A417 Missing Link

Preliminary Environmental Information Report

Chapter 9 Geology and Soils

28 September 2020

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9.1 Introduction

9.1.1 This chapter assesses the potential geology and soils impacts from the construction and operation of the proposed A417 Missing Link (the scheme) following the methodology set out in Design Manual for Roads and Bridges ("*DMRB*") LA 109 *Geology and soils*[1].

9.1.2 This chapter details the methodology followed for the preliminary assessment, summarises the regulatory and policy framework related to geology and soils, and describes the existing environment in the area surrounding the proposed scheme. Following this, the mitigation and preliminary residual effects of the proposed scheme are discussed, along with the limitations of the assessment.

9.1.3 The existing environment in the area surrounding the proposed scheme is considered with regard to:

- bedrock geology and superficial deposits (including geological designations and sensitive/valuable non-designated features);
- soil resources; and
- contamination on human health, surface water and groundwater.

9.1.4 This chapter sets out a baseline conceptual site model with respect to soil and groundwater contamination and identifies plausible contaminant linkages formed due to the construction and/or operational phases of the proposed scheme.

9.1.5 The effects on geomorphology, associated with landforms, are described in Chapter 7 Landscape and visual. Effects on geomorphology, associated with hydromorphology, are described in Chapter 13 Road drainage and the water environment.

9.1.6 The effects on mineral deposits as a resource and the suitability for reuse of soils are described in Chapter 10 Material assets and waste.

9.1.7 The effects on agricultural land holdings and development land and businesses are described in Chapter 12 Population and human health.

9.1.8 Whilst this chapter describes the potential effects on groundwater and surface water quality in a context of land contamination, Chapter 13 Road drainage and the water environment describes the potential effects on groundwater and surface water of drainage and discharge and potential effects on hydrogeology associated with the construction and operation of the proposed scheme.

9.2 Competent expert advice

9.2.1 The Geology and soils lead is a Chartered Geologist and Fellow of the Geological Society of London. They have a MESci (Hons) degree in Geology and MSc in Applied Environmental Geology, both from Cardiff University.

9.2.2 The Geology and Soils co-author is a Chartered Engineer and Member of the Institution of Civil Engineers. They have a MEng (Hons) degree in Environmental Engineering from the Wrocław University of Technology, Poland, and BSc (Hons) degree in Applied Sciences from the University of Glamorgan, Wales.

9.2.3 Full details for both are provided in Appendix 1.2 Competent expert evidence.

9.3 Legislative and policy framework

9.3.1 As discussed in Chapter 1 Introduction, the primary basis for deciding whether or not to grant a Development Consent Order (DCO) is the National Policy Statement for National Networks (NPSNN), which sets out policies to guide how DCO applications will be decided and how the effects of national networks infrastructure should be considered. Table 9-1 identifies the NPSNN policies relevant to geology and soils, and then specifies where in the preliminary environmental information (PEI) report chapter information is provided to address the policy.

Table 9-1 Relevant NPSNN policies for geology and soils assessment

Relevant NPSNN paragraph reference	Requirement of the NPSNN	Where in the PEI report chapter is information provided to address this policy
5.23	*"The applicant should show how the project has taken advantage of opportunities to conserve and enhance (…) geological conservation interests."*	Section 9.9: Design, mitigation and enhancement measures outlines preliminary mitigation measures to conserve and enhance the geological interest at Crickley Hill and Barrow Wake Special site of Scientific Interest (SSSI). Section 9.10: Assessment of likely significant effects includes a detailed preliminary assessment of the impacts on existing geological exposures at Crickley Hill from construction and operation of the proposed scheme.
5.168	*"Applicants should take into account the economic and other benefits of the best and most versatile agricultural land (defined as land in grades 1, 2 and 3a of the Agricultural Land Classification). Where significant development of agricultural land is demonstrated to be necessary, applicants should seek to use areas of poorer quality land in preference to that of a higher quality. Applicants should also identify any effects, and seek to minimise impacts, on soil quality, taking into account any mitigation measures proposed. Where possible, developments should be on previously developed (brownfield) sites provided that it is not of high environmental value. For developments on previously developed land, applicants should ensure that they have considered the risk posed by land contamination and how it is proposed to address this."*	Section 9.7: Baseline conditions identifies the Agricultural Land Classification (ALC) for land current and historical potential sources of land affected by the proposed scheme. Current and historical sources of land contamination within the study area are also identified in this section and in Appendix 9.7 Geo-environmental assessment technical note. Section 9.8: Potential impacts considers the potential impacts on agricultural land and the potential pollutant linkages during construction and operation of the proposed scheme without mitigation. Section 9.9: Design, mitigation and enhancement measures sets out headline actions, principles and mitigation in relation to prevention and control of contamination and how effects on soil resources would be mitigated. These will also be included in an Environmental management plan (EMP), which will be submitted as part of the DCO application. Section 9.10: Assessment of likely significant effects assesses the impacts on best and most versatile agricultural land and contamination risks during construction and operation of the proposed scheme.

9.3.2 The following sub-sections present the wider legislation and policy relevant to the assessment of geology and soils.

Legislation

9.3.3 Geological sites of national importance are principally afforded protection under the *Wildlife and Countryside Act 1981* (as amended) or the *National Parks and Access to the Countryside Act 1949* by designation as Site of Special Scientific Interest (SSSI) or National Nature Reserve (NNR). In addition, the Joint Nature Conservation Committee (JNCC) have carried out a Geological Conservation Review (GCR) and Earth Science Conservation Review (ESCR) to identify the best and most representative earth science sites in Great Britain, with a view to their long-term conservation. Although GCR/ESCR identification does not itself give any statutory protection, many GCR/ESCR sites have been notified as SSSIs.

9.3.4 Environmental legislation and regulation provide separate drivers to manage contamination. The main legislative drivers for managing risks to human health and the environment from land contamination are:

- Part IIA of the Environmental Protection Act (1990);
- Contaminated Land Regulations (2012);
- Environment Act (1995); and
- Environmental Permitting Regulations (2016) as amended.

9.3.5 Under Part IIA of the *Environmental Protection Act*, sites are identified as 'contaminated land' if they are causing, or if there is a significant possibility of causing significant harm to human health or significant pollution of controlled waters, as defined by Section 104 of the *Water Resources Act 1991*. In general terms, the legislation advocates the use of a risk assessment approach for the assessment of contamination and remedial requirements.

9.3.6 A list of additional key legislation considered within the assessment relating to contamination include:

- Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009;
- *EU Water Framework Directive (WFD) 2000/60/EC* (as amended by supplementary directives and decisions);
- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 which implement Water Framework Directive (2000/60/EC), and transpose aspects of the Groundwater Directive (2006/118/EEC) and the Priority Substances Directive (2008/105/EC);
- The Environmental Permitting Regulations 2016 (as amended in 2018 and 2019), which amend the Environmental Permitting (England and Wales) Regulations SI 2010/675. The 2010 regulations revoked the Groundwater Regulations (England and Wales) 2009, originally implemented in the Groundwater Directive;
- Groundwater Daughter Directive (GWDD) (2006/118/EC);
- Department for Environment Food and Rural Affairs (Defra) (2015) The Water Framework Directive (Standards and Classification) Directions (England and Wales); and
- The Environmental Damage (Prevention and Remediation) Regulations 2009.

National and regional policy

9.3.7 In addition to the NPSNN, this PEI report also considers the *National Planning Policy Framework* (NPPF)[2] and relevant Planning Practice Guidance (PPG), which emphasises the need for sustainable development in terms of the resources used, the maintenance of the environment, the economic use of land and consideration of society in the general area. The importance for the restoration of derelict and contaminated land is stated.

9.3.8 In relation to conserving and enhancing the natural environment, the NPPF states that impacts on geodiversity should be reduced by preventing harm to geological conservation interests. In the UK, geological sites are afforded consideration at a local level by designation, including:

- Geological Conservation Review (GCR) sites (England, Scotland, Wales);
- Geoparks;
- Regionally Important Geological and Geomorphological Sites (RIGS);
- Locally Important Geological and Geomorphological Sites (LIGS);
- Sites of Importance for Nature Conservation (SINC).

9.3.9 Regarding development on land affected by contamination, the NPPF emphasises the requirement to understand the ground risks, and on the development of appropriate remediation to make ground hazards material considerations during the planning process.

