10 Geology, Soils, Contaminated Land and Groundwater

This chapter considers the potential impacts of the proposed scheme on existing geology, soils, contaminated land and hydrogeology within the study area.

Baseline conditions were established through desk based assessment, consultation and site surveys. This process established that no designated Geological Receptors or Geological Conservation Review sites were identified within the study area; superficial deposits were primarily composed of alluvium and river terrace deposits with a localised hydrogeological potential as a groundwater resource; the underlying bedrock was composed of Precambrian rocks, considered to be impermeable and generally without groundwater, except at shallow depth; and several potential sources of contamination were identified within the study area (including made ground; backfilled quarries/pits; railway; burial grounds; small scale industrial/economic activities and a number of septic tanks). In addition, the location and type of groundwater receptors such as Private Water Supplies, ecological receptors with a potential groundwater dependency and surface water features were identified and documented.

The impact assessment was designed to assess the significance from both direct (within the proposed footprint) and indirect (groundwater dewatering) effects from the proposed scheme. The impact of the proposed scheme on geology, soils and mineral resources is expected to be Neutral. Moderate to Moderate/Low significance of impact was identified for a number of contaminated land source and/or pathways. The impact on groundwater flow and quality is expected to be Moderate to Moderate/Large within superficial deposits and Slight within the bedrock aquifer. Potential differential settlement has not been identified as an issue on existing infrastructure and buildings. The impacts to four active groundwater fed Private Water Supplies and/or their associated infrastructure have been identified with a Slight/Moderate to Large/Very Large significance. Neutral to Slight significance of impact was identified for surface water features from indirect groundwater dewatering.

No significant residual impacts are anticipated for the majority of receptors after the implementation of the proposed mitigation with the exception of groundwater flow within superficial aquifers. Significant residual impacts have been assessed on groundwater flow within glacial deposits/glacial till (Moderate) and alluvium/River Terrace deposits (to Moderate/Large).

10.1 Introduction

10.1.1 This chapter presents the DMRB Stage 3 assessment of the proposed scheme in relation to geology, soils, contaminated land and groundwater.

10.1.2 This includes impacts to bedrock and superficial geology, mineral extraction, soils, contaminated land, groundwater and associated receptors including private water supplies (PWS).

10.1.3 Geological impacts can occur due to excavating or masking exposures of rocks or superficial geological deposits of particular scientific interest, particularly if the features of interest are not reproduced elsewhere, nationally or regionally. Impacts can also include restrictions on existing or potential future commercial exploitation of resources, and conversely previous exploitation of resources can impose constraints on the proposed scheme; for example, where land has become unstable due to mining or has been contaminated by previous land uses. It is also recognised that rock exposures can deliver environmental benefit, such as improved access to, and exposure of, new areas of geological interest.

10.1.4 During construction, there is an inherent risk of spillage or leakage of fuel or oil from storage tanks or construction plant. Without suitable mitigation measures, these pollutants could enter the aquifers and degrade water quality. Construction work can lead to dewatering and also to contamination of superficial and bedrock aquifers.

10.1.5 Similarly, during operation of the proposed scheme, runoff from the road surface may contain elevated concentrations of pollutants, such as oils, suspended solids, metals, engine coolants (e.g. ethylene glycol) and, in winter, salt which may find their way into the groundwater system. Groundwater flows can also be intercepted or altered by new cuttings and other significant changes to landform.

10.1.6 The assessment is supported by the following appendices:

- Appendix A10.1: Contaminated Land Sources.
- Appendix A10.2: Contaminated Land Indirect Impact Assessment.
- Appendix A10.3: Infrastructure, Properties and Cultural Heritage Receptors.
- Appendix A10.4: Surface Water Indirect Dewatering Assessment.

10.2 Approach and Methods

10.2.1 This assessment has been undertaken based on the guidance contained in DMRB Volume 11, Section 3, Part 11 'Geology and Soils' (Highways Agency et al., 1993) (hereafter referred to as DMRB Geology and Soils), taking into account updated guidance on contaminated land risk assessment where appropriate (described in paragraph 10.2.17), and DMRB Volume 11, Section 3 Part 10 HD 45/09 'Road Drainage and the Water Environment' (Highways Agency et al., 2009) (hereafter referred to as HD45/09).

10.2.2 Consideration of soils includes contaminated land and made ground (included in the assessment of contaminated land), and potential impacts on peat (included in assessment of superficial deposits). Agricultural soil quality is considered as part of the assessment reported in Chapter 8 (People and Communities – Community and Private Assets), with mitigation included to address the potential deterioration of soils due to disturbance (and subsequent storage/reuse) at construction stage.

Study Area

10.2.3 The assessment covers a study area extending to a corridor of 250m from the footprint of the proposed scheme. For Groundwater Dependant Terrestrial Ecosystems (GWDTE), as agreed with SEPA, a study area extending 100m from the existing A9 was used, and extended where required, for the purpose of dewatering impact assessments. The study area for groundwater abstractions was up to a distance of 850m from the proposed scheme which corresponds to the minimum study area applied for groundwater abstractions under The Water Environment (Controlled Activities) (Scotland) Regulations 2011.

Baseline Conditions

10.2.4 Baseline conditions cover the following aspects of ground conditions:

- bedrock and superficial geology;
- features of geological importance;
- mineral extraction;
- groundwater environment and associated receptors including PWS; and
- contaminated land.

10.2.5 Baseline conditions were determined through desk-based assessment, consultation with landowners and statutory and non-statutory bodies, targeted site surveys and ground investigations.

Desk-based Assessment

10.2.6 The desk-based assessment included a review of the following information:

- British Geological Survey (BGS) data including BGS Superficial and Bedrock Geological Maps (BGS, 2014), BGS UK Hydrogeology viewer (BGS, 2015) and the BGS Geoviewer (http://mapapps2.bgs.ac.uk/geoindex/home.html).
- Macaulay Institute for Soil Research, Soil Survey of Scotland Map, Sheet 5, Eastern Scotland, 1981.
- UK Soil Observatory Soils map viewer (2016).

- Ordnance Survey (OS) historical maps dating back to 1856 for information on former land use, any potential contamination and physical hazards and information on private water supplies.
- Scottish Environment Protection Agency (SEPA) interactive River Basin Management Plan (SEPA, 2014) (http://gis.sepa.org.uk/rbmp/).
- Scottish National Heritage designation database (SNH, 2014) (https://gateway.snh.gov.uk/natural-spaces/index.jsp).
- Scotland's Environment Web (Scottish Government, 2015) (http://www.environment.scotland.gov.uk).
- Previous assessments:
  - Transport Scotland (2013) A9 Dualling Programme Strategic Environmental Assessment (SEA) Report.
  - Geotechnical Preliminary Sources Study Report (PSSR) Tay Crossing to Pitlochry. Chainage 22800 to 36300. (Jacobs, 2013a).
  - Geotechnical Preliminary Sources Study Report (PSSR) Pitlochry to Woodend. Chainage 36300 to 52500. (Jacobs, 2013b).

Consultation

10.2.7 Consultations have been undertaken with a number of statutory and non-statutory bodies. These include the following:

- SEPA for information on licenced groundwater abstractions (via The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)) and on former and current contaminated land use.
- Perth & Kinross Council (PKC) for information on former contaminated land use, Part IIA legislative led determinations, PWS, licensed fuel storage and any additional relevant information;
- SNH for information on the location and extent of environmental sensitivities in the vicinity of the proposed scheme and to establish any future development constraints.
- private property/landowners to identify presence of PWS and obtain information on water source location and type, water storage, treatment and intended use.

10.2.8 Further information on the consultation process is provided in Chapter 7 (Consultation and Scoping).

Site Walkover and Surveys

10.2.9 A site walkover was conducted on 20 and 21 September 2016 to obtain further information on targeted PWS and septic tank.

Ground Investigation

10.2.10 Fugro Engineering Services undertook a programme of ground investigation (GI), designed by Jacobs, between September and November 2015, reported in "A9 Dualling Southern Section Pitlochry to Killiecrankie Report on Ground Investigation without Geotechnical Evaluation" in 2016 (referred to hereafter as the "Advanced GI").

10.2.11 The investigation consisted of 23 cable percussive boreholes, three rotary boreholes and six sonic boreholes. Nine cable percussive and four Sonic boreholes were extended by rotary drilling. Samples of soils and encountered groundwater were collected during the investigation and sent to Derwentside Environmental Testing Services for chemical analysis.

10.2.12 Twenty-four boreholes were installed with slotted 50mm standpipes. These standpipes were monitored for groundwater and ground gas between 18 September 2015 and 13 January 2016 following completion of fieldwork. Twelve variable head permeability field tests were carried out.

