Code of Construction Practice (CoCP) to reduce the potential impacts from construction activities;
- remediation – as a form of mitigation, for example the re-provision of habitat to replace that lost to Proposed Scheme construction, or remediation such as the clean-up of contaminated soils; and
- compensation – to be considered in the context where mitigation at the affected location is not possible to avoid or reduce a significant effect, in which case offsetting measures should be considered at other locations.

5.2.3 The term 'enhancement' refers to providing measures over and above those needed to mitigate the adverse effect, and/or maximising the opportunity for beneficial effects from the Proposed Scheme.

5.2.4 Effects that remain after mitigation are referred to as "residual effects". Therefore, the key outcome of the assessment is the significance of the residual effects after mitigation or enhancement.

5.2.5 Where a Proposed Scheme element cannot be redesigned to avoid an adverse impact that would still result in a deterioration to a surface water and/or groundwater body element under the WFD, additional mitigation will be identified where reasonably practicable to avoid or minimise the impacts and ensure compliance with the WFD. Priority should be given to undertaking this within the Proposed Scheme's footprint on the same water body.

5.3 Design assumptions and mitigation included in the design

5.3.1 Mitigation has been embedded within the Proposed Scheme in order to minimise any effects on the water environment and to ensure that the Proposed Scheme is, where possible, inherently compliant with the objectives of the WFD for both surface water and groundwater bodies. This includes mitigation incorporated within the design, construction methodology and operational phase of the Proposed Scheme. This is described in the following sections.

Avoidance

5.3.2 The principal strategy adopted to limit the temporary and permanent effects of the Proposed Scheme is through avoidance of sensitive receptors wherever reasonably practicable. Where receptors cannot be avoided, mitigation will be incorporated where necessary to limit the potential effects.

5.3.3 The avoidance of sensitive receptors will reduce the risks associated with impacts on water resources and of the Proposed Scheme not complying with the requirements of the WFD. Examples of this avoidance strategy include:

- avoidance of channels and floodplain areas– where reasonably practicable, the route of the Proposed Scheme will avoid passing along river or stream valleys and their associated floodplains. Instead it will pass over larger watercourses on viaducts spanning the floodplain, with piers set back from the channel;
- avoidance, where reasonably practicable, of GWDTE, including natural springs that can play a key role in the hydrology and hydrogeology of such ecosystems; and
- avoidance, where reasonably practicable, of major public water supplies and smaller licensed and unlicensed abstractions of surface water and groundwater.

5.3.4 The presence of any unregistered private water supplies, their function and the means of protecting or if necessary replacing them would be discussed with any landowners potentially affected by the Proposed Scheme.

5.3.5 The temporary works shown on Map Series CT-05 in the Volume 2 Map Books (which are presented in the ES) will be informed by a detailed consideration of the water resources constraints and have sought to avoid sensitive features (such as those listed above) wherever reasonably practicable.

Design

5.3.6 Potential impacts to water bodies can often be addressed through the design process by including mitigation to help ensure compliance with the WFD.

5.3.7 The Proposed Scheme will, where it is reasonably practicable to do so, aim to eliminate or minimise adverse ecological impacts through avoiding ecological impacts at source.

5.3.8 Mitigation included in the design of relevant Proposed Scheme components will aim to reduce adverse effects to the water environment as far as is reasonably practicable. The included mitigation of relevance to the water environment for each of the groundwater and surface water scheme component types assessed is summarised in Table 5 and Table 6 respectively. Where there is potential for interaction between groundwater and surface water, arising as a result of groundwater scheme components, mitigation for the impacts of these scheme components on surface water is outlined in Table 5.

Table 5: Mitigation incorporated into the route alignment and design of groundwater scheme components

Groundwater scheme components	
Ground level	With regards to track drainage, where ground conditions are suitable, discharge to groundwater should be considered the first option – subject to consideration of pollution risk and the presence of any groundwater source protection zones. The second option is to discharge drainage to a surface water body, with the third option being to a sewer (surface water sewer before combined). This is in accordance with the hierarchy of drainage options[28].
Viaduct / overbridge/ bridge foundations	Where piling and penetrative procedures are to be used, environmental considerations including the presence of groundwater, the potential for contamination and any risks arising from the development to the environment will be considered through an appropriate risk assessment. Reference will be made to the Environment Agency's guide 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention'[29]. The properties of any materials being added to soils for soil mixed columns or soil stabilisation will be considered to ensure a pollution risk is not created.

[28] Environment Agency (2015), Guidance: Flood risk and coastal change. Available online at: https://www.gov.uk/guidance/flood-risk-and-coastal-change.

[29] Westcott, F.J., Lean C.M.B. and Cunningham, M.L. (2001), *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention* (National Groundwater and Contaminated Land Centre report NC/99/73), Environment Agency, Solihull.

Groundwater scheme components	
Embankments	Where ground conditions are suitable, track drainage will discharge to groundwater – subject to consideration of pollution risk, the presence of any groundwater source protection zones and assessment of subsidence risk. When excavated material is placed, consideration will be given to the origin of the material in the context of where it is to be placed. If the material to be placed has a significantly lower permeability than the underlying soils, then the impact will be assessed. Materials that come into contact with groundwater shall be approved by the Environment Agency including those used in grout for backfilling of voids and water sealing, which can affect groundwater and watercourses.
Embankments with subsurface reinforcement	Where embankments have subsurface reinforcement then combined measures for both embankments and viaduct foundations shall be taken to reduce impacts to groundwater.
Retaining walls	Retaining walls have the potential to divert groundwater by creating a hydraulic barrier that dams flow. Diverting flow may cause groundwater levels to rise on the upgradient side of the barrier, increasing groundwater flood risk, but lower the groundwater level on the downgradient side. Measures to reduce possible damming effects of retaining walls on groundwater flows and water quality include passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) that allows groundwater to bypass the structure without a groundwater level rise upstream of the underground structure. Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.
Cuttings	Cuttings will be formed by excavation in areas where the local topography is at a higher level than the desired route alignment. The impact of cuttings will be assessed in areas where the maximum invert level will intersect groundwater. This will include assessment of the likely maximum zone of influence from dewatering of cuttings (the lateral drawdown extent). Measures to reduce the effect on groundwater flows and water quality include: • cut-off structures such as sheet piles, driven/installed to the depths of underlying strata of lower permeability, will be used as a barrier to lateral inflow or longitudinal flow, reducing the flow into or along excavations, reducing the influence of dewatering on local water tables; • passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) placed below cuttings or around a tunnel perimeter allowing groundwater to bypass the structure without a groundwater level rise upstream of the underground structure; • barriers/collars will discourage groundwater flowing in zones in which the hydraulic conductivity has been increased due to the gravel blankets or the disturbance of rock/soils outside linear structures. Without such barriers, artificially created longitudinal groundwater flow paths could act as draining features resulting in post-construction dewatering of cuttings and tunnel walls and local water tables in general; • promotion of groundwater recharge, such as discharging pumped water to recharge trenches around excavations to maintain baseline groundwater and surface water conditions; and • where reasonably practicable, drainage would be designed to encourage water to soak back into the ground (e.g. using slotted land drains), for example where cuttings intercept groundwater flows. Where cutting drawdown causes mine water to drain into cutting drainage, then treatment will be included as additional mitigation
Cutting with retaining structure	Measures outlined for cuttings and retaining walls will be taken to minimise impacts on groundwater flow regimes.

Groundwater scheme components	
Cut-and-cover tunnels	Cut-and-cover tunnels are built by excavating the ground, building a tunnel structure, and then restoring the land over the top. Soil will be spread on top to integrate it with the landscape. Measures to reduce the effect of cut and cover tunnels on groundwater flows and water quality include: • cut-off structures such as sheet piles, driven/installed to the depths of underlying strata of lower permeability, will be used as a barrier to lateral inflow or longitudinal flow, reducing the flow into or along excavations, reducing the influence of dewatering on local water tables; • passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) placed below cuttings or around a tunnel perimeter allowing groundwater to bypass the structure without a groundwater level rise upstream of the underground structure; • barriers/collars will discourage groundwater flowing in zones in which the hydraulic conductivity has been increased due to the gravel blankets or the disturbance of rock/soils outside linear structures. Without such barriers, artificially created longitudinal groundwater flow paths could act as draining features resulting in post-construction dewatering of cuttings and tunnel walls and local water tables in general; • promotion of groundwater recharge, such as discharging pumped water to recharge trenches around excavations to maintain baseline groundwater and surface water conditions; and • where reasonably practicable, drainage would be designed to encourage water to soak back into the ground (e.g. using slotted land drains), for example where cuttings intercept groundwater flows. Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.
Bored tunnels	Bored tunnels are assumed to be sufficiently watertight during both construction and operation so that no discernible groundwater drawdown is expected. Completed bored tunnels have the potential to divert groundwater by creating a hydraulic barrier that dams flow. Diverting flow may cause groundwater levels to rise on the upgradient side of the barrier but lower the groundwater level on the downgradient side. Water receptors down gradient of a retaining wall will be assessed where groundwater diversion is possible. Where soil conditioning polymers are required, wherever practicable, biodegradable substances which break down to non-contaminating substances should be used in preference.
Tunnel portal	All tunnels will have portals at each entry/exit. Portals will take different forms, depending on ground conditions, local topography, train speeds and whether they need to accommodate a tunnel boring machine (TBM) during construction. The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable, with the route passing over larger watercourse and their floodplains on viaducts. However, in site specific instances where this is not possible due to the vertical alignment of the route and the existing topography, tunnels may be required. Measures to reduce the effect of tunnel portals on groundwater flows and water quality include: • cut-off structures such as sheet piles, driven/installed to the depths of underlying strata of lower permeability, will be used as a barrier to lateral inflow or longitudinal flow, reducing the flow into or along excavations, reducing the influence of dewatering on local water tables; • passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) placed below cuttings or around a tunnel perimeter allowing groundwater to bypass the structure without a groundwater level rise upstream of the underground structure; • barriers/collars will discourage groundwater flowing in zones in which the hydraulic conductivity has been increased due to the gravel blankets or the disturbance of rock/soils outside linear structures. Without such barriers, artificially created longitudinal groundwater flow paths could act as draining features resulting in post-construction dewatering of cuttings and tunnel walls and local water tables in general;

Groundwater scheme components	
	• promotion of groundwater recharge, such as discharging pumped water to recharge trenches around excavations to maintain baseline groundwater and surface water conditions; and • where reasonably practicable, drainage would be designed to encourage water to soak back into the ground (e.g. using slotted land drains), for example where cuttings intercept groundwater flows. Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.
Tunnel portal with retaining structure	Measures outlined for tunnel portals and retaining walls will be taken to minimise impacts on groundwater flows and water quality.
Cross passages	Tunnels will have cross passage evacuation escape routes, spaced approximately every 500m, between individual twin-bore tunnels and access routes from the surface. These will be used for rescue, maintenance and evacuation purposes. The cross passages will typically be a minimum of 1.5m wide and 2.25m high. Cross passages will be constructed once both tunnel drives have passed the location of the cross passage. The method of constructing the cross passages will comprise reinforcement and treatment of the ground, if required, followed by excavation, application of sprayed concrete, installation of waterproof lining and then a secondary layer of concrete either sprayed or cast in-situ, and installation of base slabs. Depending on ground and groundwater conditions, cross passages may require some form of treatment (e.g. injection of grout) to exclude groundwater and aid support during excavation. Cross passages are assumed to be sufficiently watertight during both construction and operation so that no discernible groundwater drawdown is expected.
Vent shafts	Dewatering around vertical structures, such as vent shafts may be required to lower ambient pore water pressures during construction and to generally facilitate dry working for shaft advancement and lining. Depending on the construction method detail, pre auguring with piled/secant walls (for example) may reduce or eliminate the need for dewatering. The method of constructing vent shafts will comprise reinforcement and treatment of the ground, if required, followed by excavation, application of sprayed concrete, installation of waterproof lining and then a secondary layer of concrete either sprayed or cast in-situ, and installation of base slabs. Depending on ground and groundwater conditions, vent shafts may require some form of treatment (e.g. injection of grout) to exclude groundwater and aid support during excavation. In the case that dewatering is required, then the groundwater conditions will require assessment to determine the likelihood of possible derogation by up-coning from adjacent aquifers. Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality. The completed structures have the potential to reduce the throughput of groundwater flow if, for example, fracture flow paths are intercepted. In the case that throughput is reduced then mitigation measures to minimise or counteract the effect include passive bypasses to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) placed below around or below the structure allowing groundwater to bypass.
Ground stabilisation	Where ground stabilisation is required-then there is potential that groundwater pathways may be sealed, resulting in deviation of flow paths. In the case of ground stabilisation being required then measures to reduce the effect of on groundwater flows and water quality include passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) allowing groundwater to bypass the stabilisation.
Stations/ Depots	Measures outlined for cuttings and retaining walls will be taken to minimise impacts on groundwater flows and water quality.