9.3.10 The NPPF states that planning policies and decisions should contribute to and enhance the natural and local environment by preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of land instability.

9.3.11 It also states that planning policies and decisions should ensure that a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation).

9.3.12 Whilst the environmental impact of certain ground risks, such as contaminated land, are considered within this chapter, the direct environmental impacts of land instability are excluded from this chapter in accordance with DMRB LA 109 *Geology and soils*, which states; "*Risks associated with geotechnical hazards and land stability are assessed in CD622, Managing geotechnical ris*k."

9.3.13 Indirect impacts associated with land stability mitigation, such as damage to the landscape or ecological receptors have been considered within their respective chapters.

Local policy

9.3.14 The *Cotswold District Local Plan to 2031*[3] provides guidance for development planning within the Cotswolds Area of Outstanding Natural Beauty (AONB). It provides information on the spatial strategy and emphasises the value and sensitivity of geodiversity, including guidance on the protection of geodiversity in accordance with international, national and local status and recommends mitigation.

9.3.15 Development shall conserve and enhance biodiversity and geodiversity, avoid adverse impact on existing features as a first principle and enable net gains by

designing in opportunities for geological conservation alongside new development. Appropriate mitigation or compensation would be required to enable the benefits of a development at a nationally designated site to clearly outweigh the impact it is likely to have on the special features and national network of SSSI.

9.3.16 The *Cotswolds AONB Management Plan (2018-2023)* [4] highlighted the following special qualities of the Cotswolds (relevant to geology and soils):

- limestone geology – including its visible presence as natural and artificial outcrops (i.e. worked ground such as quarries and road cuttings), use as building material, and through the plant and animal communities it supports, e.g. internationally important flower-rich limestone grasslands and ancient broadleaved woodland;
- the Cotswold escarpment – including views to and from it;
- the High Wolds – a large open, elevated landscape with commons, 'big' skies and long-distance views; and
- river valleys – the majority forming the headwaters of the Thames, with high quality water.

9.3.17 The *Tewkesbury Local Borough Plan to 2011*[5] Policy NCN3 and Pre-Submission version of the *Tewkesbury Borough Plan* (PSTBP)[6] Policy NAT1 is relevant to geodiversity and applies to designated geological sites. It states that development likely to result in the loss, deterioration or harm to features of importance to geological conservation, either directly or indirectly, would not be permitted unless:

- the need for, and benefits of, the development clearly outweigh its likely impact on the local environment, or the nature conservation value or scientific interest of the site;
- it can be demonstrated that the development could not reasonably be located on an alternative site with less harmful impacts; and
- measures can be provided (and secured through planning conditions or legal agreements), that would avoid, mitigate against or, as a last resort, compensate for the adverse effects likely to result from development.

9.3.18 The *Gloucester, Cheltenham and Tewkesbury Joint Core Strategy* (JCS) [7] 2011-2031 (adopted December 2017) presents a coordinated strategic development plan for 2011 to 2031 for the three authorities. The following policies are relevant to geology and soils:

- Policy SD6: new developments should seek to protect the character of the landscape, considering the landscape and visual sensitivity of the area.
- Policy SD7: all development proposals in or within the Cotswolds AONB will be required to conserve and, where appropriate, enhance its landscape, scenic beauty, wildlife, cultural heritage and other special qualities, consistent with the policies set out in the Cotswolds AONB Management Plan.
- Policy SD9: the biodiversity and geological resource of the JCS area should be conserved and enhanced on designated sites, ensuring that new development within and surrounding such sites has no unacceptable adverse impacts. New development should be encouraged to contribute positively to biodiversity and geodiversity whilst linking with wider networks of green infrastructure. A Geodiversity Action Plan is likely to be developed for Gloucestershire that will provide more detailed advice on the conservation of geodiversity. Developers and local authorities should work with appropriate

partner organisations including the Local Nature Partnership and Gloucestershire Geology Trust to deliver enhancements.

9.3.19 Local Planning Authority flood management plans and policies, as detailed in Appendix 13.1 Water legislative and policy framework of Chapter 13 Road drainage and the water environment, have been considered.

Guidance and standards

9.3.20 This PEI report is undertaken with due consideration of the following:

- *Geotechnics, General Information, Managing Geotechnical Risk*, CD 622, (formerly DMRB Volume 4, Section 1, Part 2 HD 22/08) [8];
- LA 104 Environmental assessment and monitoring[9];
- LA 109 Geology and Soils[10];
- *Contaminated Land Statutory Guidance*, Department for Environment, Food and Rural Affairs (Defra), 2012[11];
- *Model Procedures for the Management of Land Contamination (CLR11)* Defra and Environment Agency, 2004 (The guidance is currently under review and will be withdrawn in 2020 and replaced by the updated online guidance called *Land contamination: risk management*[12], which is currently available as draft for consultation);
- CIRIA R132: A Guide for Safe Working on Contaminated Sites[13];
- CIRIA SP73: Roles and Responsibility in Site Investigations[14];
- BS 5930: 2015: Code of Practice for Site Investigations[15];
- BS 10175:2011 + A1 2013: Code of Practice for Investigation of Potentially Contaminated Sites[16];
- Groundwater protection guidance[17], including The Environment Agency's approach to groundwater protection[18];
- CIRIA C552: Contaminated Land Risk Assessment, A guide to good practice[19];
- CIRIA C681: Unexploded ordnance (UXO) A guide for the construction industry[20];
- CIRIA C733: Asbestos in soil and Made Ground: a guide to understanding and managing risks[21];
- CIRIA C765: Asbestos in soil and Made Ground: good practice site guide[22]; and
- Eurocode 7 (BS EN 1997-1[23] and EN 1997-2[24]) and all relevant normative guidance.

9.4 Assessment methodology

9.4.1 The methodology for assessing the construction and operational impacts for geology and soils is in accordance with LA 104 *Environmental assessment and monitoring*[25] and LA 109 *Geology and soils*[26] is summarised below:

- undertake desk-based review and historical information review;
- establish outline study area and baseline scenario;
- establish the potential for significant effects based on the scoping questions in LA 109 *Geology and soils*;
- where likely significant effects are identified, complete a detailed baseline scenario;
- finalise study area based on proposed scheme design and baseline scenarios;
- establish design and mitigation measures;

- undertake assessment of likely significant effects; and
- undertake monitoring where significant effects are reported.

9.4.2 Refer to Appendix 9.6 Detailed assessment methodology for contaminated land for further details on the assessment methodology for contaminated land.

Identification of baseline conditions

9.4.3 The scope of the baseline studies for specific topic areas is listed in Table 9-2. The identification of baseline conditions for geology and soils is primarily based on desk study information included within Appendix 9.2 Preliminary Sources Study Report (PSSR) and available ground investigation information obtained up to 1 November 2019.

9.4.4 The PSSR considered two route options, termed option 12 and option 30, as the report predated the preferred route announcement in March 2019. Highways England has since progressed the proposed scheme design based on option 30. The options assessment process is set out in Chapter 3 Assessment of alternatives.