10.2.13 A second programme of ground investigation, designed by Jacobs, was undertaken by Fugro Engineering Services between September and December 2016 and reported in "A9 Dualling Tay Crossing to Killiecrankie Preliminary Ground Investigation, Pitlochry to Killiecrankie, Report on ground investigation without geotechnical evaluation" in 2017 (referred to hereafter as the "Preliminary GI").

10.2.14 The investigation consisted of 18 cable percussive boreholes (eight were extended with rotary core drilling techniques) 27 rotary cored boreholes (14 were sunk by rotary core drilling techniques and 13 were sunk by rotary open hole and rotary core drilling techniques), 17 sonic boreholes (15 were extended with rotary follow on) and 33 trial pits.

10.2.15 Thirty-seven boreholes were installed with slotted 50mm standpipes. These standpipes were monitored for groundwater between 3 October 2016 and 16 February 2017 following completion of fieldwork. Eleven variable head permeability field tests were carried out.

Impact Assessment

10.2.16 Potential impacts in relation to geology, contaminated land and hydrogeology were assessed individually as per the methodologies provided below. The criteria outlined in Tables 10.1 to 10.3 and 10.5 to 10.10 are based on those that have been applied to similar schemes in Scotland and are designed to comply with DMRB guidance.

Geology

10.2.17 The sensitivity and magnitude criteria in Table 10.1 and Table 10.2 were used for bedrock and superficial geology (including soils), features of geological importance and mineral extraction. The impact significance was then determined using Table 10.3.

Table 10.1: Sensitivity Criteria – Geology and Soils

Sensitivity	Description
High	Areas containing geological or geomorphological features considered to be of a national interest such as Sites of Special Scientific Interest (SSSI), candidate SSSI or Geological Conservation Review (GCR) sites. Presence of extensive areas of economically important minerals valuable as a national resource. Areas of peatland within designated sites such as SSSI, Special Area Conservation (SAC) or Special Protection Area (SPA) with national or European importance and/ or SNH priority peatland Class 1 (nationally important carbon-rich and peaty soils, deep peat and priority peatland habitat likely to be of high conservation value) and Class 2 (nationally important carbon-rich and peaty soils, deep peat and priority peatland habitat likely to be of potentially high conservation value and restoration potential).
Medium	Areas containing geological features of designated regional importance considered worthy of protection for their educational, research, historic or aesthetic importance, such as Local Geodiversity Sites (LGS)/ Regionally Important Geological Sites (RIGS). Presence of areas of economically important minerals of regional value. SNH priority peatland Class 3 (dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Occasional peatland habitats can be found. Most soils are carbon-rich and peaty soils, with some areas of deep peat).
Low	Sites and geological features not currently identified as SSSI, GCR or LGS/ RIGS but that may require protection in the future. Presence of mineral areas or resource of local importance only. SNH priority peatland Class 5 (soil information takes precedence over vegetation data and there is no peatland habitat recorded, but all soils are carbon-rich and peaty soil and deep peat).
Negligible	Geological features not currently protected and unlikely to require protection in the future. No exploitable minerals or geological resources. SNH priority peatland Class 4 (areas unlikely to be associated with peatland habitats or wet and acidic type, and unlikely to include carbon-rich or peat soils), Class 0 (mineral soils where peatland habitats are not typically found), Class -1 (unknown soil types) and Class -2 (non-soil (i.e. loch, built up area, rock and scree)).

Table 10.2: Magnitude Criteria – Geology and Soils

Magnitude	Description
Major	Partial (greater than 50%) or total loss of a geological site or mineral deposit, or where there would be complete severance of a site such as to affect the value of the site/ resource. Major or total loss of topsoil, soils or peatland, or where the value of the area would be severely affected.
Moderate	Loss of part of a geological/ geodiversity site or mineral deposit, major severance, major effects to the setting, or disturbance such that the value of the site would be affected, but not to a major degree. Partial loss of topsoil, soils or peatland, or where the value of the area would be affected, but not to a major degree.
Minor	Small effect on a geological/ geodiversity site or mineral deposit (up to 15%) or a medium effect on its setting, or where there would be a minor severance or disturbance such that the value of the site would not be affected. Partial loss of topsoil, soils or peatland, or where soils will be disturbed but the value of the area would not be affected.
Negligible	Very slight change from geological, mineral and soil baseline conditions.

Table 10.3: Matrix for determination of impact significance – Geology and Soils

Magnitude / Sensitivity	Negligible	Minor	Moderate	Major
High	Slight	**Moderate**	**Moderate/Large**	**Large**
Medium	Neutral/Slight	**Slight/Moderate**	**Moderate**	**Moderate/Large**
Low	Neutral	Neutral/Slight	**Slight/Moderate**	**Moderate**
Negligible	Neutral	Neutral	Neutral/Slight	Slight

10.2.18 Beneficial impacts in terms of geological features may also occur, as rock exposures can help to develop understanding of local geology and/or provide a site of interest (e.g. rock cuttings later being designated as a SSSI or GCR). This is relevant to the overall A9 project due to presence of designated sites, but not specifically to the Pitlochry to Killiecrankie section. Impacts and opportunities are considered by applying professional judgement within the context of the assessment categories set out in Table 10.2 and Table 10.3.

10.2.19 The overall material volume balances associated with quantities of materials to be generated in areas of excavation and required in areas of embankments during construction of the proposed scheme are assessed in Chapter 18 (Materials).

10.2.20 Impacts on geology and soils of **Slight/Moderate** significance and above are considered to be significant in the context of the EIA Regulations, and the level at which mitigation would be proposed.

Contaminated Land

10.2.21 In line with industry norms, the assessment focuses on the potential for impacts on receptors as a consequence of encountering contaminated land using a conceptual site model (CSM) developed for the proposed scheme. A receptor can be a person (including construction workers), the water environment, flora, fauna or building/structures. The CSM represents a network of relationships between potential sources within the study area and exposure of the receptors through different pathways. The potential receptors and pathways have been compiled based on the legal definitions used in Part IIA of the Environment Protection Act 1990, as provided in statutory guidance (Scottish Executive, 2006). The contaminated land sources have been identified through a desktop exercise using historical OS maps, consultation information and available GI.

10.2.22 The pollutant pathways and type of receptors used within the assessment are provided in Table 10.4, with individual references assigned for linkages (e.g. PP1 to PP22).

Table 10.4: Potential Pollutant Pathways

Pollutant Pathway	Receptor	Pathway
Construction		
PP1	Human Health (Construction)	Ingestion, inhalation and dermal contact with soils, soil dust, deep and shallow groundwater and surface water.
PP2		Migration of ground gases into shallow pits or site buildings.
PP3	Off-site Receptors (Local residents and transient traffic (foot, road and rail traffic) in surrounding area).	Ingestion, inhalation and dermal contact with wind-blown dust created during excavation works.
PP4		Migration of ground gases into homes or workplaces through preferential pathways created during construction posing a potential asphyxiation/explosion risk.
PP5	Groundwater – superficial aquifers	Leaching and migration of contaminants.
PP6	Groundwater – bedrock aquifers	Migration of contaminants or contaminated shallow groundwater into the deeper rock aquifer.
PP7	Surface Waters	Migration of contaminated shallow groundwater through superficial deposits or made ground.
PP8		Runoff from contaminated source(s).
PP9		Migration of contaminated bedrock groundwater towards surface water receptor.
PP10		Discharge of intercepted contaminated groundwater during passive or active dewatering.
PP11	Ecological Receptors (water dependant habitats and agricultural land/livestock)	Inhalation, ingestion and direct contact with contaminated soils/water.
Operational		
PP12	Human Health (Operational)	Ingestion, inhalation and dermal contact with soils, soil dust, deep and shallow groundwater, surface water in the long term during routine maintenance activities e.g. drainage inspections.
PP13		Migration of ground gases into confined spaces e.g. service pits, accommodation buildings creating an asphyxiation/explosion risk.
PP14	Off-site Receptors	Ingestion, inhalation and dermal contact with wind-blown dust from contaminated soils reused within road features such as embankments and landscaped areas.
PP15		Migration of ground gases into homes or workplaces through preferential pathways remaining following construction thus posing a potential asphyxiation/explosion risk.
PP16	Groundwater – superficial aquifers	Leaching and migration of contaminants.
PP17	Groundwater – bedrock aquifers	Migration of contaminated shallow groundwater into the deeper rock aquifer.
PP18	Surface Waters	Migration of shallow groundwater through superficial deposits or made ground.
PP19		Runoff from contaminated source(s).
PP20		Migration of contaminated shallow groundwater through drainage channels and associated granular bedding materials or engineered structures.
PP21		Discharge of intercepted contaminated groundwater.
PP22	Ecological Receptors	Inhalation, ingestion and direct contact with contaminated soils/water.