Groundwater scheme components	
Borrow pits	Opportunities to use borrow pit areas for strategic mitigation of WFD or flood risk related issues should be identified early. In the absence of any such proposals, the areas excavated as borrow pits will be restored to the existing levels and land use (as detailed within the draft restoration strategy for the borrow pits in Volume 5 of the ES). The materials used to backfill the borrow pit as part of the restoration plan are assumed to consist of a material with lower permeability than the current material. Drainage measures will be designed to control groundwater levels.

Table 6: Mitigation incorporated into the route alignment and design of surface water scheme components

Scheme component	Mitigation incorporated into the route alignment and design of the Proposed Scheme
Surface water scheme components	
Viaducts	Viaducts are constructed where embankments would not be a practicable or effective solution, such as crossing a river or floodplain. Viaducts will generally be built where a multi-span structure is needed to provide a continuous elevated route across undulating terrain, existing roads or floodplains. Intermediate piers are likely to be of reinforced concrete construction on pad or piled foundations, subject to ground conditions or the construction methodology. Abutments will be constructed of reinforced concrete on pad or piled foundations. The height of the viaducts will depend on local topography and on the clearances required over existing features. Where viaducts cross over waterways, they will be designed for a 1 in 100 (1%) annual rainfall probability event, including allowances for climate change and freeboard. The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable. Viaducts will therefore be designed so that the intermediate piers and foundations are set back and avoid existing river channel and riparian habitats, where reasonably practicable. Viaducts will also be designed to cross perpendicular to the river channels, where reasonably practicable; in order to reduce potential shading effects.
Viaduct with footings in water body	As above, as part of the route wide mitigation strategy to avoid sensitive environmental receptors, viaducts will generally be designed so that the intermediate piers and foundations are set back and avoid existing river channel and riparian habitats, where reasonably practicable. This scheme component type will therefore typically be avoided. However, site-specific constraints may require instances where viaduct infrastructure (such as viaduct piers and foundations) is required within or in proximity to the existing channel or riparian habitat. In such instances the design will aim to reduce impacts on the natural hydromorphology of watercourse channels, as far as is reasonably practicable. For such scheme components, site specific embedded mitigation is to be identified and developed in consultation with the Environment Agency.
Underbridges	Underbridges (i.e. bridges carrying the Proposed Scheme over other features) are likely to be constructed of reinforced concrete and/or steel. Clearances will vary as required by the type of feature being crossed. Where underbridges cross watercourses, they will be designed for a 1 in 100 annual rainfall probability event, including allowances for climate change and freeboard. Underbridge lengths will be reduced as far as reasonably practicable. Underbridges will be designed to cross perpendicular to the river channel where reasonably practicable, in order to reduce potential shading effects and subsequent potential effects to water quality and ecology. The detailed design of any localised modifications to the river channel passing beneath underbridges (including the potential provision of localised bank protection) is to be developed in general accordance with Environment Agency guidance and with input from a suitably qualified Fluvial Geomorphologist and Aquatic Ecologist to ensure that appropriate low-flow water depths and velocities for fish passage are maintained.
Clear span bridge	Bridges may be required where elements of the design (such as access roads or highway realignments) need to pass over an existing watercourse.

Scheme component	Mitigation incorporated into the route alignment and design of the Proposed Scheme
	Bridge lengths will be reduced as far as reasonably practicable. Bridges will also be designed to cross perpendicular to the river channel, wherever possible; in order to reduce potential shading effects. The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable. Bridges will therefore be designed so that abutments and foundations are set back and avoid existing river channel and riparian habitats, where reasonably practicable. The detailed design of any localised modifications to the river channel passing beneath bridges (including the potential provision of localised bank protection) is to be developed in general accordance with Environment Agency guidance and with input from a suitably qualified Fluvial Geomorphologist and Aquatic Ecologist to ensure that appropriate low-flow water depths and velocities for fish passage are maintained.
Bridge with footings in water body	As above, as part of the route wide mitigation strategy to avoid sensitive environmental receptors, bridges will generally be designed so that abutments and foundations are set back and avoid existing river channel and riparian habitats, where reasonably practicable. This scheme component type will therefore typically be avoided. However, site-specific constraints may require instances where bridge infrastructure (such as abutments) is required within or in proximity to the existing channel or riparian habitat. In such instances the design will aim to reduce impacts on the natural hydromorphology of watercourse channels, as far as is reasonably practicable. For such scheme components, site specific embedded mitigation is to be identified and developed in consultation with the Environment Agency.
Aqueduct	Aqueducts may be required where a watercourse needs to pass over the route or an element of the design such as an access road. Aqueduct lengths will be reduced as far as reasonably practicable. Aqueducts will also be designed to be perpendicular to associated track and road crossings, where reasonably practicable, in order to minimise aqueduct lengths. Aqueducts will be designed to accommodate flood flows up to and including the 1 in 100 (1%) annual probability event with an allowance for climate change based on latest guidance issued by the Environment Agency. The detailed design of all aqueducts will be developed in consultation with the Environment Agency guidance and will ensure appropriate low-flow water depths and velocities are maintained for fish passage, where reasonably possible and appropriate.
Culverts (including access road culverts and highway realignment culverts)	Culverts may be required in order to carry the route or Proposed Scheme element (such as an access road) over an existing watercourse. Culvert lengths will be limited as far as reasonably practicable. Culverts will be designed to be perpendicular to associated track and road crossings where reasonably practicable, in order to minimise culvert lengths and reduce potential shading effects. Culverts will be designed to accommodate flood flows up to and including the 1 in 100 (1%) annual probability storm with an allowance for climate change based on latest guidance issued by the Environment Agency[30]. The invert level of each culvert is to be buried below the existing bed level of the watercourse, in order to reduce disruption to sediment transfer and to allow build-up of natural substrate, whilst culvert dimensions will be sized to minimise impacts on flow continuity. The detailed design of all

[30] Environment Agency (2016), *Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities.* Available online at: https://www.gov.uk/government/publications/adapting-to-climate-change-for-risk-management-authorities.

Scheme component	Mitigation incorporated into the route alignment and design of the Proposed Scheme
	culverts is to be developed in general accordance with CIRIA[31] and Environment Agency guidance and will ensure appropriate low-flow water depths and velocities for fish passage. The detailed design will, where reasonably practicable, aim to incorporate hydromorphological improvements on the river channel, which will be undertaken immediately upstream and downstream of the culvert to compensate for footprint loss.
Drop inlet culverts	Culverts may be required in order to carry the route or Proposed Scheme element (such as an access road) over an existing watercourse. In some instances, a drop inlet culvert may be required where the vertical clearance between the existing channel bed and the Proposed Scheme crossing is limited. Drop inlet culverts would not be expected to be proposed on Main Rivers. Drop inlet culvert lengths will be reduced as far as reasonably practicable. Drop inlet culverts will be designed to accommodate flood flows up to and including the 1 in 100 (1%) annual probability flood with an allowance for climate change based on latest guidance issued by the Environment Agency. The downstream invert level of each drop inlet culvert is to be buried below the existing bed level of the watercourse on the downstream end, in order to reduce disruption to sediment transfer and to allow build-up of natural substrate, whilst drop inlet culvert dimensions will be sized to minimise impacts on flow continuity. The detailed design of all drop inlet culverts is to be developed in general accordance with CIRIA[31] and Environment Agency guidance and will ensure appropriate low-flow water depths and velocities for fish passage. The detailed design will, where reasonably practicable, aim to incorporate hydromorphological improvements on the river channel, which will be undertaken immediately upstream and downstream of the drop inlet culvert to compensate for footprint loss.
Extension of existing culvert	Extension to existing culvert structures may be required in areas where the route merges with the existing railway network. In such instances site-specific design details and embedded mitigation will be developed during the detailed design phase in consultation with the Environment Agency.
Daylighting of existing culvert	In some instances the design of the Proposed Scheme will involve the daylighting of an existing culverted section of watercourse. The detailed design of the daylighted channel will aim to restore a river channel form equivalent to reaches upstream and downstream of existing culvert and, where reasonably practicable, enhance the watercourse's hydromorphological condition. The new daylighted channel will be designed in consultation with the Environment Agency and with input from a suitably qualified Fluvial Geomorphologist and Aquatic Ecologist.
Inverted siphons	Inverted siphons may be required in order to carry the route over an existing watercourse where the vertical clearance between the existing channel bed and the Proposed Scheme crossing is limited. Inverted siphons would not be expected to be proposed on Main Rivers. Inverted siphon lengths will be reduced as far as reasonably practicable. Inverted siphons will be designed to accommodate flood flows up to and including the 1 in 100 (1%) annual probability storm with an allowance for climate change based on latest guidance issued by the Environment Agency. The detailed design of all siphons is to be developed in consultation with the Environment Agency.

[31] Balkham, M., Fosbeary C., Kitchen, A. and Rickard, C. (2010), *Culvert design and operation guide* (C689), CIRIA, London; Wallerstein, N., Arthur, S. and Blanc, J. (2013), *Culvert design and operation guide supplementary technical note* (C720), CIRIA, London.

Scheme component	Mitigation incorporated into the route alignment and design of the Proposed Scheme
	The detailed design will, where reasonably practicable, aim to incorporate hydromorphological improvements on the river channel, which will be undertaken immediately upstream and downstream of the siphon to compensate for footprint loss.
Highway Drainage Outfall	No embedded mitigation is identified at this stage. Bespoke mitigation will be required following further site investigation and design.
Realignments/ Diversions	Where permanent watercourse diversions and/or realignments are proposed, the aim will be to design these with equivalent hydraulic capacity to the existing channels. The detailed design will aim to ensure that field drainage systems can be adapted to discharge into the new diverted/realigned channels. The detailed design of permanent watercourse diversions/realignments will aim to incorporate appropriate features to retain, and, where reasonably practicable, enhance the watercourse's hydromorphological condition. (provided this is compatible with the watercourse's flood risk and land drainage functions). This may include but not be restricted to the following in-channel enhancements (as appropriate to the hydromorphological regime of the watercourse at the site location), which will be designed in consultation with the Environment Agency and with input from a suitably qualified Fluvial Geomorphologist and Aquatic Ecologist: • re-meandering of watercourses (where site extent allows); • provision of in-channel fluvial geomorphological features such as berms and bars to promote flow sinuosity and width/depth variation and provide marginal habitat; • improvement of morphological flow types such as pools, riffles and runs, to provide aquatic habitat diversity; • provision of defined low-flow channels to sustain appropriate flow depths and velocities and improve potential for fish passage; and • provision of varied channel bank profiles to improve morphological diversity, including areas of shallow-graded channel banks to allow for marginal vegetation growth. Proposed realignments/diversions have incorporated a 10m wide buffer strip on both sides of the new channel in order to allow for, where practicable, the implementation of marginal and riparian habitat improvements.
Flood embankment	No embedded mitigation is identified at this stage. Bespoke mitigation will be required following further site investigation and design.
Embankment with sub-surface reinforcement	The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable. Embankments with sub-surface reinforcement will therefore be designed to be set back from existing river channels and riparian habitats, where reasonably practicable. However, in site specific instances embankments may require sub-surface reinforcement, such as piles. In such cases the spacing of the structures will be as wide as possible so as to minimise potential reduction of groundwater flows or a damming effect. Measures to reduce the effect of embankments with sub-surface reinforcement on groundwater flows and water quality include: • passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) that allows groundwater to bypass the structure without a groundwater level rise upstream of the underground structure. Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.
Retaining wall	The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable. Retaining walls will therefore be designed to be set back from existing river channels and riparian habitats, where reasonably practicable. However, in site specific instances retaining walls may be required.