Table 9-2 Scope of baseline studies

Topic	References
Geology	• Mott MacDonald Sweco Joint Venture (2018). A417 Missing Link Preliminary Sources Study Report. (HA GDMS Ref 30509); • Edward J Wilson and Associates (1990) Addendum to Geomorphological Survey at Crickley Hill (A417) (HA GDMS Ref 21576); • Edward J Wilson and Associates (1988) Report on Geomorphological Survey at Crickley Hill (A417) (HA GDMS Ref 12609). • Relevant historical geomorphological maps extracted from these reports are provided within Historical Geomorphological Plans (Appendix 9.3). • A417 Crickley Hill Improvements – Geotechnical Investigations and Proposed schemes for Road Widening on the northern Valley Side, report by Professor John Hutchinson (1991)27 (HA GDMS Ref 12597); • WSP (2002) A417Crickley Hill Improvement scheme Preliminary Sources Study (HA GDMS Ref 16772)[28]; • WSP (2003) A417 Cowley to Brockworth bypass Improvement Preliminary Sources Study Report (HA GDMS Ref 18693[29]; and • WSP (2004) A417 Cowley to Brockworth bypass Improvement Geomorphological Survey Report (HA GDMS Ref 18694)[30]. • British Geological Survey (BGS) 1:50,000 scale geological map of Gloucester (Solid and Drift) Sheet 234[31]; • BGS 1:50,000 scale digital geological map, available on the 'Onshore GeoIndex' viewer[32]; • BGS 1:10,560 scale geological maps of Gloucestershire Sheet SO91SW33 and SO91NW[34]; • BGS Bristol and Gloucester regional geology guide, 3rd edition[35]; • Geology of the Cirencester district: BGS memoir for 1:50,000 geological sheet 235[36]; • Topographic survey undertaken for the proposed scheme; • Available information from recent ground investigations included in Appendix 9.4 Ground investigation reports*; • Findings from site walkovers carried out in August 2019 and October 2019, reported in the Geotechnical Interpretative Report (to be submitted with the ES); and • Information from historical ground investigations, listed in Appendix 9.1 Baseline scenarios; and Historical borehole records available from BGS Onshore GeoIndex[37]. * The ground investigation undertaken up to November 2019 has been included in the assessment. The exact details of the methodology employed by the ground investigation and geophysics contractors are described within their respective factual reports.
Current and historical land use	• Envirocheck report for Crickley Hill – A417. Reference 213224-1-1, prepared by Landmark Information Group (2002); • Groundsure Envirosight: A417 Missing Link. Reference COGL14R011, prepared by Groundsure Environmental Intelligence Solutions (2014); • Findings from a site walkover carried out in April 2017, reported in Appendix 9.2 Preliminary sources study report; • Groundsure Enviro Insight reports (2019) for A417 Missing Link. Reference ARUP_1, ARUP_2, ARUP_3, prepared July 2019 – included as Appendix 9.5 Groundsure enviro insight reports;

Topic	References
	• Findings from recent geo-environmental investigations carried out in 2019, reported within Appendix 9.7 Geo-environmental assessments technical note.
Soil survey	• N A Duncan and Associates (2004) A417 Cowley to Brockworth Bypass Improvement, Soil and Agricultural Land Classification Report[38]; • WSP (2006) A417 Cowley to Brockworth Bypass Improvement Scheme Stage 2 Land Use Report[39]; and • Natural England 1:250,000 Agricultural Land Classification Map South-West Region (ALC006)[40].

Assessment of likely significant effects

9.4.5 The process for assessment of likely significant effects is outlined as follows:

- Step 1: assess the value (sensitivity) of receptors, shown in Table 9-3, as per Table 3.11 in LA 109 *Geology and soils*.
- Step 2: assess the magnitude of impact on receptors, shown in Table 9-4, as per Table 3.12 in LA 109 *Geology and soils*.
- Step 3: derive impact significance from receptor value and magnitude of impacts, shown in Table 9-5, as per Table 3.8.1 in LA 104 *Environmental assessment and monitoring*. The significance of effect is determined by comparison of the identified value (sensitivity) of the receptors with the magnitude of the effect. For the purpose of this assessment, values of moderate adverse and above have been defined as significant effects, and mitigation measures are necessary.

Table 9-3 Environmental value (sensitivity) and descriptions of geology and soils receptors (from Table 3.11 in LA 109 Geology and soils)

Receptor value (sensitivity)	Receptor type	Description
Very high	Geology	Very rare and of international importance with no potential for replacement (e.g. UNESCO World Heritage Sites, UNESCO Global Geoparks, SSSIs and GCR where citations indicate features of international importance). Geology meeting international designation citation criteria which is not designated as such.
	Soils	1) soils directly supporting an EU designated site (e.g. Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar); and/or 2) ALC grade 1 and 2 or Land Capability for Agriculture (LCA) grade 1 and 2
	Contamination	1) human health: very high sensitivity land use such as residential or allotments; 2) surface water: refer to Chapter 13 Road drainage and the water environment; and 3) groundwater: refer to Chapter 13 Road drainage and the water environment.
High	Geology	Rare and of national importance with little potential for replacement (e.g. geological SSSI, Area of Special Scientific Interest (if in Northern Ireland), NNR). Geology meeting national designation citation criteria which is not designated as such.

Receptor value (sensitivity)	Receptor type	Description
	Soils	1) soils directly supporting a UK designated site (e.g. SSSI); and/or 2) ALC grade 3a, or LCA grade 3.1
	Contamination	1) human health: high sensitivity land use such as public open space; 2) surface water: refer to Chapter 13 Road drainage and the water Environment; and 3) groundwater: refer to Chapter 13 Road drainage and the water environment.
Medium	Geology	Of regional importance with limited potential for replacement (e.g. RIGS). Geology meeting regional designation citation criteria which is not designated as such.
	Soils	1) soils supporting non-statutory designated sites (e.g. Local Nature Reserves (LNR), Local Geological Sites (LGS), Sites of Nature Conservation Importance (SNCI)); and/or 2) ALC grade 3b or LCA grade 3.2.
	Contamination	1) human health: medium sensitivity land use such as commercial or industrial; 2) surface water: refer to Chapter 13 Road drainage and the water environment; and 3) groundwater: refer to Chapter 13 Road drainage and the water environment.
Low	Geology	Of local importance/interest with potential for replacement (e.g. non-designated geological exposures, former quarries/mining sites).
	Soils	1) ALC grade 4 and 5 or LCA grade 4.1 to 7; and/or 2) Soils supporting non-designated notable or priority habitats.
	Contamination	1) human health: low sensitivity land use such as highways and rail; 2) surface water: refer to Chapter 13 Road drainage and the water environment; and 3) groundwater: refer to Chapter 13 Road drainage and the water environment.
Negligible	Geology	No geological exposures, little/no local interest.
	Soils	Previously developed land formerly in 'hard uses' with little potential to return to agriculture.
	Contamination	1) human health: undeveloped surplus land/no sensitive land use proposed; 2) surface water: refer to Chapter 13 Road drainage and the water environment; and 3) groundwater: refer to Chapter 13 Road drainage and the water environment.

Table 9-4 Magnitude of impact and typical descriptions (from Table 3.12 in LA 109 *Geology and soils*)

Magnitude of impact (change)	Receptor type	Typical description
Major	Geology	Loss of geological feature/designation and/or quality and integrity, severe damage to key characteristics, features or elements.
	Soils	Physical removal or permanent sealing of soil resource or agricultural land (>20ha).
	Contamination	1) human health: significant contamination identified. Contamination levels significantly exceed background levels and relevant screening criteria (e.g. category 4 screening levels) with potential for significant harm to human health. Contamination heavily restricts future use of land; 2) surface water: refer to Chapter 13 Road drainage and the water environment; and 3) groundwater: refer to Chapter 13 Road drainage and the water environment.
Moderate	Geology	Partial loss of geological feature/designation, potentially adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements.
	Soils	Permanent loss/reduction of one or more soil function(s) and restriction to current or approved future use (e.g. through degradation, compaction, erosion of soil resource.), Including: 1) physical removal or permanent sealing of 1ha-20ha of agricultural land; or 2) permanent loss/reduction of one or more soil function(s) and restriction to current or approved future use (e.g. through degradation, compaction, erosion of soil resource).
	Contamination	3) human health: contaminant concentrations exceed background levels and are in line with limits of relevant screening criteria (e.g. category 4 screening levels). Significant contamination can be present. Control/remediation measures are required to reduce risks to human health/make land suitable for intended use; 4) surface water: refer to Chapter 13 Road drainage and the water environment; and 5) groundwater: refer to Chapter 13 Road drainage and the water environment.
Minor	Geology	Minor measurable change in geological feature/designation attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements.
	Soils	Temporary loss/reduction of one or more soil function(s) and restriction to current or approved future use (e.g. through degradation, compaction, erosion of soil resource.)
	Contamination	1) human health: contaminant concentrations are below relevant screening criteria (e.g. category 4 screening levels). Significant contamination is unlikely with a low risk to human health. Best practice measures can be required to minimise risks to human health; 2) surface water: refer to Chapter 13 Road drainage and the water environment; and

Magnitude of impact (change)	Receptor type	Typical description
		3) groundwater: refer to Chapter 13 Road drainage and the water environment.
Negligible	Geology	Very minor loss or detrimental alteration to one or more characteristics, features or elements of geological feature/designation. Overall integrity of resource not affected.
	Soils	No discernible loss/reduction of soil function(s) that restrict current or approved future use.
	Contamination	1) human health: contaminant concentrations substantially below levels outlined in relevant screening criteria (e.g. category 4 screening levels). No requirement for control measures to reduce risks to human health/make land suitable for intended use; 2) surface water: refer to Chapter 13 Road drainage and the water environment; and 3) groundwater: refer to Chapter 13 Road drainage and the water environment.