10.2.23 For the purposes of this assessment, the CSM disregards those pathways that are incomplete and therefore cannot pose a risk to any of the identified receptors. Where a source, pathway and receptor combination exists this is referred to as a complete pollutant linkage and a generic qualitative risk assessment has been undertaken.

10.2.24 Potential impacts are discussed in terms of likelihood (Table 10.5) and magnitude/consequence (Table 10.6). The Generic Qualitative Risk Assessment is then undertaken based on the matrix shown in Table 10.7.

10.2.25 The estimation of quantities of materials to be disposed of off-site is provided in Chapter 18 (Materials).

Table 10.5: Likelihood Criteria – Contaminated Land

Likelihood	Definition
High likelihood	There is a complete pollution linkage of an event that either appears very likely in the short-term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution.
Likely	There is a complete pollution linkage and all the elements are present and available, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over a long-term.
Low likelihood	There is a complete pollution linkage and the circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter term.
Unlikely	There is a complete pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long-term.

Table 10.6: Magnitude (Consequence) Criteria – Contaminated Land

Magnitude	Definition
Severe	Short-term (acute) damage to human health (significant harm). Pollution of sensitive water resources as a result of short-term exposure. Damage to a particular ecosystem as a result of acute exposure. Catastrophic damage to buildings/property/ Scheduled Monument (SM).
Medium	Long-term (chronic) damage to human health (significant harm). Pollution of sensitive water resources as a result of chronic exposure. A significant change in a particular ecosystem, or organism forming part of such an ecosystem. Substantial damage to buildings/property/ SM.
Mild	No appreciable impact on human health based on the potential effects on the critical human health receptor. Pollution of non-sensitive water resources. Damage to ecological systems with no significant impairment. Significant damage to sensitive buildings/structures/SM and/or services.
Minor	Harm (not necessarily significant), which may result in financial loss or require expenditure to resolve. Non-permanent health affects to human health. No appreciable pollution. Easily repairable effects or damage to ecological systems. Easily reparable damage to buildings/structures/SM/services.

Table 10.7: Matrix for Determination of Impact Significance – Contaminated Land

Likelihood / Consequence	Unlikely	Low Likelihood	Likely	High Likelihood
Severe	**Moderate/Low**	**Moderate**	**High**	**Very High**
Medium	Low	**Moderate/Low**	**Moderate**	**High**
Mild	Very Low	Low	**Moderate/Low**	**Moderate**
Minor	Very Low	Very Low	Low	**Moderate/Low**

10.2.26 Impacts in terms of contaminated land exposure of **Moderate/Low** significance and above are considered to be potentially significant in the context of the EIA Regulations, and the level at which mitigation would be proposed.

Groundwater

10.2.27 The assessment of the magnitude of impact on the quality and level of groundwater is based primarily on whether the road surface near a receptor is in cutting, on embankment or in transition. However, where appropriate, the vulnerability of groundwater flow to sub-surface disruptions is also considered to refine the assessment of magnitude of impact. Impacts on groundwater quality and/or flow may also have direct or indirect effects onto groundwater abstractions, ecological receptors with potential groundwater dependency and surface water features.

10.2.28 Potential groundwater flooding impacts are considered in Appendix A11.3 (Flood Risk Assessment) and are not discussed in this chapter.

10.2.29 Criteria for the definition of groundwater sensitivity and magnitude are reported in Tables 10.8 and 10.9. These consider groundwater sensitivity in the context of hydrogeological conditions including groundwater resources and ecological receptors with potential groundwater dependency.

10.2.30 Sensitivity criteria attributed for surface water receptors correspond to the importance criteria for aquatic habitats as shown in Table 12.9 (Chapter 12: Ecology and Nature Conservation). Importance definitions for aquatic habitats are considered a good representation of the sensitivity of water features to potential groundwater dewatering impacts.

10.2.31 The impact significance for groundwater aspects was determined using the matrix as shown in Table 10.10.

Table 10.8: Sensitivity Criteria - Groundwater

Sensitivity	Description
Very High	Groundwater aquifer(s) with very high productivity or Water Framework Directive (WFD) good groundwater quality and quantity status. Exploitation of groundwater resource is extensive for public, private domestic and/ or agricultural use (i.e. feeding ten or more properties) and/ or industrial supply. Important sites of nature conservation dependent on groundwater as per importance criteria attributed in Table 12.6: Importance Criteria for Ecological Features (Chapter 12: Ecology and Nature Conservation) or groundwater is considered likely to support wetland vegetation which is highly groundwater dependent. Surface water features with hydrological importance to designated sensitive ecosystems of national/ international importance.
High	Groundwater aquifer(s) with moderate/ high productivity or WFD good groundwater quality and quantity status. Exploitation of groundwater resource is not extensive (i.e. private domestic and/ or agricultural supply feeding less than ten properties). Local areas of nature conservation dependent on groundwater as per importance criteria attributed in Table 12.6 (Chapter 12: Ecology and Nature Conservation), or groundwater is considered likely to support wetland vegetation which is moderately groundwater dependent. Surface water features with hydrological importance to sensitive ecosystems of regional importance.
Medium	Groundwater aquifer(s) with low productivity or WFD variable groundwater quality and quantity status. No current known exploitation of groundwater as a resource and aquifer(s) properties make potential exploitation appear unlikely. Minor areas of nature conservation with a degree of groundwater dependency, as per importance criteria attributed in Table 12.6 (Chapter 12: Ecology and Nature Conservation). Surface water features with some but limited hydrologic importance to sensitive or protected ecosystems of authority area importance.
Low	Groundwater aquifer(s) with very low productivity or WFD poor groundwater quality and quantity status. No known past or present exploitation of groundwater aquifer(s) as a resource. Areas of vegetation with no groundwater dependency. Surface water features with minimal/ insignificant hydrological importance to sensitive ecosystems of less than authority area importance.

Table 10.9: Magnitude Criteria - Groundwater

Magnitude	Description
Major	Major or long term change to groundwater aquifer(s) flow, water level, quality or available yield. Groundwater resource use is irreparably impacted upon, with a major or total loss of an existing supply or supplies. Changes to water table level or quality would result in a major or total change in or loss of a groundwater dependent area, where the value of a site would be severely affected. Changes to groundwater aquifer(s) flow, water level and quality would result in major changes to groundwater base flow contributions to surface water and/ or alterations in surface water quality, resulting in a major shift away from baseline conditions such as change to WFD status. Dewatering effects create significant differential settlement effects on existing infrastructure and buildings.
Moderate	Moderate changes to groundwater aquifer(s) flow, water level, quality or available yield. Groundwater resource use is impacted slightly, but existing supplies remain sustainable. Changes to water table level or quality would result in partial change in or loss of a groundwater dependent area, where the value of the site would be affected, but not to a major degree. Changes to groundwater aquifer(s) flow, water level and quality would result in moderate changes to groundwater base flow contributions to surface water and/ or alterations in surface water quality, resulting in a moderate shift from baseline conditions that may be long-term or temporary. Dewatering effects create moderate differential settlement effects on existing infrastructure and buildings.
Minor	Minor changes to groundwater aquifer(s) flow, water level, quality or available yield. Changes to water table level, quality and yield result in little discernible change to existing resource use. Changes to water table level or quality would result in minor change to groundwater dependent areas, but where the value of the site would not be affected. Changes to groundwater aquifer(s) flow, water level and quality would result in minor changes to groundwater base flow contributions to surface water and/ or alterations in surface water quality, resulting in a minor shift from baseline conditions (equivalent to minor but measurable change within WFD status). Dewatering effects create minor differential settlement effects on existing infrastructure and buildings.
Negligible	Very slight change from groundwater baseline conditions, approximating to 'no change' conditions. Dewatering effects create no or no noticeable differential settlement effects on existing infrastructure and buildings.

Table 10.10: Matrix for Determination of Impact Significance – Groundwater

Magnitude / Sensitivity	Negligible	Minor	Moderate	Major
Very High	Neutral	**Moderate/Large**	**Large/Very Large**	**Very Large**
High	Neutral	Slight/Moderate	**Moderate/Large**	**Large/Very Large**
Medium	Neutral	Slight	**Moderate**	**Large**
Low	Neutral	Neutral	Slight	Slight/Moderate

10.2.32 Impacts on groundwater of **Moderate** significance and above are considered to be potentially significant in the context of the EIA Regulations, and the level at which mitigation would be proposed. .

Limitations to Assessment

10.2.33 The identification of potential contamination sources relies on the accuracy of historical mapping. Assessment of historical quarrying activity is based on a desk-based review of OS maps. It is possible that quarrying works could have been undertaken and the void backfilled between the recorded years of mapping, such that no map evidence exists.

10.2.34 Geological and hydrogeological information obtained from the Advanced and Preliminary GIs have been used for this assessment. In areas where no data were available, the nearest geological and hydrogeological information was extrapolated from the wider available dataset.