Scheme component	Mitigation incorporated into the route alignment and design of the Proposed Scheme
	Measures to reduce possible damming effects of retaining walls on groundwater flows and water quality include: • passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) that allows groundwater to bypass the structure without a groundwater level rise upstream of the underground structure. Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.
Cutting	Cuttings will be formed by excavation in areas where the local topography is at a higher level than the desired route alignment. The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable, with the route passing over larger watercourse and their floodplains on viaducts. However, in site specific instances where this is not possible due to the vertical alignment of the route and the existing topography, cuttings may be required. The impact of cuttings will be assessed in areas where the maximum invert level will intersect groundwater. This will include assessment of the likely maximum zone of influence from dewatering of cuttings (the lateral drawdown extent). Measures to reduce the effect of cuttings on groundwater flows and water quality include: • cut-off structures such as sheet piles, driven/installed to the depths of underlying strata of lower permeability, will be used as a barrier to lateral inflow or longitudinal flow, reducing the flow into or along excavations, reducing the influence of dewatering on local water tables; • passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) placed below cuttings allowing groundwater to bypass the structure without a groundwater level rise upstream of the underground structure; • barriers/collars will discourage groundwater flowing in zones in which the hydraulic conductivity has been increased due to the gravel blankets or the disturbance of rock/soils outside linear structures. Without such barriers, artificially created longitudinal groundwater flow paths could act as draining features resulting in post-construction dewatering of cuttings and local water tables in general; • promotion of groundwater recharge, such as discharging pumped water to recharge trenches around excavations to maintain baseline groundwater and surface water conditions; and • where reasonably practicable, drainage would be designed to encourage water to soak back into the ground (e.g. using slotted land drains), for example where cuttings intercept groundwater flows. Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality. Cutting slopes will generally be top-soiled and seeded to a specification suitable for the proposed final land use. In unfavourable geological conditions, stabilising elements and/or drainage may be incorporated within slopes.
Cutting with retaining structure	Measures outlined for cuttings and for retaining walls will be taken to minimise impacts on groundwater flows and water quality.
Cut and cover tunnels	Cut-and-cover tunnels are built by excavating the ground, building a tunnel structure, and then restoring the land over the top. Soil will be spread on top to integrate it with the landscape. The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable, with the route passing over larger watercourse and their floodplains on viaducts. However, in site specific instances where this is not possible due to the vertical alignment of the route and the existing topography, cut and cover tunnels may be required.

Scheme component	Mitigation incorporated into the route alignment and design of the Proposed Scheme
	Measures to reduce the effect of cut and cover tunnels on groundwater flows and water quality include: • cut-off structures such as sheet piles, driven/installed to the depths of underlying strata of lower permeability, will be used as a barrier to lateral inflow or longitudinal flow, reducing the flow into or along excavations, reducing the influence of dewatering on local water tables; • passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) placed below cuttings or around a tunnel perimeter allowing groundwater to bypass the structure without a groundwater level rise upstream of the underground structure; • barriers/collars will discourage groundwater flowing in zones in which the hydraulic conductivity has been increased due to the gravel blankets or the disturbance of rock/soils outside linear structures. Without such barriers, artificially created longitudinal groundwater flow paths could act as draining features resulting in post-construction dewatering of cuttings and tunnel walls and local water tables in general; • promotion of groundwater recharge, such as discharging pumped water to recharge trenches around excavations to maintain baseline groundwater and surface water conditions; and • where reasonably practicable, drainage would be designed to encourage water to soak back into the ground (e.g. using slotted land drains), for example where cuttings intercept groundwater flows. Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.
Cut and cover tunnel with retaining structures	Measures outlined for both cut and cover tunnels and retaining walls will be taken to minimise impacts on groundwater flows and water quality.
Tunnel portal	All tunnels will have portals at each entry/exit. Portals will take different forms, depending on ground conditions, local topography, train speeds and whether they need to accommodate a tunnel boring machine (TBM) during construction. The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable, with the route passing over larger watercourse and their floodplains on viaducts. However, in site specific instances where this is not possible due to the vertical alignment of the route and the existing topography, tunnels may be required. Measures to reduce the effect of tunnel portals on groundwater flows and water quality include: • cut-off structures such as sheet piles, driven/installed to the depths of underlying strata of lower permeability, will be used as a barrier to lateral inflow or longitudinal flow, reducing the flow into or along excavations, reducing the influence of dewatering on local water tables; • passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) placed below cuttings or around a tunnel perimeter allowing groundwater to bypass the structure without a groundwater level rise upstream of the underground structure; • barriers/collars will discourage groundwater flowing in zones in which the hydraulic conductivity has been increased due to the gravel blankets or the disturbance of rock/soils outside linear structures. Without such barriers, artificially created longitudinal groundwater flow paths could act as draining features resulting in post-construction dewatering of cuttings and tunnel walls and local water tables in general; • promotion of groundwater recharge, such as discharging pumped water to recharge trenches around excavations to maintain baseline groundwater and surface water conditions; and • where reasonably practicable, drainage would be designed to encourage water to soak back into the ground (e.g. using slotted land drains), for example where cuttings intercept groundwater flows.

Scheme component	Mitigation incorporated into the route alignment and design of the Proposed Scheme
	Application of the CoCP will ensure that materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.
Tunnel Portal with retaining structure	Measures outlined for tunnel portals and retaining walls will be taken to minimise impacts on groundwater flows and water quality.
Bored tunnel	Bored tunnels will generally be constructed where the depth between the railway and existing ground is such that open excavation is not practicable, and where the tunnel length is sufficient to make the use of TBM equipment viable. TBMs manage and control groundwater during construction meaning that dewatering will generally not be required unless for the excavation of tunnel portals, ventilation and intervention shafts, cross passages and adits. Dewatering around vertical structures, such as ventilation and intervention shafts may be required to lower ambient pore water pressures during construction and to generally facilitate excavation, especially lining construction. Depending on the construction method detail, auguring and piled/secant walls (for example) may eliminate the need for dewatering. Where soil conditioning polymers are required, wherever practicable, biodegradable substances which break down to non-contaminating substances should be used in preference. Once constructed, the potential for groundwater ingress into any bored tunnels or vertical structures will be limited by the tunnel/structure lining design.
Cross passages	Tunnels will have cross passage evacuation escape routes, spaced approximately every 500m, between individual twin-bore tunnels and access routes from the surface. These will be used for rescue, maintenance and evacuation purposes. The cross passages will typically be a minimum of 1.5m wide and 2.25m high. Cross passages will be constructed once both tunnel drives have passed the location of the cross passage. The method of constructing the cross passages will comprise reinforcement and treatment of the ground, if required, followed by excavation, application of sprayed concrete, installation of waterproof lining and then a secondary layer of concrete either sprayed or cast in-situ, and installation of base slabs. Depending on ground and groundwater conditions, cross passages may require some form of treatment (e.g. injection of grout) to exclude groundwater and aid support during excavation. Cross passages are assumed to be sufficiently watertight during both construction and operation so that no discernible groundwater drawdown is expected.
Ground stabilisation	Where ground stabilisation is required then there is potential that groundwater pathways may be sealed, resulting in deviation of flow paths and subsequently result in deterioration in water quality of downstream receiving waters. In the case of ground stabilisation being required then measures to reduce the effect of on groundwater flows and water quality include passive bypasses used to allow groundwater to bypass a barrier. Such bypasses could comprise a 'blanket' of permeable material (e.g. gravel) allowing groundwater to bypass the stabilisation.
Stations, Infrastructure Maintenance Bases (IMB), and Rolling Stock Depots (RSD)	The principal environmental mitigation strategy of the Proposed Scheme is to avoid sensitive receptors wherever reasonably practicable. The location of new stations, IMB-Rs, or RSDs will therefore be designed to avoid existing river channels and riparian habitats, where reasonably practicable. Surface water runoff from buildings and areas of hardstanding (e.g. accesses and parking) will be infiltrated to ground or will be attenuated and discharged, at a rate agreed with the relevant authority, to a nearby watercourse or a sewer. The design will employ sustainable drainage systems to manage surface water runoff and improve discharge water quality. The drainage system will also incorporate pollution control devices such as oil and silt traps where necessary. Sewage from stations, IMB-Rs, RSDs and associated facilities will be discharged into adjacent

Scheme component	Mitigation incorporated into the route alignment and design of the Proposed Scheme
	sewers, where available with appropriate capacity. Collection of foul effluent and off-site disposal may be necessary in specific cases.
Floodplain storage	Watercourse crossings will be designed to reduce losses of floodplain storage. Wherever such losses are anticipated provision will be made to replace this storage at the affected location on a 'level for level' and 'volume for volume' basis, where reasonably practicable.
Borrow pits	Opportunities to use borrow pit areas for strategic mitigation of WFD or flood risk related issues should be identified early. In the absence of any such proposals, the areas excavated as borrow pits will be restored to the existing levels and land use (as detailed within the draft restoration strategy for the borrow pits in Volume 5 of the ES). The materials used to backfill the borrow pit as part of the restoration plan are assumed to consist of a material with lower permeability than the current material. Drainage measures will be designed to control groundwater levels and to sustain baseflow to the watercourse in question.
Embankments with subsurface reinforcement	Where embankments have subsurface reinforcement then combined measures for both embankments and viaduct foundations shall be taken to reduce impacts to groundwater.
Ground stabilisation	In areas where historical coal mining is present then there will be consideration to ensure that groundwater pathways are not sealed or diverted. In the case of historical mine workings being intercepted then permeable stabilisation measures shall be included as additional mitigation.

5.3.9 Mitigation for potentially contaminated land is included within the design and detailed within the Land Quality assessment.

5.3.10 The design of the Proposed Scheme will also include sustainable drainage systems, where reasonably practicable, to control the rate, volume and quality of runoff from the rail corridor and other infrastructure, taking projected climate change impacts into account. These systems will encourage storm water to soak into the ground or, where that is not reasonably practicable, discharge it into watercourses or surface water/combined sewers at a rate matching existing runoff rates, or at an otherwise agreed rate at each location. These systems will also help to remove any suspended material within runoff from the Proposed Scheme through filtration, vegetative adsorption or settlement and, as such, will aim to ensure that the quantity and quality of water draining from the Proposed Scheme during its operational phase will have a negligible impact on the water environment.

Construction

5.3.11 Section 16 of the draft Code of Construction Practice (CoCP)[32] includes a range of mitigation measures that are developed to reduce construction impacts as far as is reasonably practicable. The measures that are of particular relevance to the water environment are described below.

[32] Volume 5: Appendix CT-002-00000, *Draft Code of Construction Practice*.

5.3.12 The CoCP will include requirements to protect water bodies and their associated water resources from the potential impacts of pollution from construction site runoff, including as appropriate:

- provision of maps showing sensitive areas and buffer zones where no pollutants are to be stored or used; and
- preparation of method statements for silt management, site drainage at compounds and satellite compounds, for the storage and control of oils and chemicals and the prevention of accidental spillages, in consultation with the Environment Agency, and if appropriate, the Lead Local Flood Authority and other relevant authorities as part of the approvals process. These method statements will cover, where applicable:
  - the avoidance of discharges of site runoff to ditches, watercourses, drains, sewers or soakaways without the prior agreement of the appropriate authority;
  - measures to prevent silt-laden runoff and other pollutants entering the water environment; and
  - restrictions or controls on excavation within watercourses to limit effects on water quality, sedimentation, fisheries and aquatic ecology.

5.3.13 Method statements will be required for all watercourse crossings and channel realignments required by construction traffic routes. The method statements will describe how potential changes to flood risk, water quality and channel hydromorphology will be safeguarded during the establishment, use and decommissioning of all construction traffic routes.

5.3.14 Existing groundwater abstraction boreholes or monitoring points will be protected from physical damage, in so far as reasonably practicable, including appropriate decommissioning of abandoned boreholes in order to prevent pollution pathways. If boreholes are to be decommissioned and replaced with alternatives, the contractors will follow the latest good practices, as far as reasonably practicable. This will also be applicable to springs potentially affected by construction works, although additional measures may be required to mitigate temporary construction impacts on springs that are to be relocated. Additional measures required to mitigate temporary construction impacts on springs that are to be relocated are outlined in the relevant Volume 2, Community area reports.

5.3.15 Measures will be introduced, as required, to mitigate the temporary and permanent effects on groundwater flows and water quality during excavation and construction of foundations, tunnels and cuttings, as far as is reasonably practicable. The exact requirements will be refined and method of mitigation will be designed following ground investigation at cutting locations. The types of measure likely to be adopted could include:

- installation of cut-off structures (impermeable barrier preventing water flow) around excavations;
- ensuring cut-off structures are driven to sufficient depths to meet an underlying strata or zone of lower permeability;

- promoting groundwater recharge, such as discharging pumped water to recharge trenches around excavations to maintain baseline groundwater and surface water conditions;
- incorporating passive bypasses within the design, which could comprise a 'blanket' of permeable material, such as gravel, placed around temporary structures allowing groundwater to bypass the below-ground works, without a rise in groundwater levels on the upstream side; and
- the Tunnel Boring Machine (TBM) will be operated in a closed face mode when tunnelling within water bearing strata and the tunnel lining will be designed to reduce leakage rates as far as is reasonably practicable, thereby reducing the requirements for dewatering and drainage.

Operation

5.3.16 A range of mitigation will be proposed to prevent deterioration of water resources and ecological function during operations.

5.3.17 Operational risks will be mitigated primarily through the design process.

5.3.18 Additional mitigation for the operational phase may include, but is not limited to, the following measures:

- a draft operation and maintenance plan aimed at ensuring that potential impacts occurring as a consequence of the Proposed Scheme are minimised as far as is reasonably practicable. This will include contingency plans to manage the consequences of unplanned incidents and protocols for use of pesticides and herbicides; and
- monitoring and management of water, habitats and species to demonstrate that ecological functionality has been maintained.