Table 9-5 Significance matrix (from Table 3.8.1 of LA 104 *Environmental assessment and monitoring*)

		Magnitude of impact (degree of change)				
		No change	Negligible	Minor	Moderate	Major
Environmental value (sensitivity)	Very high	Neutral	Slight	Moderate or large	Large or very large	Very large
	High	Neutral	Slight	Slight or moderate	Moderate or large	Large or very large
	Medium	Neutral	Neutral or slight	Slight	Moderate	Moderate or large
	Low	Neutral	Neutral or slight	Neutral or slight	Slight	Slight or moderate
	Negligible	Neutral	Neutral	Neutral or slight	Neutral or slight	Slight

Consultation

9.4.6 Consultations with Natural England, the National Trust, the Environment Agency and Gloucestershire County Council have informed the development of the geology and soils assessment. These discussions have focused on the geodiversity and environmental aspects of the proposed scheme.

9.5 Assessment assumptions and limitations

General

9.5.1 The assessment undertaken for geology and soils has been based on the collation and evaluation of available documentation listed in Table 9-2.

9.5.2 The Phase 2A ground investigation is ongoing at the time of writing. The ground investigation information available up to 1 June 2020 has been used to inform the preliminary assessment. This is considered sufficient to undertake the assessments in accordance with current DMRB standards (LA 109 *Geology and*

soils). These standards require the baseline scenario to be informed by desk study information presented in a PSSR and existing survey data, where available.

Soils

9.5.3 The assessment of ALC in this PEI report has been based on a combination of several sources of information, as described in paragraph 9.7.31.

9.5.4 The assessment of the likely effects on agricultural land would rely on the accuracy of these datasets and information as provided by third parties.

9.5.5 A detailed assessment of land take, including consideration of subgrades 3a and 3b land, and therefore best and most versatile (BMV) land, was possible using the post-1988 and 2004 datasets, but these only covered a limited section of the proposed scheme.

9.5.6 For parts of the proposed scheme where only pre-1988 data were available, it was not possible to distinguish between subgrades 3a and 3b land. For these parts of the proposed scheme, it has been assumed that all Grade 3 land is subgrade 3a, and therefore BMV land.

9.5.7 This baseline represents a 'reasonable worst case'. An ALC survey will be carried out to inform the ES to provide more accurate information on the agricultural grade of the land. The planned ALC survey would either confirm the 'reasonable worst-case' baseline, or more likely, demonstrate an improvement on the findings of the assessment.

Contamination

9.5.8 In areas of land that would be temporarily acquired, soils would be managed in accordance with Defra (2009) *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites*[41] and restored to the reasonable satisfaction of the owners of the land.

9.5.9 It is assumed that prior to completion of construction, the areas adjacent to the proposed scheme used for access, egress and other associated construction works would be restored to the reasonable satisfaction of the owners of the land.

9.5.10 It is assumed that potential effects on human health (e.g. construction and maintenance workers) would be mitigated through adherence to all relevant legislation and best practice with respect to health and safety management; including the *Construction (Design and Management) Regulations* (CDM) 2015 and the *Control of Substances Hazardous to Health Regulations* (COSHH) 2002, as amended.

9.6 Study area

9.6.1 The proposed scheme study area for this chapter comprises the DCO boundary and an additional buffer of 500 metres, as shown in Figure 9.1. This area is considered appropriate for the consideration of historical and current potentially contaminative land uses, which could be impacted by, or impact on, the proposed scheme. Where there is potential for sources of contamination outside the 500-metre buffer to migrate on-site, these have been included in the assessment and presented in the PEI report.

9.6.2 This area also considers the location of sensitive receptors that could be affected by the proposed scheme (such as controlled water receptors like aquifers and surface water below/down-gradient of study area, water abstraction points including Source Protection Zones (SPZ), or land users and neighbours). The

potential receptors have been identified and are listed in Chapter 13 Road drainage and the water environment.

9.6.3 For other receptors, including designated geological sites and BMV agricultural land, the study area comprises the DCO boundary, as these receptors are only likely to be impacted where the proposed scheme directly crosses, or interfaces with them.

9.7 Baseline conditions

Current baseline

9.7.1 The assessment of baseline scenarios is described in full in Appendix 9.1 Baseline scenarios and summarised in this section.

Geological setting

9.7.2 The south-west to north-east trending Cotswolds Escarpment dominates the regional landscape[42]. The study area comprises an asymmetrical valley adjacent to Crickley Hill, where the northern slopes are steeper than the southern slopes. The existing A417 runs along the axis of this valley. Above the escarpment, the landscape comprises an extensive limestone plateau. The topography is presented within Figure 9.2.

Artificial ground

9.7.3 Artificial ground' is a term used by the BGS for those areas where the ground surface has been significantly modified by human activity. The term includes:

- Made ground — man-made deposits such as embankments and spoil heaps on the natural ground surface;
- Worked ground — areas where the ground has been cut away such as quarries and road cuttings;
- Infilled ground — areas where the ground has been cut away then wholly or partially backfilled;
- Landscaped ground — areas where the surface has been reshaped; and
- Disturbed ground — areas of ill-defined shallow or near surface mineral workings where it is impracticable to map made and worked ground separately.

9.7.4 The study area is predominantly agricultural land, where artificial ground is rarely encountered. The artificial ground present in the study area is typically associated with the existing A417, near access roads or embankments. Previous studies indicated the presence of 'filled ground' at Grove Farm/Crickley Hill Tractors (see Appendix 9.3 Historical geomorphological plans). This area was used as a site compound during the improvement works undertaken on the existing A417 in the 1960s. The locations of Made Ground encountered during recent and historical ground investigations are presented in Figure 9.7.

Superficial deposits

9.7.5 Cheltenham Sand and Gravel is mapped in the western part of the proposed scheme. These deposits are interpreted as products of erosion of the Cotswold escarpment and may have been deposited as alluvial fans, mixed with wind-blown sand.

9.7.6 Alluvium is likely to be deposited within the narrow valley of the Norman's Brook tributary.

9.7.7 ‘Mass movement deposits’, comprising a well-graded mixture of material derived from the underlying bedrock and accumulated through slope processes, such as landsliding, hillwash, and soil creep, is mapped within the valley adjacent to Crickley Hill and the Churn valley near Shab Hill. Locally, ‘mass movement deposits’ may contain lenses of peat or organic material.

9.7.8 Tufa is commonly deposited around springs and streams in the Cotswolds. It is formed from alkaline waters, supersaturated with calcite. On emergence from the ground, waters release carbon dioxide due to the lower atmospheric partial pressure of carbon dioxide, resulting in an increase in pH. Since carbonate solubility decreases with increased pH, precipitation is induced. Tufa formation process is described in more detail in Chapter 13 Road drainage and the water environment. Tufa deposits may support specialised habitats. These are considered in Chapter 8 Biodiversity.

Bedrock geology

9.7.9 The proposed scheme is underlain by rocks of the Jurassic Lias Group, Inferior Oolite Group, and Great Oolite Group, as presented in Figure 9.3. The western part of the proposed scheme study area is underlain by the Lias Group, but the bedrock is largely buried under a cover of ‘mass movement deposits’. The Inferior Oolite Group overlies the Lias Group in the Crickley Hill area. The Great Oolite Group, which in turn overlies the Inferior Oolite Group, outcrops near Shab Hill Farm.

9.7.10 The proposed scheme is anticipated to encounter three north-west to south-east trending normal faults, namely the Shab Hill Barn, Shab Hill, and Stockwell faults, shown in Figure 9.3. It is thought that all the bedrock strata underlying the proposed scheme would be affected by faulting, which may result in increased fracturing within the bedrock and the creation of preferential pathways for groundwater flow. Refer to Chapter 13 Road drainage and the water environment for more details.