10.2.35 Information on PWS depends on the accuracy provided through consultations with landowners and the local authority, and the sections of the network infrastructure that were observed in the field during targeted surveys. Additional consultation with land owners may still be required to take place prior to construction.

10.2.36 The assessment is reliant on the accuracy of the information provided during consultation.

10.3 Baseline Conditions

Geology

Designated Geological Receptors

10.3.1 No designated Geological Receptors or Geological Conservation Review sites are present within the study area.

Soils

10.3.2 A review of the Macaulay Institute Soils Survey of Scotland Soil Map of Scotland (1:250,000 scale), in conjunction with the UK Soil Observatory interactive soils map viewer indicates that the majority of the study area is underlain by humus iron podzols with mineral and peaty alluvial soils. Brown earths are present in the northern part of the study area, associated with more steeply sloping hillsides on the eastern side of the A9 north of Loch Faskally.

10.3.3 The humus iron podzols are derived from glaciofluvial and raised beach sands and gravels with acid igneous rock parent material. Generally, humus iron podzols are nutrient deficient but can support a number of uses including arable and permanent pasture, oak and birchwood, rush pasture and sedge mires.

10.3.4 The brown earths are derived from arenaceous and argillaceaous schists. Brown earths are generally well drained, can have high levels of natural fertility and in favourable conditions are often cultivated or support better quality grassland.

10.3.5 Peat was recorded in one historical borehole as a 0.64m thick layer (Jacobs, 2013b) and encountered in three boreholes undertaken as part of the A9 Dualling associated GI works: one during the Advanced GI and two during the Preliminary GI. The historical and Advanced GI recorded peat horizons are located in the vicinity of a pond approximately 200m west of ch4500 (Figure 10.1). The peat encountered in the Advanced GI was described as brown spongy fibrous peat, with a thickness of 0.1m and was underlain by alluvial deposits. The remaining incidences of recorded peat were isolated buried horizons; at ch1560 a 2.40m thick layer of peat was encountered between sand and gravel river terrace deposits at a depth of 3.40mbgl while at ch5450 pockets of orange-brown spongey fibrous peat were encountered within a sand layer between 0.50 and 1.20mbgl.

10.3.6 Soils present within the footprint of the proposed scheme are considered to fall under SNH priority peatland Class 0. Based on the criteria in Table 10.1, these soils are considered to be of negligible sensitivity. An assessment of the impacts of the proposed scheme on soils relating to Land Capability for Agriculture Classes is reported in Chapter 8 (People and Communities – Community and Private Assets).

Made Ground

10.3.7 Made ground deposits are expected to be associated with the existing A9 and the Highland Main Line railway, albeit not indicated on BGS online datasets.

10.3.8 Initial GI pre-dating the existing A9, did not record the presence of any made ground (Jacobs, 2013a; 2013b).

10.3.9 Made ground, possible made ground and concrete were recorded in 21 boreholes and eight trial pits during the Advanced and Preliminary GIs, with a greatest proven thickness of 5.65m. The description and presence of made ground has been recorded in Appendix A10.1 (Contaminated Land Sources), associated with the identification of potentially contaminated land.

10.3.10 Based on the criteria in Table 10.1, made ground present within the study area is considered to be of negligible sensitivity.

Superficial Geology

10.3.11 Superficial deposits within the study area are primarily composed of alluvium (consisting of clay, silt, sand and gravel), with the northern section of the route at Faskally underlain by river terrace deposits (consisting of gravel, sand, silt and clay). There is also an isolated area of river terrace deposits located to the south-west of Pitlochry (ch2200-ch2900).

10.3.12 Glacial till lies over the hillsides to the east of the A9 at Craiglunie, to the north of Loch Faskally.

10.3.13 Glaciofluvial deposits border the route to the immediate west, as it passes to the south of Loch Faskally.

10.3.14 Results of the Advanced and Preliminary GIs broadly support the BGS geology data, with river terrace deposits and glaciofluvial deposits being the units most commonly recorded in borehole logs.

10.3.15 Superficial thicknesses recorded in GI boreholes and trial pits ranged from absent to a proven maximum thickness of 29.75m adjacent to the River Tummel crossing. The thickness of the superficial deposits tends to increase towards the river, with some localised areas of particularly thick or thin superficial cover.

10.3.16 Based on the criteria presented in Table 10.1, superficial deposits present in the study area are considered to be of negligible sensitivity.

Bedrock Geology

10.3.17 Underlying the superficial geology, the bedrock geology comprises predominantly metasedimentary and metavolcanic rocks. The southern extent of the proposed scheme, to the south of Pitlochry, is primarily underlain by psammites and semipelites belonging to the Southern Highland Group. A small section of metalava and metatuff, also belonging to the Southern Highland Group, underlies the route at ch3250-ch3550. The northern extent of the route is underlain by metamorphic rocks of the Argyll Group, successively the Loch Tay Limestone Formation (meta-limestone), Ben Lui Schist Formation (semi pelite), Farragon Volcanic Formation (meta-limestone and metatuff), Ben Lawers Schist Formation (calcareous pelite), Ben Eagagh Schist Formation (graphitic pelite) and Carn Mairg Quartzite Formation (gritty psammite). No faults are indicated in this area.

10.3.18 Previous ground investigations encountered bedrock in eight historical borehole logs, with seven of these recording bedrock as mica-schist, at depths of between 2.8mbgl and 15.6mbgl around Pitlochry and the Pass of Killiecrankie (Jacobs, 2013b). The rock was generally described as slightly to moderately weathered, closely foliated, moderately strong to very strong mica schist (occasionally quartz mica schist).

10.3.19 The Advanced and Preliminary GIs recorded bedrock in 70 boreholes. Bedrock was identified as the Southern Highland Group (ch1000–ch4000), the Ben Lui Schist (ch4200–ch4600), the Farragon Volcanic Formation (ch4900–ch5300), and the Ben Lawers Schist (ch5400–ch5900). The Ben Eagagh Schist was identified in one location, overlain by the Ben Lawers Schist (ch5900). The Ben Lawers Schist, Ben Lui Schist and Farragon Volcanic Formation all belong to the Argyll Group. A volcanic intrusion, identified as a felsite dyke associated with the Dunfallandy Hill Pluton granite, was recorded at ch1850.

10.3.20 Depth to rockhead varied from 0.25mbgl west of Creag na Ciche, to 32.10mbgl at Easthaugh of Dalshian. Generally, depth to bedrock was greatest in the centre of the valley, near the river, with a general trend of increasing depth to bedrock towards the north of the study area.

10.3.21 Based on the criteria in Table 10.1, bedrock present in the study area is considered to be of negligible sensitivity.

Mineral Extraction

10.3.22 There are no records of historic or current coal mining activity within the study area.

10.3.23 A review of historical OS maps recorded four sand and gravel pits (referred to as PK-C4, PK-C20, PK-C21 and PK-C23 in Appendix A10.1: Contaminated Land Sources). These are shown on Figure 10.2.

10.3.24 Based on this historical evidence of sand and gravel extraction and recorded superficial geology information, there is potential for further sand and gravel resources to be available within the study area. Future sand and gravel extraction resources are assessed to be of local importance and therefore of low sensitivity as per definitions in Table 10.1.

Geotechnical Hazards

10.3.25 There is evidence of historic instability within the study area with previous landslides known to have occurred and associated road defects reported. The reported defects are all located in the northern part of the proposed scheme, to the north of Clunie Bridge (ch4200-ch4300); however, none are recorded to have resulted in closure of the A9 carriageway.

10.3.26 Previous reports have highlighted a potential soil instability as a result of landslide risk at several locations along existing A9 road cuttings. This is generally associated with alluvial or river terrace deposits, particularly in areas where erosion may have occurred (Jacobs, 2013a; 2013b). Erosion impacts and changes in fluvial geomorpohology along surface waters are assessed separately in Chapter 11 (Road Drainage and the Water Environment).

Contaminated Land

10.3.27 Fifty-two potentially contaminated land sources were identified within the study area. Details of the identified sources are provided in Appendix A10.1 (Contaminated Land Sources and locations) shown on Figure 10.2.

10.3.28 The Advanced and Preliminary GIs identified 29 areas where made ground was proven to be present the majority of which are associated with the existing A9 or various side roads. Two locations recorded concrete obstructions at 0.15mbgl and two locations were recorded with possible made ground. Composition of the identified made ground falls into two categories: silty sand and gravel of varying lithologies and concrete/tarmacadam. Visual and olfactory evidence of contamination was noted at two locations, a strong organic odour was noted at ch3150 and multi-coloured stained brown sandy gravel was noted at ch6030.