Monitoring

Construction phase

5.3.19 The nominated undertaker will require its lead contractors to implement appropriate surface water and groundwater inspection and monitoring procedures as part of their Environment Method Statement (EMS). This will include, but will not be limited to, procedures to monitor the effectiveness of the mitigation measures associated with potentially significant effects outlined in the water resources and flood risk sections of the Volume 2, Community area reports of the ES.

5.3.20 Requirements will cover monitoring of potentially adverse effects on WFD water bodies identified in the WFD Assessment.

5.3.21 The nominated undertaker will require its contractors to consult the Environment Agency regarding water quality, flow and level monitoring to be undertaken for watercourses and groundwater that will be affected by construction works or discharge of surface water runoff, which will include the following, as appropriate:

- pre-construction monitoring to establish baseline water quality conditions for watercourses and groundwater;
- monitoring during construction works to enable the effectiveness of mitigation measures to limit pollution risk to be monitored and any pollution incidents to be identified; and
- monitoring of watercourses or groundwater receiving surface water runoff during construction to enable the effectiveness of treatment and other sustainable drainage systems measures to be determined and to ensure that an unacceptable rise in groundwater levels does not occur.

5.3.22 The nominated undertaker will require its contractors to carry out appropriate monitoring to identify:

- pollution risks that are unacceptably high;
- spillages and leakages;
- non-compliance with the CoCP; and
- suspected pollution incidences.

5.3.23 Appropriate actions will be taken where pollution risks are unacceptably high, where there is non-compliance with the CoCP, where spillages and leakages are unacceptable or where there are any suspected pollution incidents.

5.3.24 Groundwater monitoring will be undertaken at any groundwater sensitive areas, as required, to inform the detailed design of the Proposed Scheme and the development of construction methods to mitigate potential impacts.

5.3.25 The contractors will also consult with the relevant regulatory body regarding the pollution incident control plan which will set out the measures to be implemented to address any adverse findings from the monitoring procedures during and following completion of construction works.

Operational phase

5.3.26 The nominated undertaker will be responsible for ensuring that monitoring is undertaken to identify any residual impacts following construction and confirm the efficacy of implemented mitigation. This will include monitoring of potentially adverse effects on WFD water bodies identified in the WFD Assessment.

5.3.27 The duration of this monitoring will be agreed with the Environment Agency and will depend on the nature of the potential impact concerned. Monitoring will ensure that sufficient data is collected to fulfil regulatory requirements.

5.3.28 Provided the construction phase mitigation proves effective, as demonstrated through post-construction monitoring, the remaining measures comprise procedures for inspection, operation and maintenance of the Proposed Scheme as set out in the draft water resource and flood risk operation and maintenance plan[33].

5.4 Enhancements

5.4.1 A primary driver of the WFD is to promote improvements in overall or element status and/or take advantage of opportunities to enhance the environmental and ecological quality of water bodies.

5.4.2 Specific water body pressures are listed within the relevant RBMPs at the outset and where reasonable and practical enhancement opportunities are identified.

5.4.3 Small scale enhancements such as, for example, planting, fencing, setting back existing embankments, shall be considered for implementation on a site-by-site basis where reasonably practicable. These may not directly mitigate impacts but may further contribute towards the wider objectives of the WFD.

[33] Volume 5: Appendix WR-007-00000, *Water Resources and Flood Risk, Draft Operation and Maintenance Plan.*

6 Detailed impact assessment

6.1 Overview

6.1.1 The objective of the detailed impact assessment is to establish the nature and likely magnitude of the effects of relevant Proposed Scheme components on the WFD quality elements of the surface water and groundwater bodies affected by the Proposed Scheme. These effects will be considered in terms of whether the Proposed Scheme has the potential to result in:

- a deterioration in current status/potential; and/or
- prevention of the achievement of good status/potential objectives in the future.

6.1.2 As with the preliminary assessment, the detailed impact assessment therefore comprises two key parts, as follows:

- assessment of the individual effects of the Proposed Scheme components on the current status of all relevant quality elements and the combined effect of all Proposed Scheme components at the water body scale; and
- assessment of the individual effects of Proposed Scheme components on the status objectives of all relevant quality elements and the combined effect of all Proposed Scheme components at the water body scale (with regard to those RNAG, PoM and AWB/HMWB mitigation measures identified as being at risk as a result of the Proposed Scheme during the preliminary assessment stage).

6.1.3 These two parts of the detailed impact assessment are described in further detail in the following sections.

6.2 No deterioration assessment

6.2.1 The UK Technical Advisory Group (UKTAG) provides guidance on the definition of no deterioration[34]. Necessary measures must be taken to prevent deterioration from one water body status class to a lower one. Furthermore, according to the recent European Union Court of Justice ruling (see Section 2.2 of this technical note), within-class deterioration will also be considered as an overall deterioration of the water body status.

6.2.2 A detailed impact assessment will therefore be undertaken on all components of the Proposed Scheme identified during the preliminary assessment as having the potential to have an effect on the WFD status elements of the relevant WFD surface and groundwater water bodies.

[34] UKTAG (2006), *Prevent Deterioration Of Status (Draft)*. Available online at: https://www.wfduk.org/sites/default/files/Media/Setting%20objectives%20in%20the%20water%20environment/Prevent%20deterioration%20of%20status_Draft_010506.pdf.

6.2.3 The assessment process for determining the potential for a deterioration of current status uses the following traffic light rating system agreed with the Environment Agency, in order to assign the magnitude of the effect anticipated on each of the quality elements of the affected water body. The system was developed for the Phase One ES and then revised following the European Union Court of Justice ruling (see Section 2.2 of this technical note). The revised system identifies the following effects:

- **Dark Blue**: beneficial effect of a scale sufficient to increase status class for the quality element at water body scale;
- **Light Blue**: minor/localised beneficial effect resulting in a localised improvement but insufficient to increase status class for the quality element at water body scale;
- **Green**: no measurable change to (or effect on) status class for the quality element at water body scale;
- **Yellow**: minor localised effect when balanced against likely mitigation included in the design – insufficient to affect status class for the quality element at water body scale;
- **Amber**: an adverse effect is possible when balanced against likely mitigation included in the design – the extent of effect is uncertain, and there remains a potential to affect status class for the quality element at water body scale. Additional mitigation and residual effects need to be considered; and
- **Red**: adverse effect of sufficient scale to impact on status class for the quality element at a water body scale.

6.2.4 The matrix presented in Table 7 will be used to assign surface water bodies into colour-coded categories according to the potential effect on the status class of each quality element. These effects range from a major beneficial effect i.e. a positive change in overall WFD status (dark blue); through no effect; to certain deterioration in overall status class (red). The colour codes, summarised in Table 7, are applied in the assessment worksheets for each surface water body.

6.2.5 The matrix presented in Table 8 will be used to assign groundwater bodies into colour-coded categories according to potential effect on the status class of each quality element. These effects range from a negligible effect (green) to certain deterioration in overall status class (red). The colour codes, summarised in Table 8, are applied in the assessment worksheets for each groundwater body.

6.2.6 The outcome of the assessment will identify the overall, 'combined' effect of all of the relevant Proposed Scheme components on each quality element at a water body scale.

6.2.7 As part of this process, the assessment will also consider the 'cumulative effects' on quality elements associated with the impacts of Proposed Scheme components located within other, adjacent water bodies.

6.2.8 Where adverse (amber or red) overall effects are identified with the risk of status deterioration, the assessment will identify, where possible, 'additional mitigation' (i.e. beyond those measures embedded within the Proposed Scheme) that is required in order to avoid and/or minimise the risk. The assessment will then identify the residual effect on the status class of the relevant quality element(s) following consideration of additional mitigation. Where any residual adverse effects remain, with a risk of causing a deterioration in quality element status, a Regulation 19 assessment will be undertaken for the water body (see Section 7, Appendix A of this technical note).

Table 7: Decision matrix for assessing effect on surface water status class

Type of effect	Impact of Proposed Scheme element on WFD element.	Impact on WFD element	Impact on WFD water body i.e. the combined effect on the water body as a result of all the effect on WFD elements	Examples	Outcome
Dark Blue – Beneficial effect	Impacts when taken on their own have the potential to lead to significant improvement.	Impacts in combination with others have the potential to lead to the improvement in the class of a WFD element.	Impacts in combination with others have the potential to lead to the improvement in the WFD status of the water body.	Creation or enhancement of significant areas of aquatic and/or riparian habitats (for example, within a river diversion or via daylighting of significant sections of existing culverts) which enhance the value of the water body.	Increase in status of WFD water body.
Light Blue - Minor/localised beneficial effect	Impacts when taken on their own have the potential to lead to a minor localised improvement.	Impacts in combination with others have the potential to lead to a minor localised improvement of the WFD element.	Impacts in combination with others have the potential to lead to a minor localised improvement that does not affect the WFD status of the water body.	Minor habitat creation or enhancement measures resulting in the improvement of aquatic and/or riparian habitats as part of a localised river realignment or via daylighting of an existing culvert.	Localised improvement, but no change in status of WFD water body.
Green - no effect/negligibl e effect	No measurable change to any quality elements.	No measurable change to any quality elements.	No measurable change to any quality elements.	Clear span viaduct which causes no significant light shading, no changes to flow, and no encroachment of riparian habitat.	No change.
Yellow – Minor/localised adverse effect	Impacts when taken on their own have the potential to lead to a minor localised adverse effect.	Impacts in combination with others have the potential to lead to a minor localised or adverse effect on the WFD elements.	Impacts in combination with others have the potential to lead to a minor localised adverse effect that does not affect the WFD status of the water body.	Permanent shading and/or loss of aquatic or riparian habitat resulting from construction of culvert or bridge structure.	No change in status of WFD element and/or water body when balanced against mitigation included in the Proposed Scheme.

Type of effect	Impact of Proposed Scheme element on WFD element.	Impact on WFD element	Impact on WFD water body i.e. the combined effect on the water body as a result of all the effect on WFD elements	Examples	Outcome
Amber – adverse effect (uncertain)	Impacts when taken on their own have the potential to lead to an adverse effect despite mitigation included within the design.	Impacts in combination with others have the potential to have an adverse effect on the WFD element. Additional mitigation will be applied.	Impacts in combination with others have the potential to have an adverse effect on the WFD status of the water body. Extent of effect is uncertain at this stage. Additional mitigation will be applied.	Significant lengths of permanent shading and/or loss of aquatic or riparian habitat resulting from construction of culvert or bridge structure. Obstruction to upstream migration of fish to spawning grounds in a salmonid river therefore affecting fish in the whole of the WFD water body.	Adverse effect with risk of decrease in status of WFD element and/or water body. Needs consideration of additional mitigation, taking into account the level of confidence.
Red – adverse effect (certain)	Impacts when taken on their own have the potential to lead to a significant/widespread adverse effect despite mitigation included within the design.	Impacts in combination with others have the potential to have an adverse effect on the WFD element and change its class. Additional mitigation or design amendment is required.	Impacts in combination with others will have an adverse effect on the WFD status of the water body and change its status. Additional mitigation or design amendment is required.	As above but with certainty of impact at a water body scale.	Adverse effect leading to a decrease in status of WFD element and/or water body despite mitigation included within the design. Outcome is considered to be certain. Additional mitigation or design amendment is required.

Table 8: Decision matrix for assessing effect on groundwater body status class

Type of effect	Magnitude of impact of Proposed Scheme element on WFD element	Impact on WFD element at scale of scheme	Impact on WFD element at groundwater body scale	Example	Outcome
Green - no effect/negligible effect	No measurable change to groundwater levels or quality.	No measurable change to groundwater levels or quality.	No measurable change to groundwater levels or quality.	Cutting above the water table.	No change.
Yellow – minor/ localised adverse effect	Impacts when taken on their own have the potential to lead to a minor localised adverse effect.	Combined impacts have the potential to lead to a minor localised or temporary effect on the WFD element.	Combined impacts have the potential to lead to a minor localised or temporary effect on the WFD element. No change to groundwater body status.	Cutting above the water table but drainage returned to ground within the same groundwater body and surface water catchment.	No change in status of WFD water body when balanced against mitigation included in the Proposed Scheme.
Amber – adverse effect (uncertain)	Impacts when taken on their own have the potential to lead to an adverse effect despite mitigation included within the design.	Combined impacts have the potential to have an adverse effect on the WFD element.	Combined impacts have the potential to have an adverse effect on the WFD status of the water body.Extent of effect is uncertain at this stage. Additional mitigation will be applied.	Dewatering of cutting reducing baseflow to a tributary.	Adverse effect with risk of decrease in status of WFD element and/or water body. Needs consideration of additional mitigation, taking into account the level of confidence.
Red – adverse effect (certain)	Impacts when taken on their own have the potential to lead to a significant/widespread adverse effect despite mitigation included within the design.	Combined impacts in combinations with others will have a significant/widespread adverse effect on the WFD element and change its class. Additional mitigation or design amendment is required.	Impacts in combination with others will have an adverse effect on the WFD status of the water body and change its status.	Dewatering of cutting reducing baseflow to a surface water body with adverse effects at scale of whole surface water body.	Adverse effect leading to a decrease in status of WFD element and/or water body despite mitigation included within the design. Outcome is considered to be certain. Additional mitigation or design amendment is required.