9.7.11 Cavities, gulls and fissures are anticipated close to the edge of the Cotswold escarpment, predominantly within the Inferior Oolite Group. The formation of gulls and fissures is associated with cambering and dissolution of the limestone bedrock and may be enhanced by this process.

Hydrology and hydrogeology

9.7.12 The hydrological and hydrogeological baseline conditions are described in full in Chapter 13 Road drainage and the water environment. A summary is provided in this chapter and Appendix 9.1 Baseline scenarios.

9.7.13 The Norman’s Brook tributary is a stream running from east to west below Crickley Hill and is primarily groundwater fed. It is connected to the River Severn and rises from springs on the escarpment. A small stream was also noted above the escarpment, immediately south of Birdlip junction, which is possibly associated with the Churn valley near Shab Hill.

9.7.14 The limestones of the Great Oolite and Inferior Oolite groups are classified as Principal Aquifers, separated by the less permeable Fuller’s Earth Formation. The Lias Group is classified as a Secondary (undifferentiated) Aquifer. The Bridport Sand Formation (the uppermost formation in the Lias) is considered to be in hydraulic continuity with the Inferior Oolite aquifer, though the available ground investigation findings suggest it is not laterally persistent within the study area.

9.7.15 Groundwater flow is largely through secondary fractures and fissures, which can be enhanced by dissolution. Fracture density, and therefore groundwater flow, increases towards the edge of the escarpment due to cambering and gull-formation within the limestone. The Fuller's Earth Formation acts as an aquitard between the Great Oolite and Inferior Oolite, with localised leakage likely to occur where it thins, fractures, or becomes faulted.

9.7.16 Groundwater springs and seepages in the study area generally occur locally at the contact between the more impermeable mudstones in the Upper Lias, and the more permeable limestones of the Inferior Oolite Group or Bridport Sand Formation, and between the limestones of the Great Oolite Group and mudstones of the Fuller's Earth Formation. Springs also emanate from the 'mass movement deposits' found on the slopes along the Cotswold escarpment and Crickley Hill, where preferential flow paths have developed through more permeable zones of the mixed material. However, the flow pathways are complicated by cambering of the limestone bedrock and the disturbed nature of the 'mass movement deposits'.

Ground investigations

9.7.17 Several historical ground investigations have been undertaken within the study area, as summarised in Appendix 9.2 Preliminary Sources Study Report. The locations of the ground investigations are shown in Figure 9.4. The findings from these ground investigations have been reviewed to inform the baseline scenarios in this chapter, as presented in Appendix 9.1 Baseline scenarios.

9.7.18 A description of the ground investigations is presented here:

Phase 1 investigations

- The Phase 1 ground investigation was completed in February 2019. This comprised 8No. boreholes within the scheme alignment and its vicinity. The primary purpose of this investigation was to provide initial information on the hydrogeological setting of the scheme. Factual information is presented within the factual GI report43 enclosed in Appendix 9.4 of the PEI report. The locations of the exploratory holes are also shown on Figure 9.4 of the PEI report.

Phase 2A investigations

- Phase 2A investigations the initial scope of the Phase 2 investigations was compiled, as detailed in the ground investigation specification[44]. Exploratory holes were completed across the areas of Crickley Hill and Air Balloon as part of an early outline design input. The purpose of the Phase 2 investigation was to inform the design and environmental impact assessments with respect to ground hazards (including land contamination) and hydrogeology.

9.7.19 The existing ground investigation information has generally confirmed that the site (other than the areas of existing highway) is predominantly underlain by natural soils, with minor areas of Made Ground identified.

9.7.20 The results from the recent geo-environmental investigations are discussed in detail within Appendix 9.7 Geo-environmental assessment technical note. On receipt of data from the on-going Phase 2A investigations, these assessments will be reviewed and presented as part of the draft Ground Investigation Report and will be included within the Environmental Statement.

9.7.21 Further proposed scheme specific intrusive investigations will provide supplementary information on the ground conditions across the proposed scheme. The primary objective of these investigations is to inform the design. An interpretation of the findings would be presented in a Ground Investigation Report on completion of the Phase 2A investigations. Information obtained from these investigations and the future ground investigations, including the results of soils and groundwater chemical analysis would be used to support the detailed design stage prior to construction.

Geological designated sites

9.7.22 Crickley Hill and Barrow Wake SSSI and Knap House Quarry SSSI are designated geological SSSIs located within the study area, as shown in Figure 9.5. Both SSSIs are also designated as GCR sites. Crickley Hill and Barrow Wake SSSI is also a designated biological SSSI.

9.7.23 The southern slopes of Crickley Hill exhibit the best sections in the Cotswolds of the Crickley Member (formerly 'Pea Grit') and overlying coral bed (Scottsquar Member). The lowest part of the exposed sequence of bedrock is one of the very few to show the basal Leckhampton Member (formerly 'Scissum Beds'), which overlies the Lias Group. Currently the upper part of the sequence is well exposed, as it forms the prominent Crickley Hill escarpment. However, the lower part of the sequence is concealed by a build-up of 'mass movement deposits' and vegetation.

9.7.24 The proposed scheme encroaches into Crickley Hill and Barrow Wake SSSI, as shown in Figure 9.5. Through consultations with Natural England it is understood that the geological importance is due to the exposure of the Leckhampton Member at the base of the Inferior Oolite. The proposed scheme would not directly affect the existing exposures of the Leckhampton Member within the SSSI, therefore would not result in any impact on the geological importance of the SSSI.

9.7.25 Knap House Quarry contains important exposures of Middle Jurassic sediments, and the best illustration of the effects of tectonic uplift in between the deposition of the Birdlip Limestone and Salperton Limestone formations (Inferior Oolite Group). The proposed scheme would not pass through Knap House Quarry and therefore would not result in any impact on the SSSI in this location.

9.7.26 A site walkover was undertaken with Natural England on 7 November 2019 at Crickley Hill and Barrow Wake SSSI to identify the geological boundary between the Lias Group and Inferior Oolite Group, which would, in turn, identify locations where the Leckhampton Member was exposed.

9.7.27 The locations of the existing geological exposures of the Leckhampton Member identified with Natural England are shown on Figure 9.5. The easternmost observed exposure of the Leckhampton Member was found close to existing road level, and largely concealed by dense vegetation. This exposure is located adjacent to the existing A417, which would become the new Cold Slad Link Road.

9.7.28 The other observed outcrops of the Leckhampton Member were found further to the west, above a bench in the existing cut slope. These geological exposures were also largely concealed by 'mass movement deposits' and vegetation.

Soils

9.7.29 Agriculture is the main land use within the areas surrounding the proposed scheme. Figure 9.6 shows the agricultural land classifications across the proposed scheme.

9.7.30 The principal physical factors influencing agricultural production are climate, site and soil. These factors together with interactions between them form the basis for classifying agricultural land into one of five grades; Grade 1 land being of excellent quality and Grade 5 land of very poor quality. Grade 3 land is divided into two subgrades designated 3a and 3b. Best and most versatile (BMV) agricultural land includes Agricultural Land Classification (ALC) grades 1 to 3a.

9.7.31 The assessment of ALC in this PEI report has been based on a combination of the following sources of information:

- A detailed assessment of the Brockworth bypass section (with ALC data acquired post-1988);
- An assessment and ALC survey undertaken in 2004, where parts of a previous scheme (A417 Cowley to Brockworth Bypass Improvement) remain relevant for the current proposed scheme; and
- Where the datasets above do not cover parts of the current proposed scheme, an assessment was carried out using pre-1988 ALC data.

9.7.32 An ALC survey will be carried out before the ES to provide more accurate information on the agricultural grade of the land.

9.7.33 The assumptions and limitations of this assessment are detailed in Section 9.5.

9.7.34 The total area of agricultural land that would be affected by the construction of the proposed scheme has been estimated to be approximately 168.9ha, as shown in Table 9-6.

Table 9-6 Agricultural land affected by the construction of the proposed scheme

ALC Grade	Description	Area (ha)
Subgrade 3a	Good quality (BMV)	95.6
Subgrade 3b	Moderate quality	21.9
Grade 4	Poor quality	51.3
Total agricultural land affected		168.9
Other land (non-agricultural)		27.1

9.7.35 The figures reported in Table 9-6 represent the most conservative, worst-case scenario, but nonetheless show subgrade 3a (BMV) agricultural land would be affected by the proposed scheme (refer to Section 9.10 for the assessment).