10.3.29 The soil sample chemical analysis results from the Advanced and Preliminary GIs have been compared against Generic Assessment Criteria (GAC; industry standard criteria) suitable for a residential end use to assess the potential risks to construction workers. This is considered to be a conservative approach. There will be limited potential exposure pathways to end users given the proposed use as a road. However, potential pathways remain including those for maintenance workers. Therefore, the soil sample chemical analysis results have also been compared against GAC suitable for public spaces and commercial/industrial end uses. The aim of the assessment is to identify any contaminants that exceed the GACs and may be considered as Contaminants of Potential Concern (COPCs).

10.3.30 The following hierarchy of GACs has been used to screen soil sample analysis results (based on a soil organic matter concentration of 6% in recognition of the range observed in the Advanced GI laboratory results):

- Jacobs derived GACs based on the Contaminated Land Exposure Assessment (CLEA) tool (version 1.06), Soil Guideline Values (SGVs) and Toxicity reports published by the Environment Agency (EA);
- Suitable for Use Limits (S4ULs) for Human Health Risk Assessment, Land Quality Management (LQM)/Chartered Institute of Environmental Health (CIEH) (2015); and
- Category 4 Screening Levels (C4SL) for Assessment of Land Affected by Contamination, Department for Environment, Food and Rural Affairs (Defra) (2014).

10.3.31 Using this approach one COPC was identified, with benzo(a)pyrene marginally exceeding the residential GAC value at 0.3mbgl, associated with an un-named side road. All determinant

concentrations within the remaining 47 soil samples scheduled remained below their relevant GAC threshold values.

10.3.32 Ground gas monitoring has been carried out within 24 monitoring boreholes following completion of the GI during September 2015 and through to December 2015. Ground gas concentrations could pose a potential risk to site workers working below ground and/or in confined spaces. Ground gas concentrations were compared to the GACs considered appropriate for the protection of construction and maintenance workers from the following UK guidance for methane, carbon dioxide and oxygen; carbon monoxide; and hydrogen sulphide respectively:

- National House Building Council (NHBC) 2007, Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present, Report Edition No.: 4, March 2007;
- Health and Safety Executive (HSE) 'EH40/2005 Workplace Exposure Limits' 2011; and
- Mines and Quarries Act (1954), 27 (Section 55(2)(B)).

10.3.33 Recorded methane concentrations were below the recommended safety threshold of 20% of the lower explosive limit for methane (1% volume per volume (v/v)) in all locations.

10.3.34 Carbon dioxide concentrations exceeded the short term (15 minutes) occupational exposure limit (1.5% v/v) in seven locations, and the long term (8 hour) exposure limit (0.5% v/v) in 17 locations. Carbon monoxide is above the short term exposure limit (200ppm) in one location, and the long term exposure limit (30ppm) in three locations.

10.3.35 Depleted oxygen values below the 19% limit from the Mines and Quarries Act (1954) were recorded in 12 locations.

10.3.36 Hydrogen sulphide concentrations were predominantly below the monitoring equipment's level of detection (1ppm) with the exception of one location. This location is not associated with any identified potential contaminated land source and nor was any peat or made ground recorded on the borehole log. Elevated hydrogen sulphide concentrations were observed during the first three monitoring rounds with one equal to the long term (8 hour) exposure limit (5ppm) and one equal and one above the short term (15 minute) exposure limit (10ppm). During the five subsequent monitoring visits hydrogen sulphide concentrations were all recorded below the monitoring equipment's level of detection.

Groundwater

10.3.37 The SEPA River Basin Management Plan (RBMP) interactive map (SEPA, 2015) describes the study area as being underlain by the Tummel Valley sand and gravel aquifer and the Upper Tay bedrock and localised sand and gravel aquifer, which correlate with the alluvium and river terrace deposits geological units shown on BGS Geoviewer (http://mapapps2.bgs.ac.uk/geoindex/home.html).

10.3.38 BGS digital hydrogeological mapping describes the study area as being underlain by low productivity bedrock aquifers of the Southern Highland Group and Argyll Group. The Hydrogeological Map of Scotland (BGS, 1988) notes that the Quaternary superficial deposits situated on the valley floor are considered to be an aquifer of limited local potential with typically small yields. Higher ground, on the sides of the valley and underlain by Precambrian rocks, is considered to be impermeable and generally without groundwater, except at shallow depth. Groundwater vulnerability mapping classifies the Quaternary superficial deposits situated on the valley floor as moderately permeable and the bedrock as weakly permeable.

10.3.39 The RBMP's 2008 classification for groundwater in both bedrock and superficial deposit aquifers is Good with High Confidence for both quantity and quality with no trend of pollutants.

10.3.40 Groundwater was encountered during drilling in 30 boreholes. Depth to water strike varied from 0.6mbgl to 24.8mbgl. Most groundwater strikes occurred within the superficial deposits, with the exception of two locations where strikes occurred within weathered bedrock.

10.3.41 Groundwater monitoring data were undertaken in 24 boreholes from September 2015 to January 2016 and in 34 boreholes from October 2016 to February 2017. Of these, 45 were screened solely in the superficial deposits, seven were screened solely in the bedrock, and six spanned the superficial and the bedrock. Recorded maximum groundwater levels varied from 0.37mbgl to 12.5mbgl. The largest temporal variation within a single borehole was 5.78m, occurring within the bedrock aquifer. The largest variation that occurred within the superficial deposits was 2.6m.

10.3.42 Twenty-three variable head permeability field tests were carried out to provide permeability estimates across the proposed scheme. The coefficient of permeability (k) was recorded to range between $6.0 \times 10^{(-6)}$ m/s and $5.0 \times 10^{(-9)}$m/s. The full results are presented in the Fugro reports (Fugro, 2016 and 2017).

10.3.43 Groundwater flow within the superficial deposits is likely to follow surface topography towards the local surface watercourses. The direction of bedrock groundwater flow is unknown.

10.3.44 The hydrogeological characteristics of superficial and bedrock units within the study area are summarised in Table 10.11.

Table 10.11: Hydrogeological Characteristics of Superficial and Bedrock Units (flow and quality)

Geological Unit		Geological Characteristic	Hydrogeological Characteristic	Sensitivity
Superficial Deposits	Peat	Decomposed organic deposits	Very poor groundwater potential due to compacted nature, low permeability and limited spatial extent.	low (from a resource point of view)
	Made Ground	Composition of any Made Ground present unconfirmed.	Variable - Dependent on composition.	low
	Alluvium	Composed of clay, silt, sand and gravel.	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	high
	River Terrace Deposits	Composed of gravel, sand, silt and clay.	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	high
	Glaciofluvial Deposits	Composed of gravel, sand and silt	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	high
	Glacial Till	Heterogeneous deposits	Poor groundwater potential due to generally low and variable permeable nature.	medium
Bedrock	Southern Highland Group	Metamorphic – psammites and semipelites.	Low productivity aquifer – small amount of groundwater in near surface zone and secondary fractures.	medium
	Argyll Group	Metamorphic – meta-limestone, meta-volcanics, schist and quartzite.	Low productivity aquifer – small amount of groundwater in near surface weathered zone and fractures.	medium

Abstractions and Groundwater Flow

10.3.45 Details of the PWS identified within the study area are presented in Table 10.12 and the active PWS are shown on Figure 10.1. It should be noted that some of the PWS identified at DMRB Stage 2 using OS map information have now been found to be abandoned/inactive following landowner consultation and these have been discounted from the assessment. These are included in Table 10.12 with an update on their status. All PWS networks identified are of high sensitivity. Impacts on surface water fed PWS are covered in Chapter 11 (Road Drainage and the Water Environment) and these receptors are not further discussed in this chapter.