Presentation of assessments

6.2.9 The detailed impact assessments for each surface water and groundwater body affected by the Proposed Scheme will be presented in table format. Within each, the relevant WFD quality elements will be listed in the left-hand column (along with their current status), with the relevant Proposed Scheme components presented across the top of the table (grouped by the relevant watercourse for surface water bodies). The name of the Proposed Scheme component, its unique reference ID, and a summary of the available associated engineering design and embedded mitigation information will also be provided. Impacts arising from each Proposed Scheme component (following consideration of mitigation included in the design; as described in Section 4.2 of this technical note appendix) will be grouped into a set of columns under the Proposed Scheme component.

6.2.10 The effects of each of the Proposed Scheme components are considered individually. The overall effect of all Proposed Scheme components on each quality element of the water body will be presented towards the right-hand side of the table. Any cumulative effects from Proposed Scheme components located within other water bodies (e.g. upstream or downstream) will also be considered.

6.2.11 Where required, details of additional mitigation and residual effects on the relevant quality elements is documented at the far right-hand side of the table.

6.3 No prevention of future attainment of ecological status or ecological potential objective assessment

6.3.1 The preceding preliminary assessment screens the Proposed Scheme against the available RBMP Cycle 2 RNAG and PoM datasets derived by the Environment Agency for each of the relevant WFD surface water and groundwater bodies affected by the Proposed Scheme, as well as any available Environment Agency MMAs derived for HMWB or AWB.

6.3.2 Any RNAG or measures identified under the preliminary assessment as potentially being at risk from the Proposed Scheme will be subject to further assessment in order to derive likely effects on water body status objectives. This will involve a detailed review of the relevant Proposed Scheme component(s) and the baseline condition of the relevant water body/watercourse at the relevant location(s), against available cause of failure and measure investigation outputs provided by the Environment Agency. This assessment process will be undertaken in consultation with the Environment Agency.

7 Application of Regulation 19 test

7.1.1 Article 4.7 of the WFD directs that Member States will not be in breach of the Directive when failure to meet its environmental objectives is the result of either new modifications to the physical characteristics of a water body or as a result of new human sustainable development, on the proviso that the modifications or new development proposed are compliant with four key conditions as outlined below. In so doing, Article 4.7 provides a means whereby a derogation for a proposed modification or sustainable development may be granted where it meets these four conditions. The requirements of Article 4.7 of the WFD are replicated entirely within Regulation 19 of the WFD Regulations.

7.1.2 The content of a Regulation 19 test report should document clearly how:

- all practicable steps have been taken to mitigate the adverse impact on the status of the water body;
- the reasons for the modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the objectives are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development;
- the beneficial objectives served by the modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option; and
- in addition, the reasons for the modifications or alterations will need to be clearly identified to the Environment Agency so that they can be specifically set out and explained in the RBMP required under Part 6 of the WFD Regulations. These objectives are reviewed every six years. This condition will be addressed at a route-wide level.

7.1.3 Whilst every effort will be made to ensure a Regulation 19 test is not required, where unavoidable such a test may need to be prepared for particular water bodies. In all circumstances, appropriate evidence will need to be collated and presented to aid in the design decision making process and ensure that any justification is appropriate.

8 Further assessment

8.1.1 The WFD Assessment will provide an initial assessment of the compliance of the Proposed Scheme with the objectives of the WFD. The assessment will be updated as a living document in response to any design changes during the detailed design stage and evidence of compliance will be agreed with the Environment Agency during the consenting process, prior to the commencement of pre and post construction WFD monitoring works.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Water resources and flood risk – Groundwater assessment method

Contents

1 Introduction

1.1.1 This technical note has been prepared to provide guidance in the assessment of the effects of the Proposed Scheme on groundwater quantity and quality. It should be read in conjunction with the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR). Mitigation of these effects and reporting of residual effects should be carried out as stated in the EIA SMR.

1.1.2 This technical note is intended as a guide to ensure a consistent approach across the Proposed Scheme, not as an exhaustive and prescriptive methodology.

1.1.3 This note should not be used to assess the following:

- effects on surface water (see Water resources and flood risk technical note – Surface water quality and spillage risk assessment);
- effects on flooding (see Water resources and flood risk technical note – Flood risk); or
- effects on Water Framework Directive (WFD) designated groundwater bodies (see Water resources and flood risk technical note – Water Framework Directive compliance assessment process).

1.1.4 This technical note is set out in four sections covering baseline, impact assessment, mitigation (including monitoring) and residual effects.

1.1.5 There is overlap between groundwater and other topics including surface water, flood risk, WFD compliance, ecology, land quality and geotechnics. These are referred to as necessary in the following sections to provide guidance on areas of responsibility.

2 Baseline assessment

2.1.1 The requirements for baseline data collection are set out in Section 21 of the EIA SMR.

2.1.2 Where recent (since 2015) groundwater quality datasets are available, these can be used to define up to date baseline groundwater quality. In the absence of such data, the WFD status of groundwater bodies will be used, if available. Historical data prior to 2015 should be considered where these may help to interpret the current groundwater status, particularly where trends can be identified leading up to the present day or where bulk water-rock interactions may be in evidence and are likely to be ongoing.

2.1.3 Water quality standards (WQS) can be used to indicate baseline groundwater quality. Two forms of WQS are available: drinking water standards (DWS) and environmental quality standards (EQS). DWS are defined to protect human health (i.e. are suitable for potable supply); whereas EQS are defined to protect sensitive aquatic ecology from any surface water body receiving groundwater via baseflow. The appropriate WQS should be chosen based upon site conditions; where both are applicable, the more stringent WQS should be applied. Reference should be made to the conditions of each WQS, for instance, whether the standard applies to an annual average concentration or the maximum admissible concentration, and a consistent and appropriate approach should be taken, based upon WQS conditions and data quality and availability.

2.1.4 Groundwater level data should be of a sufficient duration so that seasonal and long-term fluctuations can be identified. Peak wet years and extended drought periods should be used to determine maximum and minimum ranges in groundwater levels where possible.

2.1.5 Where there is no available groundwater level data in the vicinity and no means of extrapolating this from nearby groundwater fed features, groundwater level should be assumed to be at or near surface and follow the topographic gradient (i.e. a conservative approach should be taken).

2.1.6 Project specific groundwater data should be collected if the opportunity arises in sensitive areas.

2.1.7 The base case to be adopted will depend on data availability but ideally should extend to 2020 for variables such as water quality and groundwater levels.

2.1.8 Information on licensed groundwater abstractions, discharges to ground (soakaways), groundwater level monitoring and groundwater quality monitoring data must be sought from the Environment Agency (EA) or Scottish Environment Protection Agency (SEPA).

2.1.9 Information on any unlicensed private abstractions (groundwater and surface water) held by Local Authorities must also be sought.

2.1.10 The cut-off date for data, such as groundwater levels and licensed/private groundwater abstractions, should be clearly stated.

2.1.11 Information on aquifer hydraulic parameters (e.g. hydraulic conductivity data) are unlikely to be time sensitive and so all published data may be relevant.

2.1.12 The main geological mapping scale to be used is 1:50,000, with detail at 1:10,000 in selected areas if needed.

2.1.13 The following baseline information will be collected to ensure consistency between topics:

- baseline contamination data will be collected by the land quality teams;
- the geology baseline description will be based on that prepared by the land quality teams to ensure consistency;
- baseline topography and soils data will be collected by the agriculture, forestry and soils team; and
- baseline ecology and identification of groundwater dependent ecosystems will be collected by the ecology teams.

3 Scope of groundwater impact assessment

3.1 Assessment methodology

3.1.1 The construction and operational impacts will be assessed as per the EIA SMR, which sets out the criteria for definition of receptor value, magnitude of impact and significance of effect. The maximum and minimum groundwater level or other condition may be more relevant in some circumstances.

3.1.2 All springs that contribute flow to a national or international statutory designated water dependent habitat (listed in Ecology surveys) will be attributed a very high importance receptor value. All other potential springs identified from Ordnance Survey (such as issues, springs, seeps and spreads) or detailed river network mapping will be assigned a high value on a precautionary basis, until a site survey is carried out. Following site survey, those springs that do not contribute flow to a water dependant habit but do provide baseflow to surface waters shall be classified with the same receptor value of the surface water feature they contribute to.

3.1.3 All sinks will be attributed as a high value receptor. All other potential sinks identified from Ordnance Survey (such as collects, dolines, shake holes, sinks and sink holes) or detailed river network mapping will be assigned a high value on a precautionary basis, until a site survey is carried out.

3.1.4 All potential spring and sink features will be listed in the BID Water Resources Assessment (WRA) baseline table under “groundwater-surface water interaction”. If a survey confirms it is not a spring or sink i.e. part of land drainage and not a true expression of groundwater, then it will be listed as ‘following survey, this was confirmed as a land drainage feature’ and can be omitted from the subsequent Volume 5 WRA impact assessment table.

3.1.5 Potential differences between groundwater and surface water catchments are to be noted and addressed where relevant.

3.2 Groundwater quantity and flow

3.2.1 Dewatering and mounding effects will be assessed qualitatively unless the design can be used to quantify effects in combination with accepted hydrogeological solutions, for example Theim, Dupuit-Thiem, Sichardt or Darcy’s Law formulae.

3.2.2 Greater emphasis and attempts to quantify impacts should be focussed on areas of high risk, demonstrated by a source-pathway-receptor style narrative. Where aquifer thicknesses are relatively thin, and/or drawdowns relatively large compared to aquifer thicknesses, a conservative opinion should be expressed and qualified considering the specific conditions present.

3.2.3 Dewatering calculations (active or passive) will give an indication of magnitude of impact based on selected hydraulic conditions. The aim is to estimate the potential effect and thus identify mitigation rather than make accurate predictions. Once site specific data are available the estimates may change.

3.2.4 The equations to use are outlined below. Further details and approach to be used for dewatering assessments, are provided in the CIRIA Publication on Groundwater control: design and practice (Second Edition)[1].

3.2.5 Dewatering impacts (flow rates and drawdown) as a result of temporary shafts, cuttings or portal dewatering will be quantified for the purpose of the Environmental Statement (ES) using site data where available or using data from existing groundwater models where available. In the absence of such data, hydraulic values from the British Geological Survey (BGS) Aquifer Properties Manual[2], or other published literature sources, should be used. To be conservative a higher hydraulic conductivity and lower storage coefficient are recommended. Professional judgement may also need to be used.

3.2.6 Drawdowns will be based on measured groundwater levels, where available, or on water strikes from borehole/drillers logs where applicable (with appropriate qualifications).

3.2.7 Bored tunnels are assumed to be sufficiently watertight during both construction and operation so that no discernible groundwater drawdown is expected. The cross passages will be constructed using ground improvement, where required, to avoid groundwater ingress. Therefore, no dewatering is expected during construction.

3.2.8 Cuttings, porous portals and cut and cover tunnels will be assessed using the same methodology. The first step is to assess the design element qualitatively by comparing the lowest element level (metres above Ordnance Datum (mAOD)) to groundwater level (mAOD). If groundwater level is below the lowest element level, it is assumed that dewatering is not required and therefore quantitative assessment is not required.

3.2.9 Quantitative assessment of cuttings, porous portals and cut and cover tunnels can be made using the Sichardt equation. This equation applies to an idealised aquifer which is unconfined, infinite in horizontal extent, constant thickness, homogenous and isotropic with respect to its hydrogeological parameters.

[1] Preene, M., Roberts, T.O.L. and Powrie, W., (2016), *Groundwater control: design and practice*. CIRIA Publication C750.

[2] Allen, D. J. *et al.* (1997), *The physical properties of major aquifers in England and Wales*, Keyworth: British Geological Survey.

$$R_o = C(H-h)\sqrt{k}$$ Sichardt formula

Where;

Ro = radius of influence (m)

C = empirical calculation factor (taken to be 1750 as design elements are linear)

H = piezometric level in the aquifer (mAOD) (i.e. rest groundwater level)

h = target drawdown level in the equivalent well (mAOD) (i.e. lowest element level)

k = hydraulic conductivity (m/s)

3.2.10 For shaft dewatering, if the highest groundwater level in the aquifer is below the base of the excavation at the time of casting, then it will be assumed that dewatering is not required.