9.7.36 The remaining land take required includes agricultural land of both Grades 3b and 4, which are not considered to be BMV land.

9.7.37 The proposed scheme would require both temporary and permanent land take, as well as land for wider mitigation and enhancement as part of the proposed scheme. A review of the agricultural land quality within the DCO boundary was undertaken for the purposes of the PEI report, presented in Table 9-7.

Table 9-7 Proportion of ALC types identified to be affected by the proposed scheme

Works	ALC Grade	Area (ha)
Permanent Works	Subgrade 3a (BMV)	69.8
Permanent Works	Subgrade 3b	15.0
Permanent Works	Grade 4	39.2
Temporary Works	Subgrade 3a (BMV)	25.8
Temporary Works	Subgrade 3b	7.0
Temporary Works	Grade 4	12.1
TOTAL AGRICULTURAL LAND AFFECTED		**168.9**

9.7.38 Table 9-7 identifies 69.8ha of BMV agricultural land would be permanently lost due to the construction of the proposed scheme, and 25.8ha of BMV land would be temporarily lost, to be reinstated following construction. However, in the absence of detailed ALC data, all Grade 3 agricultural land within the pre-1988 dataset was assumed to be subgrade 3a (i.e. BMV land), as discussed in Section 9.5. This extent of the pre-1988 dataset is presented within Figure 9.6.

Environmental setting

Site history

9.7.39 The area has historically undergone very little development, aside from the construction of a radio communication station complex in Birdlip c. 1940s. Records of a road along approximately the same route up Crickley Hill as the present day A417 exist from around 1777. It was converted into a two-lane road in the early 1960s. Most recently, closed-circuit television (CCTV) masts were erected mid-slope and at the top of Crickley Hill in around 2009. The site history is described in detail in Appendix 9.2 Preliminary Sources Study Report.

Unexploded ordnance

9.7.40 The summary of the unexploded ordnance (UXO) assessment, presented in Appendix 9.2 Preliminary Sources Study Report, indicates that the UXO risk for the proposed scheme is low.

Historical land use

9.7.41 Most of the features within the study area are related to unspecified old quarries and pits, many of which have since been infilled. For example, Birdlip Quarry was historically mined for limestone, and is the biggest identified infilled quarry within the study area. It is located directly to the north of the proposed Cowley junction and encroaches on the proposed scheme footprint, as shown on Figure 9.7.

9.7.42 All surface water, groundwater and potable water abstractions within 0.6 miles (1 kilometre) of the proposed scheme are historical.

Current land use

9.7.43 No fuel stations have been identified within the study area. However, there are a number of ‘tank’ features, which based on historical and current land use and their location, are likely to be associated with agricultural irrigation, private water supply, or livestock/farm use. The telecommunications mast and electrical substation associated with Birdlip Radio Station are present adjacent to the proposed scheme. Refer to the land use features plan presented in Figure 9.7.

Regulatory data

9.7.44 There have been seven records of Environment Agency Recorded Pollution Incidents within the study area. Three incidents did not record any impacts. Three incidents along the existing A417, close to Air Balloon roundabout, recorded an impact to land (category 3 minor impact). One incident, recorded to the south of the proposed scheme along the B4070, was also classified as category 3 – minor impact.

9.7.45 Eight Licenced Discharge Consents were noted within the study area. Seven were related to sewage discharge of treated effluent, while one was related to domestic soakaway drainage at the Air Balloon public house.

9.7.46 Six individual landfill cells were indicated, associated with Crickley Lodge, north of the proposed scheme. These cells were used for the disposal of inert waste however no further information is given as to the types of materials disposed.

9.7.47 The above-mentioned pollution incidents, discharge consents and landfill cells may have had a detrimental impact on soils and controlled waters quality.

Environmental designations

9.7.48 The proposed scheme is situated in an area of significant environmental sensitivity. The proposed scheme lies within an Area of Outstanding Natural Beauty and a Nitrate Sensitive Area. Ullen Wood ancient woodland lies to the east of Air Balloon roundabout. The western part of the proposed scheme, above the existing A417, lies within the Gloucester Green Belt and includes Crickley Hill and Barrow Wake SSSI.

9.7.49 A SPZ 3 is located to the east of the proposed scheme. This is further discussed in Chapter 13 Road drainage and the water environment.

Conceptual Site Model (CSM)

9.7.50 The potential sources of contamination, potential pathways and potential receptors are described in detail in Appendix 9.1 Baseline scenarios.

9.7.51 A CSM has been produced within Section 4 of Appendix 9.7 Geo-environmental Assessment Technical Note. This presents the potential pollution linkages between the potential sources, pathways and receptors identified from the review of baseline scenarios within the study area. It also identifies potential impacts to human health, groundwater and surface water (i.e. controlled waters) from contamination.

Future baseline

9.7.52 In Chapter 4 Environmental assessment methodology, the ‘Do Minimum’ and ‘Do Something’ scenarios have been set out, with the ‘Do Minimum’ scenario representing the future baseline with minimal interventions and without new infrastructure. Potential changes to geology and soils receptors in the future would not be noticeable, e.g. topography is unlikely to change, and the receptor groups are unlikely to be different to those identified in the baseline text above. Therefore, the future baseline would remain as set out above.

9.8 Potential impacts

9.8.1 Prior to the implementation of mitigation measures (set out in Section 9.9), the proposed scheme has the potential to affect geology and soils (positively or negatively), both during construction and once in operation. Details are provided below.

Construction

9.8.2 The construction of the proposed scheme could affect a designated geological site (see Figure 9.5) and result in the permanent loss or alteration of a small, but rare and nationally important geological exposure.

9.8.3 Tufa deposits formed by the precipitation of calcium carbonate at the location of springs may be damaged or concealed due to the construction activities.

9.8.4 The potential impacts on agricultural land are anticipated to mainly occur during the construction of the proposed scheme. Permanent construction impacts would comprise areas of agricultural land permanently required on completion of construction and severance impacts.

9.8.5 Construction activities would also result in physical damage to soil, including the excavation process for the proposed cuttings, soil compaction as a result of heavy construction vehicle movements, and the exacerbation of soil erosion through handling and storage of soils.

9.8.6 Other potential construction effects would include impacts on the function or quality of soil as a resource, including the deposition of dust on sensitive land uses, disruption to drainage, irrigation and water supply systems, unintentional pollution of soil and water courses, and spread of injurious weeds to adjacent agricultural land from soil and material stockpiles.

9.8.7 In the event of disturbance of contaminated soils or groundwater during construction, and in the absence of any mitigation measures, there is a potential for human, ecological or controlled water receptors to be affected, and for ground conditions to impact on the design of the proposed scheme.

9.8.8 Potential impacts in relation to contamination include, but are not limited to:

- mobilisation of existing contaminants in soil and groundwater as a result of exposure following ground disturbance during construction;
- increased potential for contaminants in unsaturated soils to leach to groundwater in open excavations during construction;
- increased potential for contaminated surface run-off to migrate to surface water and groundwater receptors as a result of contaminant mobilisation from uncovered stockpiles;
- introduction of new sources of contamination, such as fuels and oils used in construction plant; impact on the water environment is presented in Chapter 13 Road drainage and the water environment;
- creation of new migratory pathways between potentially contaminated soils or shallow groundwater and underlying Principal and Secondary Aquifers, through ground disturbance such as piling activities or compromising geological formations currently acting as aquitards;
- use of site won or imported contaminated materials during construction;
- introduction of new human health receptors such as site staff or construction workers during construction;
- creation of migratory pathways between potentially contaminated land and construction workers and neighbouring site users through ground disturbance;
- removal or remediation of any areas of contaminated soils identified.

9.8.9 Potential impacts associated with temporary dewatering, if required during construction, are assessed in Chapter 13 Road drainage and the water environment.

Operation

9.8.10 During the operational stage of the proposed scheme, conditions would be altered from the baseline as a result of, but not limited to:

- introduction of road users, operational maintenance staff and road infrastructure as new receptors;
- contamination which has been encountered having been removed or remediated;
- reduction in soil erosion through improved drainage design and improvement in surface water run-off quality as a result of additional treatment compared to existing conditions.