Table 10.12: Summary of identified abstractions/springs/PWS

PWS Reference	Source of Information	Nature of PWS	Property	Status	Comments
PK-W1	OS Map	n/a	n/a	Assumed abandoned	No response received from land owner consultation despite various attempts
PK-W2	OS Map and land owner consultation	n/a	n/a	Abandoned/ Not Active	
PK-W3	OS Map	n/a	n/a	Assumed abandoned	No response received from land owner consultation despite various attempts
PK-PWS1	PWS identified in land owner consultation	n/a	n/a	Abandoned/ Not Active	
PK-PWS2	PWS identified in land owner consultation	n/a	n/a	Abandoned/ Not Active	Land owner consultation suggests that only one PWS is used on this land holding. Location of this supply correlated with PK-PWS9
PK-PWS3	Land owner consultation questionnaire	n/a	n/a	n/a	Same PWS network as PK-PWS4
PK-PWS4	Land owner consultation questionnaires & Local Authority	Surface water/Capture tank (groundwater fed)	Littleton of Fonab, Milton of Fonab & Wester Ballinliug	Active	A capture tank feeds Littleton of Fonab. It is unclear whether the tank captures a spring or is fed by the upstream, surface water abstraction. The upstream, surface water abstraction is understood to be the source of Milton of Fonab and Wester Ballinliug. Supply fed by gravity through underground supply pipes. Unknown where pipes cross A9. PWS used for all purposes.
PK-PWS5	Land owner consultation questionnaire (completed by agent)	Spring	Balmore Cottages 1 + 2, Cluniemore Sawmill, Tombane Cottage	Active	Spring from Clunie Wood behind property. Domestic, including drinking water, and agricultural (cattle, field troughs and irrigation) use.
PK-PWS6	Land owner consultation questionnaire	n/a	Tigh-na-Beithe; property to be demolished - therefore considered as abandoned supply	Abandoned/ Not Active	Taken from burn Allt Na Aglastair. PWS used for domestic purposes & gravity fed.
PK-PWS7	PWS identified in land owner consultation	n/a	n/a	n/a	Same PWS network as PK-PWS4
PK-PWS8	Land owner consultation questionnaires & Local Authority	Well	5 properties on this supply; including Middlehaugh of Dalshian and Middle Cottage	Active	Borehole, between 57 and 300ft deep with 12inch diameter. Domestic supply. Groundwater actively pumped and equipped with filter and UV screen.
PK-PWS9	Landowner and tenant consultation questionnaires	Spring	Dunfallandy Home Farm, Dunfallandy House & properties on the Estate, Mains of Dunfallandy Farmhouse	Active	Springs on hillside behind properties, fed by gravity through underground pipes. Domestic and agricultural use (cattle sheds, field troughs and irrigation).
PK-PWS10	Tenant consultation questionnaire	Spring/surface water	Ballintuim Farm	Active	Gravity fed. Domestic supply

PWS Reference	Source of Information	Nature of PWS	Property	Status	Comments
PK-PWS11	Landowner consultation questionnaire/Site visit, Local Authority	Capture tank (groundwater fed)	Faskally Cottages	Active	Brick lined capture tank and large plastic storage tank. Very reliable supply
PK-PWS12	Local Authority, Land owner	Surface water/spring	Overton of Fonab	Active	The water supply for Overton was previously an underground supply which is no longer in operation, the landowner believes it silted up. The supply is now fed from a burn with a tank. It only supplies this property.
PK-PWS13	Landowner Consultation, Local Authority	Spring	Wyandotte Cottage	Active	Rises into a tank and pumped to the cottage. Domestic use - supplies cottage only.

10.3.46 Given the uncertainty on the source of Littleton of Fonab for PK-PWS4, impacts on the surface water intake are discussed in Chapter 11 (Road Drainage and the Water Environment) while this chapter considers the potential impact on the supply infrastructure associated with PK-PWS4. It is understood based on the consultation information that PK-PWS12 is a surface water abstraction; however, it could not be ascertained that the abstraction is directly made from a surface water feature rather than a shallow spring near to the surface water feature. For this reason, PK-PWS12 is being conservatively assessed from both a groundwater and surface water abstraction point of view in this assessment.

Groundwater Quality

10.3.47 No data on groundwater quality for the study area were available from BGS or SEPA.

10.3.48 The groundwater sample chemical analysis results from the Advanced and Preliminary GI have been compared against Resource Protection Values as defined within SEPA Position Statement WAT-PS-10-01 (SEPA, 2014). This screening exercise has identified elevated concentrations of cadmium (three locations), mercury (14 locations), selenium (four locations), ammoniacal nitrogen (one location) and speciated hydrocarbons (six locations). The majority of exceedances are marginal with a number of isolated greater exceedances observed within mercury, selenium and speciated hydrocarbons. The majority of locations sampled are not directly associated with any identified potential contaminated land source with the exception of one location within an existing A9 embankment (recording only a marginally elevated concentration of mercury), one location within proximity to the existing Highland Main Line railway (with no recorded exceedances) and two locations on existing side roads (both with marginal exceedances in mercury, one with a marginal exceedance in ammoniacal nitrogen and the other with an elevated concentration of speciated hydrocarbons). Made ground was not recorded on the borehole logs.

Ecological Receptors with Potential Groundwater Component

10.3.49 The preliminary assessment of ecological receptors based on Phase 1 habitat mapping undertaken during the SEA by Transport Scotland (2013) did not identify any habitats with the potential for either full or partial reliance on groundwater inflows. This was subsequently confirmed by additional ecological surveys undertaken in 2015.

10.3.50 Other ecological receptors are identified and described further in Chapter 12 (Ecology and Nature Conservation).

Surface Water Features

10.3.51 Surface water features are expected to have a groundwater baseflow component, and groundwater may be a contributor to river flooding mechanisms.

10.3.52 The main water course within the study area is the River Tummel. The existing A9 crosses the River Tummel to the east of Mains of Dunfallandy. The River Tummel is dammed by Pitlochry Dam, located

to the south of Pitlochry, to form Loch Faskally. The existing A9 crosses Loch Faskally at the Clunie Underbridge. The River Tummel and Loch Faskally both form part of the River Tay Special Area of Conservation (SAC), which is designated for the protection of Atlantic salmon, lamprey (sea, brook and river), otter and aquatic vegetation. Additional information is provided in Chapter 12 (Ecology and Nature Conservation) on protected species and habitats.

10.3.53 The confluence of the Rivers Tummel and Garry is located towards the northern end of the study area, to the west of Faskally, approximately 900m to the west of the existing A9. The River Garry flows north to south, west of the current A9 alignment to its confluence with the River Tummel. The River Garry is also designated as part of the River Tay SAC.

10.3.54 The River Tay SAC, including its surface water features previously identified, is considered to be of high sensitivity (as defined in Chapter 11, Road Drainage and the Water Environment).

10.3.55 All watercourses are identified and described further in the Chapter 11 (Road Drainage and the Water Environment).

10.4 Potential Impacts

Introduction

10.4.1 Potential impacts are assessed prior to the implementation of mitigation. Mitigation measures are then identified and described in Section 10.5 (Mitigation).

10.4.2 Construction and operational phases have been considered together as the majority of construction effects (such as removal of excavated material or dewatering due to proposed cuttings) would extend through to the operational phase. Where differences in impacts are predicted between the construction and operational phases, these impacts have been assessed for each in turn.

10.4.3 There are a variety of ways in which road development schemes can impact on geological resources, as follows:

- excavating or masking exposures of bedrock or superficial geological deposits of specific scientific interest if the features of interest are not reproduced elsewhere in the area;
- constraint/limitation to existing or potential commercial exploitation of resources;
- effects on underlying groundwater aquifers, for example through the dewatering of aquifers as a result of construction works involving excavation;
- risk of spillage or leakage of fuel or oil from storage tanks or construction plant, which without suitable mitigation measures can enter aquifers;
- effects of changes to groundwater flow or quality on secondary receptors such as groundwater abstractions, surface water or groundwater dependant terrestrial ecosystems; and
- surface runoff from the operational dual carriageway alignment may contain elevated concentrations of pollutants such as oils, suspended solids, metals (e.g. copper and zinc) and, in winter, salt and antifreeze agents (e.g. ethylene glycol), leading to pollution of the aquifers.

10.4.4 A key aspect of the impact assessment is to identify areas of excavations. Information on proposed excavated areas is provided in Table 10.13 and locations are shown on Figure 10.1 and Figure 10.2. It should be noted that only cuttings deeper than 1m are included and that a differentiation has been made between widening of existing cuttings (labelled as “widening”) and new proposed cuttings (labelled as “cutting”). Groundwater level and depth to bedrock data from the Advanced and Preliminary GI (including monitoring work) has been assessed and interpolated to produce indicative bedrock and groundwater surfaces as far as possible across the footprint of the proposed scheme.