3.2.11 Estimates of the flow rates required for dewatering shafts can be made using the Thiem equation (confined aquifer) or Dupuit-Thiem equation (unconfined aquifer). The equations apply to an idealised aquifer which is horizontal, infinite in horizontal extent, of constant thickness and homogeneous and isotropic with respect to its hydrogeological parameters.

$$Q = \frac{2\pi k D(H-h)}{\ln(R_o/\mathrm{R_e})}$$ Thiem formula (confined)

$$Q = \frac{\pi k(H^2-h^2)}{\ln(R_o/\mathrm{R_e})}$$ Dupuit-Thiem formula (unconfined)

Where;

Q = flow rate (m^3/d)

D = thickness of the aquifer (m)

Re = effective radius of dewatering (m) (taken as 5m more than the shaft radius)

3.2.12 Where the dewatering wells are partially penetrating the flow rate will be adjusted to Qpp as follows:

$$Qpp = Q \times \frac{d}{D}$$

Qpp = flow rate adjusted for partial penetrating wells

d = depth well penetrates into aquifer (m)

3.2.13 The equations above represent steady state conditions and are therefore appropriate if dewatering is likely to occur over a number of months to a point where groundwater level changes stabilise. For shorter scale works, such as manholes, transient, non-steady state methods will be applied, where appropriate, to determine the dewatering requirements.

3.2.14 Impacts of temporary dewatering in shallow aquifers where a steady state is not reached will be based on the Cooper Jacob equation for non-steady state conditions where appropriate. The drawdown, s, at a distance, r, from the dewatering borehole assuming semi-confined aquifer conditions, is given by:

$$s = \frac{2.303Q\log 10(2.25kDt/(r^2S))}{4\pi kD}$$

Where;

Q = flow rate from well (m^3/day)

t = time (days)

r = radius of interest (m)

s = drawdown (m)

S = specific yield of aquifer

3.2.15 The impact of dewatering shafts on sites of special scientific interest (SSSI) and other sensitive receptors will be estimated, where appropriate, using the following mathematical equations:

$$L_0 = \sqrt{\frac{12Tt}{S}}$$ For plane flow (into a linear design element)

$$R_0 = \sqrt{\frac{2.25Tt}{S}}$$ For radial flow (e.g. to a well)

Where;

Lo or Ro = distance of influence (m)

T = transmissivity in (m^2/d)

S = confined or unconfined storage depending on aquifer conditions

3.2.16 The assessment of the impact of borrow pits will be assessed qualitatively, unless potential impact to a sensitive receptor is identified in which case further quantitative assessment may be required. These are construction related features that will be restored after construction. The dewatering depth to be used in the quantitative assessment is 1m below the base of the floor of the borrow pit.

3.2.17 Dewatering impacts on surface water bodies and wetland hydrology (where these are known or anticipated to be in hydraulic continuity (linked) with groundwater) will be covered by the groundwater section, based on the baseline conditions provided by these topics.

3.2.18 The assessment of potential groundwater mounding, for example due to tunnels, retaining walls or ground stabilisation, will be assessed qualitatively, unless potential impact to a sensitive receptor is identified in which case further quantitative assessment may be required.

3.3 Groundwater quality

3.3.1 The Land Quality topic assesses potential impacts from contaminated land. It is assumed that contaminated land contamination will be either removed or remediated during construction.

3.3.2 Risks posed to groundwater quality are from accidental spillages or routine runoff from highway drainage. The assessment methodology for highways drainage risks will use Highways England's Water Risk Assessment Tool (HEWRAT). The groundwater assessment methodology is provided in Method C of Volume 11, Part 10 of the Design Manual for Roads and Bridges (DMRB)[3].

3.3.3 The highways risk assessments are only relevant to the groundwater assessment where the highway being assessed exposes a risk by virtue of being a source and/or pathway connecting via groundwater to a sensitive receptor.

3.3.4 The groundwater section will assess pollution risks as a result of groundwater being both a pathway and/or receptor. The land quality topic will assess these effects as well as pathways other than groundwater and receptors other than groundwater.

[3] Highways England (2019), Design Manual for Roads and Bridges (DMRB), Sustainability and Environment Appraisal, LA 113 Road drainage and the water environment (formerly HD 45/09). Available online at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/LA%20113%20Road%20drainage%20and%20the%20water%20environment-web.pdf.

4 Mitigation measures

4.1.1 The general approach to mitigation (including environmental monitoring) will be set out in Volume 1 of the ES. Other avoidance and mitigation measures such as minimising dewatering, groundwater cut-off or re-routing of groundwater flows, water recirculation, re-injection and pollution control are discussed in the water resources and flood risk assessments. Note that water discharges during construction and operation will require environmental permits from the Environment Agency or SEPA.

5 Reporting residual effects

5.1.1 The ES will present the residual effects following the implementation of mitigation measures. Measures to mitigate residual effects may include compensation for derogation of licensed abstractions or other effects where monitoring confirms that the effect is significant.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Water resources and flood risk – Surface water quality assessment and spillage risk assessment

Contents

1 Introduction

1.1.1 This technical note provides guidance on the assessment of potential impacts on surface water quality during both the construction and operation of the Proposed Scheme. It also provides guidance on assessing the potential risk of spillages occurring during operation of the Proposed Scheme. It should be read in conjunction with the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR). Mitigation of these effects and reporting of residual effects should be carried out as stated in the SMR.

1.1.2 This technical note is intended as a guide to ensure a consistent approach across the Proposed Scheme, not as an exhaustive and prescriptive methodology.

1.1.3 This technical note should not be used to assess the effects on groundwater (see Water resources and flood risk technical note – Groundwater assessment method).

2 Baseline assessment

2.1 Baseline definition

2.1.1 The baseline characteristics of water receptors within the study area shall be defined in accordance with the approaches outlined in the SMR.

2.1.2 Within the context of the surface water quality and spillage risk assessment, the following elements of a water body's WFD status will be considered within the baseline:

- physico-chemical and specific pollutants components of the water body's 'ecological status';
- where appropriate, the priority substances components of the water body's 'surface water chemical status'; and
- The targets for future ecological status or ecological potential should also be considered. This baseline should be consistent with that set out in the WFD compliance assessment report.

2.1.3 Where a baseline assessment is required, but no published data is available at the point of potential impact, the next downstream location where data is available will be preferentially used. If no data is available from a suitable downstream location, professional judgment should consider whether the next upstream monitoring location is appropriate. If none exists or are not appropriate, then the Environment Agency should be approached directly to establish whether it holds any unpublished data that would be appropriate.

2.1.4 Use of a suitable downstream or the next upstream location, as described above, may not be appropriate with respect to the consideration of ambient background concentrations of dissolved copper in the Highways England Water Risk Assessment Tool (HEWRAT, see paragraphs 3.2.1 and 3.3.1). Background concentrations used in HEWRAT should be representative of the point of discharge in order to accurately identify potential failures of relevant Environmental Quality Standards (EQS). If the next downstream or next upstream locations is insufficiently similar to the point of discharge in terms of land-use and potential sources of dissolved copper, supplementary water quality sampling may be necessary.

2.1.5 Where supplementary water quality sampling is deemed necessary to define the baseline, the consultant/contractor should consult with the Environment Agency prior to undertaking any field work to make sure that the data obtained is aligned with Environment Agency water quality monitoring protocols.

3 Scope of water quality impact assessment

3.1 Introduction

3.1.1 Potential sources of impacts on water quality could include:

- pollution from a construction compound;
- pollution from construction of new rail track, including all associated tunnels, embankments, cuttings, viaducts, bridges, culverts, watercourse diversions/realignments etc;
- pollution from a new station;
- pollution from a new depot;
- pollution from other Proposed Scheme infrastructure;
- pollution from a public road, including from diversion/realignments and from increased trafficking of existing roads both within and outside of the area required for the Proposed Scheme; or
- physical changes to water body hydromorphology (e.g. resulting from a channel diversion).

3.1.2 The sources may derive from both construction and operational phase activities.

3.2 Construction impacts

3.2.1 The method in this section should be used to assess the potential impacts of construction on surface water quality for all water receptors potentially affected by the Proposed Scheme, with the exception of:

- roads that are affected by the Proposed Scheme's construction traffic, where both of the following criteria are met:
  - where the annual average daily traffic is greater than 10,000 vehicles per day;
  - where the annual average daily traffic of heavy goods vehicles (HGV) is forecast to exceed 500;
- And one of the following two criteria are met:
  - where there is a very high value surface water body (e.g. a public water supply, SSSI, SPA, SAC or Ramsar site) within 1km downstream and an increase in HGV of 10%; or
  - where the increase in HGV is forecast to be greater than 50% of the baseline.

- where the Highways England Water Risk Assessment Tool (HEWRAT) method in Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10 (LA 113)[1] should be used where data allows, otherwise CIRIA's Simple Index Approach in The SuDS Manual (CIRIA C753)[2] (see Section 3.4); and
- sites where drainage to foul or combined sewers is proposed. In these instances, the relevant sewerage authority should be consulted to ascertain if there is adequate capacity within the existing system.

3.2.2 The impacts of construction on receptor water quality will only be those which are estimated to remain after the application of the control measures outlined in the draft Code of Construction Practice (CoCP). It should also be assumed that all relevant approvals to discharge to surface waters are in place.

3.2.3 Assessments will be made based on a combination of professional judgement and analysis. They will be conservative, assuming little or no dispersion. The following factors will be taken into consideration, where appropriate:

- the duration of construction;
- the space available within which to provide the mitigation measures set out in the draft CoCP (and hence the likelihood of these measures being effective);
- the pathways available for impacts to affect surface water bodies; and
- the impact of diversions on the flows and dilution available in receiving watercourses.

3.3 Operational impacts

3.3.1 The method in this section should be used to assess the routine operational impacts on surface water quality for all locations on the project, with the exception of:

- roads affected by the Proposed Scheme's operation, where the annual average daily traffic is forecast to exceed 10,000 vehicles per day and only where there is new road or realignments of road. Here the Highways England Water Risk Assessment Tool (HEWRAT) method in Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10 (LA 113)[1] should be used where data allows, otherwise CIRIA's Simple Index Approach in The SuDS Manual (CIRIA C753) (see Section 3.4); and
- sites where drainage to foul or combined sewers is proposed. In these instances, the relevant sewerage authority should be consulted to ascertain if there is adequate capacity within the existing system.

[1] Highways England (2019), *Design Manual for Roads and Bridges (DMRB), Sustainability and Environment Appraisal, LA 113 Road drainage and the water environment (formerly HD 45/09).* Available online at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/LA%20113%20Road%20drainage%20and%20the%20water%20environment-web.pdf.

[2] Construction Industry Research and Information Association (2015), *The SuDS Manual* C753.

3.3.2 The impacts of operation on receptor water quality will only be those which are estimated will remain after the impacts of mitigation included in the design is taken into consideration. Mitigation included in the design will include:

- sustainable drainage systems, which will be used where reasonably practicable. These will help to remove any suspended material within runoff from the Proposed Scheme through filtration, vegetative adsorption or settlement;
- use of balancing ponds and shut-off valves upstream of the outfalls from surface water drainage systems; and
- implementation of an operation and maintenance manual, including emergency response procedures (a draft of which will be included in the ES).

3.3.3 Assessments will be made based on a combination of expert judgement and analysis. They will be conservative, assuming little or no dispersion.

3.3.4 Where flow information for a watercourse is not available from a suitable monitoring location, natural flow estimates will be derived for that location using, where appropriate, either the method in Institute of Hydrology Report 108[3] or from Low Flows or Low Flows Enterprise software, available from Wallingford HydroSolutions Ltd, or an appropriate alternative.

3.4 Screening methodology

3.4.1 A decision matrix demonstrating the screening approach described in paragraphs 3.2.1 and 3.3.1 is presented in Table 1.

Table 1: Water quality assessment screening methodology

	Application of HEWRAT
During Construction	AADT > 10,000 and HGV > 500 and there is a Sensitive Receptor and HGV > 10% Increase from baseline OR AADT > 10,000 and HGV > 500 and HGV > 50% Increase from baseline
Operation	AADT > 10,000 and there is a New Road or Realignment

3.4.2 When undertaking the screening assessment and when applying the any subsequent assessment the traffic data used for each reach of road should conservatively use the highest predicted flow over the construction period or the highest increase relative to the baseline, whichever is the highest, to ensure that the assessment considers a worst-case scenario.

[3] Gustard, A., A. Bullock and J.M. Dixon (1992), *Low flow estimation in the United Kingdom*, Institute of Hydrology Report 108, Wallingford: Institute of Hydrology.

4 Spillage risk methodology

4.1 Railway and associated infrastructure

4.1.1 The risk of pollution from a spillage is primarily a function of trains using the Proposed Scheme. Therefore, spillage risks will be assessed on a route-wide basis. This risk is considered to be very low, as the significant majority of trains will be electric passenger trains with the possible exception of diesel maintenance trains, and the Proposed Scheme will not be used to transport freight[4]. Spillages on the route of the Proposed Scheme are only likely following derailments, collisions, or major on-board incidents, all of which are considered highly unlikely.