9.8.11 Other than potentially reducing severance and improving inter and intra-farm connectivity, there are no potential new or additional impacts on agricultural land during operation.

9.9 Design, mitigation and enhancement measures

Construction mitigation

9.9.1 Where agricultural uses are to be resumed on land disturbed during the construction of the proposed scheme, for example slopes for false cutting sections, these areas would be returned to agricultural use to mitigate the land take for BMV land. Good practice techniques would be adopted in the handling, storage and reinstatement of soils in these areas to avoid any reduction in the long-term capability and quality of the disturbed land.

9.9.2 An Environmental Management Plan (EMP) (to be submitted with the DCO application) will be developed, which will contain measures to ensure compliance with relevant standards and legislation. The EMP will set out the environmental mitigation requirements and project-level expectations on how the proposed scheme would be constructed. Measures contained within the EMP will be designed to limit the possibility for dispersal and accidental releases of potential contaminants, soil-derived dusts, spread of weeds, and uncontrolled run-off during construction. For example, the EMP will set out how material would be excavated, segregated and stockpiled to reduce run-off, soil quality degradation and wind dispersal of dusts. The EMP will also establish procedures for dealing with unexpected soil or groundwater contamination that may be encountered.

9.9.3 Potential impacts specific to construction workers during site preparation and construction would be mitigated by the following measures and through working in accordance with CIRIA C741 4th Edition *Environmental Good Practice on Site* (2015), included in the EMP.

9.9.4 The contractor would refine the EMP during the construction stage for the proposed scheme, in advance of construction. This would be done in conjunction with stakeholders to ensure compliance with the environmental requirements.

9.9.5 Construction activities would be undertaken in line with current best practice and guidance in accordance with the EMP. Construction-related receptors and sources would be managed to negate their impact on the environment. The commitments incorporated in the EMP will include, but are not limited to:

- dust control;
- health and safety training and provision of suitable welfare facilities;

- a watching brief for the duration of site works in areas of potential contaminated land or groundwater (by a suitably qualified and experienced person);
- provision and use of Personal Protective Equipment (PPE);
- an Action Plan for safely dealing with unexpected contamination;
- management of construction-related waters;
- sustainable use of soils on a construction site;
- environmental monitoring; and
- Foundation Works Risk Assessments for piling (if undertaken), to identify appropriate piling techniques.

9.9.6 The removal of topsoil may be required during construction to prevent permanent burial beneath other earthworks. This would be carried out in accordance with Defra guidance on the *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites*. Such soils would be stockpiled and re-used as soon as is practicable, subject to acceptability, in the general earthworks for the proposed scheme, such as landscaping and noise bunds. Topsoil excavated from areas of known high quality agricultural land would be stored separately and, where possible, reused on-site in areas that would be returned to agricultural use.

9.9.7 The effects on soil resources would be mitigated by employing high standards of soil handling and management during construction, and by avoiding the creation of bare areas of exposed soil that would be vulnerable to erosion processes.

9.9.8 The reuse of site won or imported materials to the proposed scheme would be managed by a verification system applied via the *Specification for Highway Works, Series 600 Earthworks*[45], and only materials found suitable for use would be acceptable for construction works.

9.9.9 All materials proposed for re-use would be required to meet risk-based acceptability criteria derived based on the conceptual site model for the operational phase and applying the assessment methodology set out in Appendix 9.6 Detailed assessment methodology for contaminated land. Soils would be protected from accidental contamination during storage and transit. Methods of soils handling and storage, including measures to prevent erosion by wind and surface water, would be detailed in method statements that would be prepared prior to the commencement of construction activities.

9.9.10 The re-use of excavated material would also be governed by a Materials Management Plan (MMP). This will be outlined in an Annex of the EMP (to be submitted along with the DCO application) and developed in accordance with the CL:AIRE Code of Practice, which is a voluntary framework for excavated materials management and re-use. Sufficient information would be generated to demonstrate that the excavated material has been re-used appropriately and is suitable for its intended use. The code of practice would demonstrate that unsuitable material or waste would not be used in the development. The MMP would detail the procedures and measures that would be taken to classify, track, store, reuse and dispose of all excavated materials that would be encountered during construction.

9.9.11 The use of the EMP and MMP throughout the construction process would prevent contamination being introduced into the environment, existing contamination being mobilised, or pathways to contamination being present. Where necessary, remedial action would be undertaken during construction, which would permanently remove unacceptable risks.

Embedded mitigation

9.9.12 Embedded mitigation measures for geology and soils are reported in Chapter 2 The Project.

Essential mitigation

9.9.13 There are no essential mitigation measures for geology and soils.

Enhancement measures

9.9.14 The construction of the proposed scheme would enhance the existing sensitive geological exposures of the Leckhampton Member at Crickley Hill and Barrow Wake SSSI. Enhancement measures would include lowered slope angles and vegetation clearance where exposures have previously been concealed on the north side of the A417 (see Figure 9.5 for locations).

9.9.15 New exposures of the Leckhampton Member would be created within the cuttings.

9.9.16 To provide further information on the geology at the Crickley Hill and Barrow Wake SSSI, the British Geological Survey and/or Natural England geologists would be approached to offer them the opportunity to carry out detailed sampling of fossils and recording of stratigraphic horizons during construction.

9.10 Assessment of likely significant effects

9.10.1 This section presents the preliminary assessment of likely significant effects on geology, soils and land contamination resulting from the construction and operation of the proposed scheme.

9.10.2 The potential effects (set out in Section 9.8) that are considered to be non-significant have been reported in Appendix 9.8 Non-significant effects and appropriate environmental management measures will be recorded and implemented within the EMP for submission with the DCO application.

Geology

9.10.3 The proposed scheme encroaches into Crickley Hill and Barrow Wake SSSI, however it would not directly affect the existing exposures of the Leckhampton Member within the SSSI, therefore would not result in any impact on the geological importance of the SSSI.

9.10.4 The construction of the proposed scheme would conceal a tufa deposit that has formed within the vicinity of spring. These deposits are of local importance/interest and are not designated, therefore they have a low value. The construction will result in the complete loss of this specific tufa spring, however there are numerous tufa springs within the area. This is therefore considered to result in the partial loss of the feature and a moderate magnitude of impact. Overall the effect of the proposed scheme on tufa deposits is assessed as *permanent slight adverse* and not significant.

9.10.5 The assessment of the proposed scheme on the tufaceous vegetation and the hydrogeological value have been assessed in Chapter 8 Biodiversity and Chapter 13 Road drainage and the water environment, respectively.

Soils

9.10.6 Sections 9.7 and 9.8 identified that the construction of the proposed scheme would affect ALC grade 3a (BMV) land, which is a high-value receptor, in addition

to Grade 3b and Grade 4 land which are medium- and low-value receptors respectively.

9.10.7 The construction of the mainline carriageway would lead to the permanent loss of >20ha of BMV agricultural land (Grade 3a). This would result in a *major* impact on that land given the permanent sealing of the soil resource. Using the significance matrix in Table 9-5, the significance would be large or very large. Due to the lack of differentiation and the assumption that all Grade 3 land is BMV agricultural land (Grade 3a), the significance has been assigned as large. Therefore, following mitigation, the overall effect of the proposed scheme on BMV agricultural land is assessed as *permanent large adverse* and significant.

9.10.8 The permanent loss of Grade 3b agricultural land would result in a *moderate* impact given the permanent sealing of <20ha of the soil resource. Given the lower sensitivity of this receptor (medium) and following mitigation, the overall effect on this ALC grade is assessed as *permanent moderate adverse* and significant. This would be completed before or during construction.

9.10.9 The permanent loss of Grade 4 agricultural land would result in a *major* impact given the permanent sealing of >20ha of the soil resource. Given the lower sensitivity of this receptor (low) and following mitigation, the significance would be slight or moderate. Given that the sensitivity of this receptor is lower than Grade 3b, the overall effect on this ALC grade is assessed as *permanent slight adverse* and not significant. This would be completed before or during construction.

9.10.10 The construction also requires temporary use of land which would take soil out of agricultural use for the period of construction. Following completion of construction, all temporary facilities would be removed, and the soil reinstated in accordance with the agreed end use for the land. The slopes of false cutting sections would be returned to agricultural use. The agricultural soil temporarily displaced by the proposed scheme would, after land restoration, generally be able to fulfil its primary soil functions on-site.