Table 10.13: Cutting depths

Name	Approximate Chainage	Approximate Maximum Excavation Depth (mbgl)	Depth to Bedrock (drift thickness) (mbgl)	Depth to Groundwater Level (mbgl)	Likelihood to Intercept Bedrock	Likelihood to Intercept Groundwater
W1	ch1610-ch1800	3.7	9.5	6.5	unlikely	unlikely
W2	ch1870-ch2220	6.7	9	6.5	unlikely	likely
C1	ch4845-ch4965	14.7	2	3	likely	likely
C3	ch5460-ch6000	24.1	1.5	1.5	likely	likely
C4	ch5225-ch5460	15.4	1	1.5	likely	likely
C5	ch6050-ch6280	1.5	7	1.5*	unlikely	likely
CS1	ch0-ch165	12	2.5	2.5	likely	likely
CS2	ch0-ch27	1.3	11.5	3	unlikely	unlikely
CS4	ch0-ch70	3.2	1*	1*	likely	likely
CS5	ch10-ch150	3.0	14	2.5	unlikely	likely
CS6	ch0-ch110	3.4	13.6	8.5	unlikely	unlikely
CS7	ch0-ch220	9.8	2.5	2	likely	likely
CS8	ch380-ch530	1.8	1*	1*	likely	likely
CS9	ch50-ch260	5.2	7.5	1	unlikely	likely
CS10	ch950-ch1030	3.5	1*	1*	likely	likely
Basin C	ch5-ch55	1.6	25.5	4	unlikely	unlikely
Basin D	ch0-ch158	4.5	11	1	unlikely	likely
Basin G	ch0-ch150	8	5	6.5	likely	likely
Basin I	ch0-ch182	4.2	1*	1*	likely	likely
CC1 (WF65)	n/a	4.5	4	3.5	likely	likely
CC2 (WF66)	n/a	4	9	4.5	unlikely	unlikely
CC3 (WF74)	n/a	3	3	1.5	possibly	likely
CH1	ch140-ch162	4.9	4	2.5	likely	likely
CH2	ch295-ch330	1.6	10	5	unlikely	unlikely
CH3	ch400-ch450	2.05	1.5	1.5	likely	likely
CH4	ch540-ch600	6.25	4.5	3	likely	likely

* Groundwater level/depth to bedrock estimated due to insufficient groundwater/superficial data extending the length of the design. Level data were estimated by extending the closest available drift thickness contours/maximum groundwater contours.

Geology

Designated Geological Receptors

10.4.5 There are no designated geological receptors expected to interact directly or indirectly with the proposed scheme therefore no impacts are expected.

Soils

10.4.6 No areas of SNH priority peatland are expected to be impacted by the proposed scheme.

10.4.7 Two localised and isolated areas of peat (ch1560 and ch5450) could potentially be impacted by construction of the proposed scheme with limited removal of peat. The estimated total volume of peat required to be excavated is 1,950m^3. The removal of these peat volumes is expected to represent a minor impact magnitude, resulting in an impact of Neutral/Slight significance.

Superficial Geology

10.4.8 Superficial geology within the study area is likely to be impacted by the construction of cuttings and other earthworks as part of the proposed scheme. The reduction in extent of superficial deposits, including made ground, as a result of the construction activities is considered to be of minor

magnitude because of the widespread presence of these deposits elsewhere in the region. This results in an overall impact significance of Neutral during both the construction and operation phases.

Bedrock Geology

10.4.9 Table 10.13 indicates that bedrock is likely to be intercepted by fifteen of the proposed cuttings. This is expected to represent a minor magnitude of impact because of the widespread presence of these deposits, resulting in an overall impact significance of Neutral during both the construction and operation phases.

10.4.10 The use of blasting to excavate bedrock is anticipated as being required during the construction of the proposed scheme, particularly in the cutting associated with the Pitlochry North Junction. There are three major mechanisms where rock blasting can impact on rock structure:

- generation of new fractures in previously intact rock;
- dilation of existing joints and discontinuities by the action of high pressure explosive gases; and
- promotion of slip planes along favourably oriented joints and fracture surfaces.

10.4.11 The generation of new fractures in previously intact rock and the dilation of existing joints and discontinuities occur close to the blast zone (termed 'near-field' effects), and the promotion of slippage along favourably oriented joints can occur several hundreds of metres from the blast (termed 'far-field' effects).

10.4.12 Blasting effects on rock mass, as described above, may result in consequential impacts on hydrogeology by creating or changing groundwater pathways. Potential impacts could therefore occur if the contractor opts to use explosives in the excavation of the cuttings where there are sensitive hydrogeological receptors and significantly contaminated sites in relatively close proximity. The potential impact of blasting on groundwater is assessed in the groundwater section. Blasting on solid geology is considered to be a potential impact of negligible magnitude.

10.4.13 On this basis the overall significance of potential impacts from blasting operations on solid geology is considered to be Neutral.

Mineral Extraction

10.4.14 There is evidence of previous mineral extraction from the superficial deposits within the study area, and there is potential for future exploitation of these resources. Due to the relatively widespread occurrence of these deposits (low sensitivity) within the region, the construction impact of the proposed scheme is considered to be of negligible magnitude, resulting in a potential impact of Neutral significance during both the construction and operation phases.

Geotechnical Hazard

10.4.15 Risks identified in paragraph 10.3.26 along the current A9 are currently being re-visited. Early assessment outcomes suggest generally low potential landslide risk associated with alluvial or river terrace deposits and with slopes above the proposed new earthworks, however some areas may require mitigation measures to be put in place. These have been proposed in Section 10.5 (refer to Mitigation Items P04-G16 to P04-G18).

10.4.16 There are no existing rock cuttings between Pitlochry and Killiecrankie. It is anticipated that bedrock is at shallow depth to the north of this section, specifically in the area of the Pitlochry North Junction (approximate ch4850 to ch6000). Therefore, the proposed re-alignment in this area is likely to involve the construction of new rock slopes on both sides of the carriageway but mainly on the southbound side. At this stage, it is not clear whether bedrock will be exposed over the full depth of the cutting or whether the cuttings will be formed of both soil and rock.

10.4.17 The construction of new rock slopes is seen as an opportunity to enhance the existing landscape, providing new exposures of geological interest. These exposures will supplement the existing Glen Garry SSSI and GCR sites found further to the north along the A9, beyond the extents of the Pitlochry

to Killiecrankie section. There may be opportunities to expose key geological features of interest and the proposed works should allow exposures to be clean and clear to view.

10.4.18 On the basis of the above and following the criteria defined in Tables 10.1 to 10.3, the geotechnical hazards associated with the proposed dualling works have been assessed as having negligible to minor magnitude, resulting in a potential impact of Neutral significance during both construction and operation phases.

Contaminated Land

10.4.19 A number of potential pollution sources, migration pathways and potential receptors that may be at risk as a result of the proposed scheme have been identified. Potential risks have been assessed where complete pollutant linkages have been identified between contamination sources and receptors.

10.4.20 There are two potential ways in which the proposed scheme could impact contaminated land:

- direct disturbance of potentially contaminated land sites (i.e. sources are within the proposed scheme footprint); and/or
- indirect disturbance of potentially contaminated land sites as a result of construction of the proposed scheme (i.e. potential pathways which exist within the proposed scheme footprint).

Construction Phase – Direct Disturbance

10.4.21 Direct disturbance with a number of potentially contaminated land sources has the potential to impact on human receptors as summarised in Table 10.14.

Table 10.14: Potential Direct Contaminated Land Impacts During Construction

Source Ref	Source Name	Pollutant Pathway	Magnitude	Likelihood	Significance
PK-C1	Existing A9	PP1 & PP3	mild	likely	**Moderate/Low**
PK-C2	Highland Main Line Railway	PP1 & PP3	mild	likely	**Moderate/Low**
PK-C3	Curling Pond	PP1, PP2, PP3, & PP4	medium	likely	**Moderate**
PK-C4	Gravel Pit	PP1, PP2, PP3, & PP4	medium	likely	**Moderate**
PK-C5	Saw Mill	PP1 & PP3	mild	likely	**Moderate/Low**
PK-C6	Old Limekiln	PP1, PP2, PP3, & PP4	mild	likely	**Moderate/Low**
PK-C24	Old Limekiln	PP1, PP2, PP3, & PP4	mild	likely	**Moderate/Low**
PK-C26	Old Saw Mill	PP1 & PP3	mild	likely	**Moderate/Low**
PK-C37	Septic Tank	PP1 & PP3	mild	likely	**Moderate/Low**
PK-C46	Septic Tank	PP1 & PP3	mild	likely	**Moderate/Low**
PK-C56	Septic Tank	PP1 & PP3	mild	likely	**Moderate/Low**
PK-C57	Septic Tank	PP1 & PP3	mild	likely	**Moderate/Low**
n/a	Made ground removed and temporarily stored	PP1, PP3, PP5 to PP9	medium	likely	**Moderate**

Construction Phase – Indirect Disturbance

10.4.22 Indirect disturbance may occur where proposed cuttings intercept groundwater, as they could draw contaminated groundwater towards the cutting. Twenty of the proposed cuttings/widenings have the potential to intercept groundwater. The risk assessment for the cuttings drawing in contaminated groundwater which then needs to be discharged (PP10) is presented in Appendix A10.2 (Contaminated Land Indirect Impact Assessment) with 13 cuttings predicted **Moderate/Low** or greater significance of impact.

10.4.23 Construction personnel could be at risk of direct contact with contaminated groundwater through pathway PP1. The potential of this event occurring has been assessed as likely with an impact magnitude of medium, resulting in a potential impact of **Moderate** significance.

Operation Phase – Direct Disturbance

10.4.24 The same list of potentially contaminated land sources as shown in Table 10.14 has the potential to be directly disturbed during the operation phase as during the construction phase, but with a reduced likelihood, except for made ground potentially re-used during the construction of the proposed scheme.