4.1.2 If a spillage does occur, it will not necessarily lead to a pollution incident, as the pollutant may not reach a receiving water body. This is because:

- it may be intercepted by sustainable drainage systems, which will be used where reasonably practicable. These will help to remove any pollutants within spillages from the Proposed Scheme through filtration, vegetative adsorption or settlement;
- it may be contained by the pollution control measures included in the design (e.g. balancing ponds, shut-off valves); or
- it may be contained and controlled by the emergency services responding to the incident.

4.1.3 The assessment should take into account any residual risks that exist in spite of these control measures.

4.1.4 At depots and stations, roof drainage is not considered to pose a pollution or spillage risk. Areas draining to a foul sewer do not need to be assessed for the risk of spillages. Remaining areas, such as those used for the storage of potential contaminants, should be assessed using an appropriate combination of expert judgment and analysis.

4.2 Roads

4.2.1 The spillage risks for all roads affected by the Proposed Scheme should be assessed using the methodology set out in the DMRB Volume 11, Section 3, Part 10 (LA 113)[1] Annex I Method D.

[4] Any future changes to the use of the Proposed Scheme (such as for freight transportation) will be required to comply with the Environmental Minimum Requirements (EMR), and specifically the level of impact identified in the original Environmental Impact Assessment (EIA). Should freight transportation be considered in the future, and the updated assessment identify a significant additional adverse effect then pollution prevention measures will have to be agreed with the Environment Agency and applied as appropriate.

4.2.2 Where roads are identified as having an increase in traffic loading as a result of the Proposed Scheme, which results in its annual average equalling or exceeding 500 HGV movements per day, and where there is either a high-value surface water body and a 10% increase in HGV movements or a 50% increase in HGV movements, the spillage risks should be quantified.

4.2.3 Roads where the annual average traffic of HGVs is less than 500 vehicle movements per day are unlikely to pose a significant spillage risk. Quantitative assessment of such roads is not required unless there are local conditions that warrant it. Examples of such conditions could include the use of a road to convey highly-polluting material, or the existence of a clear pathway to a very high value surface water body (e.g. a public water supply, SSSI, SPA, SAC or Ramsar site). Table 2 sets out the proposed assessment criteria. Note that the only difference between the screening criteria for spillage risk assessment and the application of HEWRAT is that a spillage risk assessment is applicable in all cases where the criteria in Table 2 are met, whereas the application of HEWRAT also requires there to be a forecast average annual daily traffic in the proposed scenario of more than 10,000 vehicles per day. As per paragraph 3.4.2, traffic volumes used in the spillage assessment should be the most conservative during the relevant construction or spillage period.

Table 2: Spillage assessment screening methodology

	Application of spillage risk assessment
During Construction	HGV > 500 and where there is a Sensitive Receptor and HGV > 10% Increase from baseline OR HGV > 500 and HGV > 50% Increase from baseline
Operation	HGV > 500 and where there is a New Road or Realignment as part of the Proposed Scheme

5 Other mitigation measures

5.1.1 Other mitigation measures will be identified to avoid, reduce or offset any potentially significant residual pollution or spillage risks identified. These will be described in the formal ES. Reference will be made to pollution prevention guidance, including that available from Netregs[5].

5.1.2 For roads, reference should be made to the DMRB: Volume 4, Section 2, Part 1 (4.2.1) (HA 103/06)[6]; 4.2.3 (HD33/06)[7] and 4.2.8 (HA118/06)[8]. All three documents give examples of measures that can be used to control the effects of routine runoff from highways on receiving water bodies. The first two documents also provide examples of suitable measures to reduce spillage risk from roads.

5.1.3 It is possible that impacts are identified beyond the CCB and outside of the study area where the power to implement other mitigation measures is limited. These locations should be identified in the formal ES as requiring additional provision.

5.1.4 Surface water monitoring may be required to monitor the effectiveness and on-going management of mitigation measures to protect the water environment. Monitoring will be undertaken as part of a wider environmental monitoring strategy and will cover the period before, during and after construction. The purpose of any such monitoring will be to better define the baseline conditions and to monitor the effectiveness of the mitigation measures proposed.

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[5] Netregs Pollution Prevention Guidelines (PPG) and replacement series. Available online at: http://www.netregs.org.uk. GPPs provide environmental good practice guidance for the whole UK, and environmental regulatory guidance directly to Northern Ireland, Scotland and Wales only. Regulatory guidance for England is available from GOV.UK: https://www.gov.uk/guidance/pollution-prevention-for-businesses.

[6] Highways Agency (2009), *Design Manual for Roads and Bridges (DMRB), Volume 4 Section 2 Part 1: HA 103/06 Vegetative Treatment Systems for Highway Runoff.* Highways Agency, London. Available online at: https://www.standardsforhighways.co.uk/dmrb/.

[7] Recently withdrawn and superseded by: Highways England (2019), *Design Manual for Roads and Bridges (DMRB),* Volume 4 Section 2 Part 3: CG 501 Design of highway drainage systems (formerly known as HD33/06 Surface and Sub-surface Drainage Systems for Highways).

[8] Recently withdrawn and superseded by: Highways England (2019), *Design Manual for Roads and Bridges (DMRB),* Volume 4 Section 2 Part 8: CD 530 (formerly known as HA118/06) Design of soakaways.

6 Reporting residual effects

6.1.1 The ES will present any residual effects following the implementation of the mitigation measures included in the design. It will also state whether the other mitigation proposed is likely to be sufficient to fully mitigate the adverse effects identified.

Environmental Impact Assessment Scope and Methodology Report Part 3: Technical note – Water resources and flood risk – Flood risk

Contents

1 Introduction

1.1.1 This technical note describes the approach to flood risk assessment for the Proposed Scheme. It is intended as a guide to ensure a consistent approach to flood risk assessment, not as an exhaustive and prescriptive methodology. It should be read in conjunction with the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR).

1.1.2 The approach to flood risk assessment is based on the Government's planning practice guidance on flood risk and coastal change[1], CIRIA Publication C624 'Development and flood risk: guidance to the construction industry'[2] and the Design Manual for Roads and Bridges (DMRB)[3].

1.1.3 The Environment Agency published guidance ('Flood risk assessments: climate change allowances') in February 2016 based on percentiles from UK Climate Projections 2009 (UKCP09). For the hybrid Bill ES, the 2016 versions of the guidance and allowances will be used as the basis of assessment[4]. This technical note covers how the Environment Agency's guidance should be applied in practice in the flood risk assessments prepared for the Proposed Scheme.

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[1] Department for Communities and Local Government (2017), *Planning practice guidance: flood risk and coastal change.* Available online at: https://www.gov.uk/government/collections/planning-practice-guidance.

[2] CIRIA (2004), *Development and flood risk: guidance to the construction industry, C624.*

[3] Highways Agency (2018), *Design Manual for Roads and Bridges.* Available online at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/.

[4] Environment Agency (2016), Adapting to Climate Change. Advice for Flood and Coastal Erosion Risk Management Authorities. Available online at: https://www.gov.uk/government/publications/adapting-to-climate-change-for-risk-management-authorities.

2 Approach overview

2.1 Introduction

2.1.1 The approach to the flood risk assessment should proceed as follows.

2.2 Step 1: Baseline assessment

2.2.1 All existing potential sources of flooding should be identified, together with the pathways or mechanisms by which they have potential to cause risk to life, economic or environmental damage, disruption or nuisance. All existing property and assets (receptors) at risk from these sources, and their relative vulnerability to flooding impacts, should then be determined. This process is described in Section 3 of this technical note.

2.3 Step 2: Incorporation of flood risk mitigation into the design

2.3.1 The design should be developed using the flood risk baseline as the basis for identification of appropriate flood risk mitigation measures. Section 4 of this technical note outlines the approach to flood risk mitigation that should be adopted, wherever reasonably practicable.

2.4 Step 3: Assessment of impacts and effects

2.4.1 An assessment of the magnitude of the impacts at each receptor, taking into consideration the mitigation measures incorporated into the design, should then be undertaken. The significance of the flood risk issues at affected receptors should be identified, together with suggestions for additional mitigation, where this is necessary to address any potentially significant residual effects identified. This process is described in Section 5 of this technical note.

2.5 Incorporation of climate change allowances

2.5.1 Section 6 outlines how climate change should be factored into the above process.

3 Step 1: Baseline assessment

3.1 Relevant flood sources and pathways

3.1.1 Baseline definition, and scoping of all flood risk issues, is to be undertaken on the basis of existing information in close consultation with flood risk consultees and stakeholders if appropriate, including the Environment Agency, Lead Local Flood Authorities, Canal & River Trust, Internal Drainage Boards and water companies. Key sources of information include:

- the Environment Agency's Flood map for planning (rivers and sea)[5] to scope the baseline flood hazard associated with main rivers and ordinary watercourses;
- the Environment Agency's Risk of flooding from surface water (RoFSW) map[6] to scope surface water flood hazards or the potential flood hazard associated with main rivers and ordinary watercourses in the absence of Environment Agency flood zones;
- reservoir failure flood hazards should be scoped using the Environment Agency Risk of flooding from reservoirs national dataset; and
- the British Geological Survey (BGS) national Susceptibility to groundwater flooding dataset[7], should be used to scope the future risk of groundwater flooding.

3.1.2 This should be supplemented with other information that provides more detailed insight to the baseline that is available from flood risk consultees.

3.1.3 At locations where this scoping exercise identified a potential for the Proposed Scheme to increase flood risk, hydraulic modelling, or other suitable quantitative techniques, should be used to define the baseline in more detail (see section 7).

3.2 Identification of flood risk receptors

3.2.1 Receptors with potential to be affected by the Proposed Scheme will be identified using Ordnance Survey mapping information and address point data. Receptor vulnerability is based on the definitions in Table 2 of the Government’s planning practice guidance on flood risk and coastal change[8].

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[5] Environment Agency's Flood map for planning (rivers and sea). Available online at: https://flood-map-for-planning.service.gov.uk/.

[6] Environment Agency's Risk of flooding from surface water (RoFSW) map. Available online at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/.

[7] British Geological Survey (2020), *Groundwater Flooding.* Available online at: http://www.bgs.ac.uk/products/hydrogeology/groundwaterFlooding.html.

[8] Ministry for Housing, Communities and Local Government (2014), *Guidance: Flood risk and coastal change*. Available online at: https://www.gov.uk/guidance/flood-risk-and-coastal-change.

4 Step 2: Incorporation of flood risk mitigation into the design

4.1 Overall aims

4.1.1 The Proposed Scheme will aim to avoid an increase in the risk of flooding from all sources, taking into account the projected impact of climate change.

4.1.2 Where impacts that could lead to significant flood risk effects are unavoidable, the Proposed Scheme will incorporate mitigation into the design in order to reduce the magnitude of the impact as far as practicable.

4.2 Route selection

4.2.1 The route of the Proposed Scheme has been selected with consideration for the sequential approach advocated in the technical guidance to the National Planning Policy Framework (NPPF)[9]. This approach aims to steer new development to areas with the lowest probability of flooding. Avoidance of areas with a high probability of flooding was a key consideration in the Phase 2 Appraisal of Sustainability[10] and consequently the route of the Proposed Scheme avoids flood zones wherever reasonably practicable. It is recognised within the NPPF that essential transport infrastructure has to cross areas at risk of flooding, for example at river crossings. In such circumstances, the Exception Test requires that it be demonstrated that the infrastructure would be safe from flooding over its lifetime, would not increase flood risk elsewhere and that the wider benefits to society outweigh flood risk. The manner in which the Proposed Scheme aligns with the Sequential Test and Exception Test in the NPPF is outlined in Volume 3 of the Environmental Statement.

4.3 Design standard

4.3.1 The Proposed Scheme will be protected against flooding from any source during the current 1 in 1,000 (0.1%) annual probability flood, with water levels not rising closer than 1m to the top of rail level. Where this is not applicable (for example at tunnel portals) then flood protection measures may be required with appropriate freeboard, depending on local uncertainties and the consequence of design exceedance.

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[9] Ministry for Housing, Communities and Local Government (2014), *Guidance: Flood risk and coastal change.* Available online at: https://www.gov.uk/guidance/flood-risk-and-coastal-change .

[10] Temple and ERM (2012), *Options for Phase 2 of the high speed network – Appraisal of Sustainability.* Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/68981/options-for-phase-two-of-the-high-speed-rail-network-appraisal-of-sustainability.pdf.

4.4 Hydraulic capacity

4.4.1 In locations where the route of the Proposed Scheme will cross watercourses or surface water flow paths, the design aim is for structures to accommodate flood flows up to and including the 1 in 100 (1%) annual probability storm with an appropriate allowance for climate change.