9.10.11 The temporary loss of Grade 3A agricultural land would result in a *minor* impact given the temporary loss of soil function. Following mitigation, the significance would be slight or moderate. Given that the land would be returned to agricultural use, it is considered that the significance of impact should be lower of the two. Therefore, the overall effect on this ALC grade is assessed as *temporary slight adverse* and not significant.

9.10.12 The temporary loss of Grade 3B agricultural land would result in a *minor* impact given the temporary loss of soil function. Following mitigation, the significance would be slight. Therefore, the overall effect on this ALC grade is assessed as *temporary slight adverse* and not significant.

9.10.13 The temporary loss of Grade 4 agricultural land would result in a *minor* impact given the temporary loss of soil function. Following mitigation, the significance would be neutral or slight. Given that the land would be returned to agricultural use, it is considered that the significance of impact should be lower of the two. Therefore, the overall effect on this ALC grade is assessed as *temporary neutral* and not significant.

9.10.14 As stated, this preliminary assessment represents the precautionary approach and the planned ALC survey would either confirm the ‘reasonable worst-case’ assumption, or more likely, demonstrate an improvement on the findings of the assessment.

Contamination

9.10.15 The potential for impacts from contamination on human health, surface water and groundwater are reported in Appendix 9.7 Geo-environmental Assessment Technical Note. The assessment includes the development of a Conceptual Site Model (CSM), Preliminary Risk Assessment (qualitative risk assessment) and a Generic Quantitative Risk Assessment of available results. The assessments consider pollution linkages that may exist during the construction and operational phases of the proposed scheme.

9.10.16 Pollution linkages deemed to pose a 'moderate' risk or greater, in accordance with best practice guidelines CIRIA C552, required further risk assessment in the form of a Generic Quantitative Risk Assessment (GQRA). In this assessment, soil and groundwater contamination data have been screened against published guideline values based on the relevant receptors considered in the CSM.

9.10.17 The following pollution linkages were considered in the Generic Quantitative Risk Assessments:

- Construction workers encountering potentially contaminated soils/materials, primarily through the inhalation of soil dusts and direct dermal contact.
- Proposed scheme neighbours (e.g. walkers and ramblers) being exposed to potentially contaminated materials via inhalation and dermal contact with soils or dust during construction works and operation.
- Leaching of contaminants into the groundwater during the construction and operational phases through rainwater infiltration.
- Discharge of contaminated groundwater into surface water as a result of new drainage.
- Maintenance workers coming to contact with potentially contaminated soils/materials.

9.10.18 All construction activities would be undertaken in line with current best practice and guidance and will be presented in the EMP which would also mitigate contamination risks with respect to controlled waters during construction (i.e. management of construction related waters and environmental monitoring). This also includes consideration of appropriate dust suppression measures which would reduce the impacts to adjacent scheme neighbours.

9.10.19 The quantitative risk assessments for human health indicated that some areas of localised made ground corresponded to exceedances in relation to the applied guideline values for construction workers (receptor of low sensitivity). All of the identified exceedances relate to polycyclic aromatic hydrocarbon (PAH) compounds in made ground. The adoption of mitigation measures such as health and safety training and the provision and use of appropriate PPE is considered to be sufficient in mitigating the identified risks posed to construction personnel. The health and safety management systems would incorporate appropriate mitigation measures and therefore the works would have a minor adverse impact, with a *temporary slight adverse* effect, which is not significant.

9.10.20 With respect to scheme neighbours (walkers, ramblers and cyclists – high sensitivity of receptor) or future maintenance workers, the identified exceedances were not widespread, rather, they were localised to made ground encountered in DSRC415 (located offline of the existing alignment close to Birdlip, in an area of proposed de-trunking works). Should these materials be reused within the proposed scheme, these may pose a risk to human health. Therefore, further assessments of suitability for reuse of these materials would be required. The

reuse of made ground, site won materials and material imported from off-site sources would be in accordance with the *Specification for Highway Works, Series 600 Earthworks* and as a result, only material that is demonstrated to be suitable for reuse would be used along the proposed scheme. Therefore, post completion of the works, there is unlikely to be a negligible impact above the current baseline scenario with respect to contamination with a *permanent slight adverse* and not significant effect. The full specification for reuse would be outlined in a Project Specification for earthworks and an MMP.

9.10.21 The controlled waters risk assessment indicated that the encountered made ground may pose a risk to controlled waters (of low to high sensitivity of receptors, as presented in Chapter 13 Road drainage and the water environment) due to leachable contaminants. In addition, elevated concentrations of PAH compounds were measured in installation in OH416 located next to DSRC415. As no excavations are proposed in this area, the elevated concentrations of PAHs are unlikely to pose a risk to controlled waters as a result of the works. The source of the elevated concentrations in the soils and groundwater has not been identified and may pose a risk to the underlying groundwater with a minor adverse impact resulting in a *permanent moderate adverse* and therefore significant effect. Further investigations and assessments would be required to identify the source, confirm the risks and design appropriate remediation measures, if required. Further assessments would be undertaken to confirm the risks associated with the leachability of contaminants within encountered made ground.

9.10.22 Generally, no significant contamination has been encountered during ground investigation to date. This is with an exception of elevated concentrations of petroleum hydrocarbons within groundwater sampled in DSRC229. On three consecutive occasions aliphatic hydrocarbons were measured between 1.6mg/l and 11mg/l. The source of this contamination has not been identified. The proposed scheme may introduce drainage solution as part of the ground stabilisation measures. This would create a pathway for that contamination migration into the Norman's Brook tributary, posing a risk to that controlled water receptor with a moderate impact resulting in a *permanent moderate adverse* and therefore significant effect. Further investigations and assessments would be required to identify the source, confirm the risks and design appropriate remediation measures.

9.10.23 Notwithstanding the above, based on the available desk study review, including information on the historical and current land use, together with the available ground investigation data, no requirement for extensive remedial works is expected. In addition to the above identified locations, some other localised areas of unexpected contamination may be present within the proposed scheme area. These may pose a risk to construction workers (low sensitivity of receptor) and controlled waters (low to high sensitivity of receptors). This would be mitigated by an action plan and procedures on how to manage and assess unexpected contamination that will be presented in the Environmental Statement. On account of these mitigation measures the potential impact would be negligible resulting in a *temporary slight adverse* and therefore not significant effect.

9.11 Monitoring

9.11.1 There are several significant effects associated with land contamination. Further ground investigations and specific risk assessments would be required to identify the source, confirm the risks, design appropriate remediation measures and inform any monitoring required.

9.12 Summary

Preliminary construction assessment

9.12.1 With appropriate mitigation, the construction of the proposed scheme is not considered to result in a significant effect on the designated geological features at Crickley Hill and Barrow Wake SSSI.

9.12.2 Enhancement measures such as allowing access for the BGS and/or Natural England geologists during construction would provide a benefit in the form adding to the existing geological knowledge of the area.

9.12.3 Similarly, with mitigation measures in place, no significant effects related to contamination are considered likely during the construction of the proposed scheme.

9.12.4 The construction of the proposed scheme would result in non-significant effects on tufa deposits, Grade 3A, Grade 3B and Grade 4 agricultural land. The land taken for temporary use would be reinstated to fulfil its primary agricultural use.

Preliminary operational assessment

9.12.5 Enhancement measures such as creating new or improving existing rock exposures would provide a benefit in the form of an increased understanding of the geology.

9.12.6 In the absence of mitigation, land contamination is considered to result in localised significant effects on controlled waters and therefore further action would be required to reduce the impact to not significant.

9.12.7 The permanent operation of the proposed scheme would result in residual significant effects on Grade 3A and Grade 3B agricultural land.

Further Work

9.12.8 An ALC survey will be carried out to provide more detailed information on the soils in relation to the agricultural class. This would be used to update the assessment on ALC.

9.12.9 On receipt of further data from the ongoing groundwater and surface water monitoring, the assessments of potential impact on controlled waters will be reviewed and updated. These will be presented within the draft Ground Investigation Report to be submitted with the ES.

9.12.10 Two areas of concern have been identified with respect to controlled waters. Further investigations and assessments would be required to identify the pollution source, confirm the risks and design appropriate remediation measures, if required. These would be targeted during future ground investigations.

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