4.4.2 A minimum of 600mm freeboard above the 1 in 100 (1%) annual probability plus climate change flood event has been allowed to the soffit of all bridges and viaducts.

4.4.3 A minimum of 300mm freeboard above the 1 in 100 (1%) annual probability plus climate change flood event has been allowed to the soffit of all culverts.

4.5 Floodplain storage

4.5.1 Watercourse crossings will be designed where reasonably practicable to avoid encroachment into floodplains.

4.5.2 Nevertheless, it is recognised that where the Proposed Scheme crosses areas of floodplain, losses of flood storage may be unavoidable. Whilst individually these losses may not give rise to significant local increases in flood level, cumulatively they can amount to a significant reduction in flood storage volume. This loss of storage volume may lead progressively to increases in flood risk either local to the watercourse crossing or elsewhere within the catchment as a result of a cumulative effect.

4.5.3 Therefore, wherever losses of flood storage are anticipated, regardless of the predicted magnitude of impact within the area of assessment, provision has been made on a precautionary basis to replace this storage at the affected location on a 'volume for volume' and where practicable a 'level for level' basis.

4.5.4 Future design development of flood mitigation should also consider the benefits of nature based approaches to tackling flood risk. At locations where it can be demonstrated through more detailed analysis of the flooding mechanisms that natural flood management strategies have the potential to achieve wider strategic environmental benefits, this should be discussed at the earliest opportunity with the Environment Agency.

4.6 Maintenance access

4.6.1 An appropriate vertical clearance should be provided above floodplain ground level to the underside of viaducts to ensure ac cess to riverbanks for inspection and maintenance purposes. Piers should be set back from the bank top. Specific local details should be agreed with the relevant risk management authority.

4.7 Off-site effects

4.7.1 The design of the Proposed Scheme's drainage systems will ensure that there are no significant increases in flood risk to vulnerable receptors downstream, during storms up to and including the 1 in 100 (1%) annual probability design event, with an allowance for climate change.

5 Step 3: Assessing and reporting residual impacts and effects

5.1.1 Impact magnitude shall be considered in terms of increases in peak flood levels associated with floods with a range of annual probabilities. The significance of the resulting effects on flood risk reflects the vulnerability of the receptor and the magnitude of the predicted impact, as defined by the matrix in Table 1, which is based on Section 21 of the EIA SMR.

Table 1: Significance of flood effects

Receptor value	Magnitude of impact on peak flood levels			
	Negligible (< +/- 10mm)	**Minor > 10mm ≤ 50mm**	**Moderate > 50mm ≤ 100mm**	**Major > 100mm**
Very high (Essential infrastructure or highly vulnerable development)	Negligible - not significant	**Moderate adverse - significant**	**Major adverse - significant**	**Major adverse - significant**
High (More vulnerable development)	Negligible - not significant	**Moderate adverse - significant**	**Moderate adverse - significant**	**Major adverse - significant**
Moderate (Less vulnerable development)	Negligible - not significant	Minor adverse - not significant	**Moderate adverse - significant**	**Moderate adverse - significant**
Low (Water compatible development)	Negligible - not significant	Negligible - not significant	Minor adverse - not significant	Minor adverse - not significant

5.1.2 Recommendations should be made for additional mitigation, where this is necessary to address any potentially significant effects identified. Regardless of the significance of the flood risk effects, the design aim will be to mitigate all impacts on flood risk during design development.

6 Climate change allowances

6.1 Introduction

6.1.1 The additional guidance set out below clarifies how the Environment Agency guidance should be applied in practice to the assessment and design of the Proposed Scheme.

6.2 Peak river flow allowances

Introduction

6.2.1 Peak river flow climate change allowances shall be used for any assessment within a catchment larger than $5km^2$. Where catchment size is less than $5km^2$, the peak rainfall guidance described in section 6.3 shall be used.

6.2.2 The allowances used are selected according to the location (i.e. flood zone), the relevant river basin district (in this case North West) and sensitivity of the individual receptors potentially affected. Table 2 shows the percentages used for each allowance category and which of these allowance categories should be used dependent on the flood zone and sensitivity of receptor.

River basin districts

6.2.3 Table 2 shows the percentage change that shall be applied for each allowance category for North West river basin district.

Table 2: Allowance percentages for each allowance category in North West river basin district

River basin district	Allowance category	Allowance
North West	H++	95%
	Upper end	70%
	Higher central	35%
	Central	30%

Flood zones

6.2.4 The allowance category used depends on the flood zone within which the receptor lies. Except where agreed otherwise with the Environment Agency, the Flood map for planning (rivers and sea) should be used for the purposes of identifying which flood zone each flood risk receptor is located within.

6.2.5 The allowance categories for different flood zones are adapted versions of those described in ‘Flood risk assessments: climate change allowances’ (Environment Agency, 2016). These allowances are primarily designed for new developments, whereas their use in this approach is for both a new development (i.e. the HS2 infrastructure) as well as an assessment of impacts on existing properties or land uses.

6.2.6 The allowance categories that shall be used are shown in Table 3.

Table 3: Allowance categories for each existing property or land use type in different flood zones

Flood Zone	Receptor sensitivity	Allowance category
Flood Zone 2	Essential infrastructure	Upper end
	Highly vulnerable	
	More vulnerable	Higher central
	Less vulnerable	Central
	Water compatible	Central
Flood Zone 3a	Essential infrastructure	Upper end
	Highly vulnerable	
	More vulnerable	
	Less vulnerable	Higher central
	Water compatible	Central
Flood Zone 3b	Essential infrastructure	Upper end
	Highly vulnerable	
	More vulnerable	
	Less vulnerable	
	Water compatible	Central

6.2.7 The upper end allowance should be used on a precautionary basis to assess off-site impacts and calculate floodplain storage compensation regardless of land use in affected areas.

6.2.8 All components of the HS2 railway corridor itself are considered essential infrastructure. Railways, motorways and ‘A’ roads with one or two number identifiers (e.g. A1 or A34) are considered essential infrastructure, while all other roads are considered less vulnerable.

6.2.9 When assessing impacts of flooding on receptors, the sensitivity level used for each assessment will correspond with the existing property or land use with the highest sensitivity within the area considered.

6.3 Peak rainfall

6.3.1 Peak rainfall intensity climate change allowances shall be used for any assessment within a catchment of a size smaller than $5km^2$. Where catchment size is more than $5km^2$, the peak river flow guidance described in section 6.2 of this technical note shall be used.

6.3.2 A peak rainfall intensity allowance of 40% will be used to assess the future performance of track drainage and runoff attenuation elements.

6.3.3 For surface water flow assessments not on permanently flowing watercourses (e.g. dry valleys) the 40% allowance will be used in line with the peak rainfall allowance.

6.3.4 Where no modelling is required based on the outcome of the decision tree, the RoFSW 1 in 1000 (0.1%) annual probability event will be used as a climate change proxy.

6.4 Sensitivity analysis

6.4.1 The H++ scenarios should be used to understand the worst case climatic conditions that the Proposed Scheme could feasibly experience during its design life. Sensitivity analysis using the H++ flooding scenarios should be carried out for all catchments (i.e. peak river flow and peak rainfall).

6.4.2 The H++ scenario assessments should be undertaken using either: expert judgement based on the results of the 2080s assessments (i.e. where it is unlikely that the H++ scenarios will have a significant impact on receptors), or; a further hydraulic modelling assessment using the H++ scenario (i.e. where this is likely to be a significant impact on receptors).

6.4.3 For peak river flow, the H++ scenario allowance category to be used in each river basin district is shown in Table 2.

6.4.4 The H++ scenario for peak rainfall intensity is an allowance of 60%.

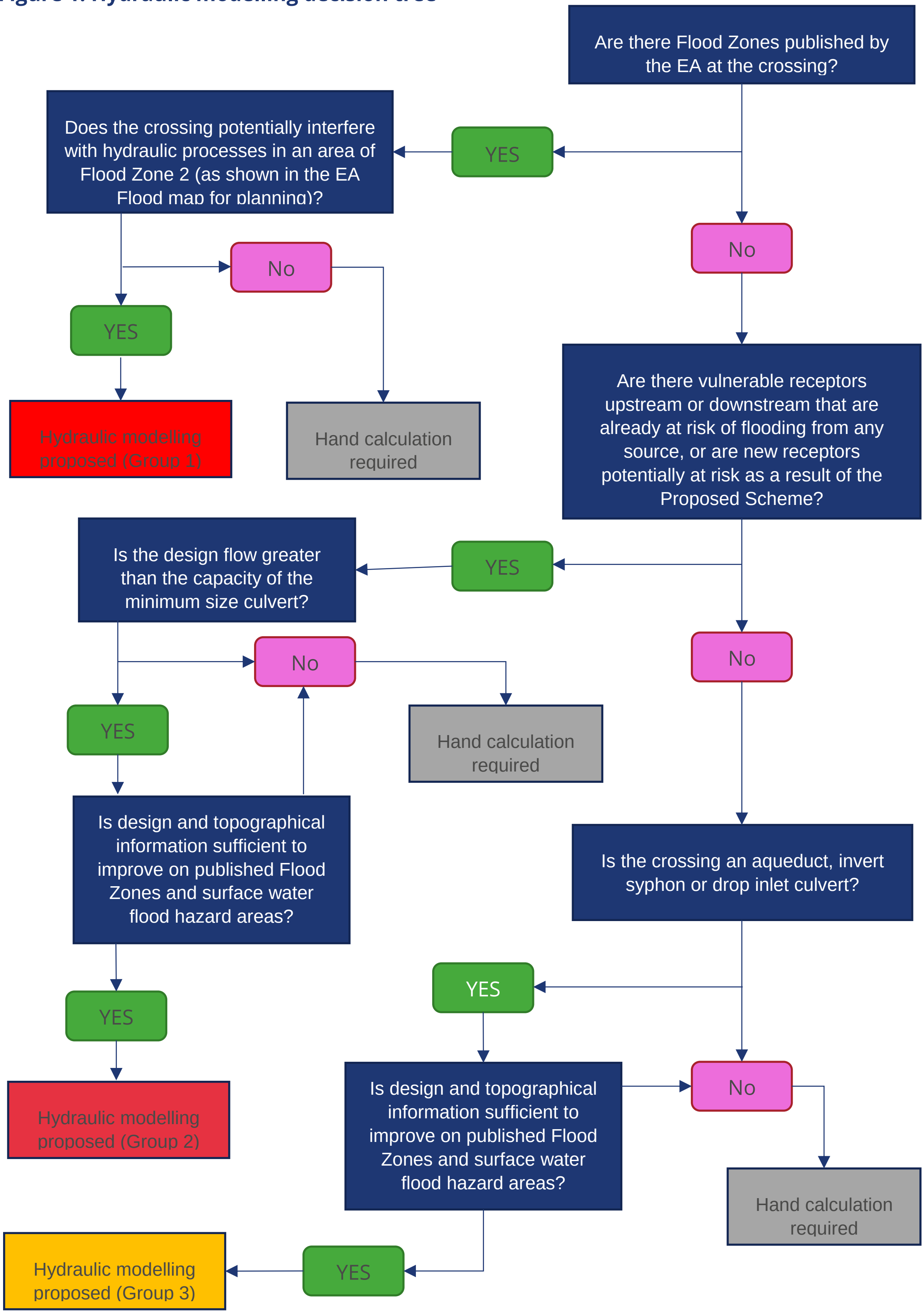
6.4.5 Where sensitivity analysis indicates that the Proposed Scheme could potentially result in new or increased significant effects on receptors under this extreme H++ scenario, the design should be reviewed to ensure that the mitigation is still suitable and that the Proposed Scheme is resilient to changes in climate for different future scenarios.

7 Hydraulic modelling decision tree

7.1.1 The decision tree in Figure 1 sets out the general approach to hydraulic modelling at each watercourse crossing or area of surface water flood hazard. Use of the decision tree results in four possible modelling decisions, as follows:

- **Group 1**: these sites correspond to crossings where there is known fluvial flooding (Flood Zone 2) and the Proposed Scheme has potential to increase associated flood levels. Hydraulic modelling is proposed even if there are no receptors currently at risk, as the hydraulic model can inform the decision to replace a viaduct with a bridge or culvert for cost saving purposes.
- **Group 2**: these sites correspond to crossings where the capacity of the minimum HS2 culvert size is inadequate to convey the peak 1 in 100 (1%) annual probability flow, including an allowance for climate change, where there are receptors with potential to be affected.
- **Group 3**: these sites are where the proposed hydraulic infrastructure is more complex (e.g. inverted siphons) and checks may be required to assess whether the design flows can be conveyed through the Proposed Scheme without causing flooding problems.
- **Group 4**: these sites correspond with straightforward crossings, with no existing flood risk issues, where only hand calculations are required. These are also locations where this represents the best data available subject to more detailed design or topographical survey data being made available.

Figure 1: Hydraulic modelling decision tree



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