10.4.25 Potential impact significance for all sources, other than made ground, is therefore proportional to but one level lower than that shown in Table 10.14. Potential pollutant pathways during the operation include PP12, PP13, PP14 and PP15. Ten of the identified potential sources have an impact significance of Low, with only two (PK-C3 and PK-C4) having an impact significance of **Moderate/Low**.

10.4.26 For made ground removed and temporarily stored potential pollution pathways PP12, PP14 and PP16 to PP20 are applicable. The potential of an impact occurring has been assessed as being likely and the impact magnitude as medium, resulting in a potential impact of **Moderate** significance.

Operation Phase – Indirect Disturbance

10.4.27 Groundwater intercepted by proposed cuttings would need to be drained and discharged (PP21). The same list of potential contaminant source as shown in Appendix A10.2 (Contaminated Land Indirect Impact Assessment) has the potential to impact the receiving water environment as during the construction phase, but with a reduced likelihood due to a reduced rate of discharge.

10.4.28 Potential impact significance for all cuttings and sources is therefore proportional to but one level lower than that shown in Appendix A10.2 (Contaminated Land Indirect Impact Assessment). All cuttings have a potential impact significance ranging from Very Low to Low with the exception of CS1 which will have a potential impact significance of **Moderate/Low**.

10.4.29 Maintenance personnel could be at risk of having direct contact with contaminated groundwater, through pathway PP12. The potential of this event occurring has been assessed as being of low likelihood with an impact magnitude of medium, resulting in potential impact of **Moderate/Low** significance.

Groundwater

10.4.30 The Sichardt method (e.g. Preene et al, 2000) was used to estimate the zone of influence of dewatering around each of the cuttings considered likely to intercept groundwater, using the dimensions of the cuttings and the estimated drawdown of groundwater levels due to the excavation. The potential impacts on receptors within this zone of influence were then assessed for each proposed cutting.

10.4.31 The same zone of dewatering influence was also used to determine potential indirect contaminated land impacts via the groundwater pathway (refer to paragraph 10.4.18).

Groundwater Flow

10.4.32 Table 10.13 indicates that 17 cuttings and widenings and three SuDS detention basins have been assessed as likely to intercept groundwater within the superficial deposits. This is expected to create a local dewatering effect within the superficial deposits (medium to high sensitivity) around these locations, assessed as being of moderate magnitude. This results in an overall impact significance of **Moderate** to **Moderate/Large** during both the construction and operation phases

10.4.33 Bedrock groundwater is expected to be intercepted in 13 cuttings and widenings and two detention basins, which is expected to create a local dewatering effect within shallow bedrock groundwater.

This would result in a localised impact of minor magnitude with a resultant overall impact significance of Slight during both construction and operation phases.

10.4.34 Where dewatering occurs in superficial deposits, there is a risk that differential settlement could impact nearby infrastructure and properties, as well as listed buildings and scheduled monuments. Listed buildings and scheduled monuments have been attributed a high sensitivity, while the remaining infrastructure and properties are of medium sensitivity. The potential impacts due to settlement along the proposed scheme are summarised in Appendix A10.3 (Infrastructure, Properties and Cultural Heritage Receptors).

10.4.35 Settlement within the sands and gravels due to the drawdown of groundwater are generally negligible in magnitude, including in cutting areas where the greatest dewatering impacts are expected (C1, C3, C4, CS1 and CS7). This results in a Neutral impact significance, as indicated in Appendix A10.3 (Infrastructure, Properties and Cultural Heritage Receptors).

10.4.36 The construction of embankments may result in localised compaction of superficial deposits. This would result in localised impacts of negligible magnitude for groundwater flow and has therefore been assessed as being of Neutral significance on groundwater within the superficial deposits.

Groundwater Quality

10.4.37 In the event of accidental spillage during construction or operation, potential contamination may migrate from the ground surface through the unsaturated zone, reaching the shallow superficial aquifers and impairing groundwater quality, unless appropriate measures for control of discharge and drainage are taken.

10.4.38 The magnitude of potential impact from accidental spillages is considered to be moderate for both superficial groundwater and bedrock groundwater, because of bedrock being shallow in various areas and based on the limited potential for attenuation in places before it reaches bedrock groundwater. The assessment of accidental spillage impacts on these aquifers is provided in Table 10.15. Hydrogeological units are groupings of geological units with similar hydrogeological characteristics.

Table 10.15: Potential Impact of Accidental Spillages on Key Hydrogeological Units During Construction and Operation

Hydrogeological Unit	Sensitivity	Magnitude	Significance
Superficial - Made Ground, Peat	low	moderate	**Slight**
Superficial - Glacial Till	medium	moderate	**Moderate**
Superficial - Alluvium, River Terrace Deposits, Glaciofluvial Deposits	high	moderate	**Moderate/Large**
Bedrock - Argyll Group, Southern Highland Group	medium	moderate	**Moderate**

10.4.39 Potential impacts of accidental spillages on surface water features are discussed in Chapter 11 (Road Drainage and the Water Environment).

Abstractions

10.4.40 One active PWS is located in proximity to cuttings considered likely to intercept groundwater has been identified. Cutting C1 is considered to have a potential major magnitude impact on PK-PWS11 because the cutting is located laterally to this shallow supply. This is expected to result in a potential impact significance of **Large/Very Large** .

10.4.41 Assuming that PK-PWS12 is sourced at proximity to Overton of Fonab's property, then this supply would be borderline to the calculated zone of influence as a result of dewatering at CS1. The potential impact magnitude is assessed as minor, resulting in a potential impact significance of Slight/Moderate.

10.4.42 Cuttings C3/C4 are considered to have a potential moderate magnitude impact on PK-PWS11 which would result in a potential impact significance of **Moderate/Large.** This impact may combine with potential dewatering impacts resulting from Cutting C1 described in paragraph 10.4.40.

10.4.43 In addition, two PWS connections (i.e. pipelines) cross the footprint of the proposed scheme, at chainages ch1850 and ch3650, associated with PK-PWS4 and PK-PWS5 respectively. Along with the PWS they serve, these connections are of high sensitivity and the potential impact magnitude is major, resulting in a potential impact of **Large/Very Large** significance.

10.4.44 It should be noted that the potential impact of blasting on groundwater and PWS has been assessed and no PWS is expected to be at risk.

Ecological Receptors with Potential Groundwater Component

10.4.45 As no ecological receptors with potential groundwater components have been identified within the study area, no impacts are expected on this type of receptor.

Groundwater Effects on Surface Water

10.4.46 Potential surface water quality impairment or reduction in baseflow contribution as a result of impacts on the groundwater environment has been assessed based on the proximity of surface water features to areas where impacts on the groundwater environment could potentially occur. It is assumed that a degree of hydraulic connectivity exists between the groundwater and surface water systems.

10.4.47 Surface water features are referenced as per the water feature (WF) numbering system developed in Chapter 11 (Road Drainage and the Water Environment). The assessment of potential impacts on surface water features as a result of interaction with proposed road cuttings in summarised in Appendix A10.4 (Surface Water Indirect Dewatering Assessment).

10.4.48 Magnitude of impact is assessed based on both the degree of potential impact on the groundwater environment and the ecological sensitivity of the surface water feature.

10.4.49 Appendix A10.4 details a tiered assessment reviewing potential impacts on surface water receptors and no impacts of significance are expected. In addition, groundwater abstracted via road cuttings and widenings will be returned to the same general catchment during the operational phase, which will compensate the losses at the catchment scale. Further details are provided in Appendix A10.4 (Surface Water Indirect Dewatering Assessment).

10.5 Mitigation

10.5.1 Mitigation measures for the proposed scheme in relation to geology, contaminated land and groundwater are detailed below and take into account best practice, legislation, guidance and professional experience.

10.5.2 This chapter makes reference to overarching standard measures applicable across A9 dualling projects ('SMC' mitigation item references), and also to project-specific measures ('P04' mitigation item references). Those that specifically relate to geology, soils, contaminated land and groundwater as assigned a 'G' reference.

Embedded Mitigation

10.5.3 The DMRB Stage 3 design process has avoided or reduced many potential impacts by reducing land-take wherever possible.

10.5.4 No specific embedded mitigation measures have been included for geology, soils or contaminated land as part of the proposed scheme.

Standard Mitigation

Geology

10.5.5 Where peat is encountered during construction, it will be excavated, stored and re-used if possible, taking cognisance of 'Development on Peatland: Guidance on the Assessment of Peat Volumes,

Reuse of Excavated Peat and the Minimisation of Waste' (Scottish Renewables and SEPA, 2012) and The Waste Management Licensing (Scotland) Regulations 2011. This will be captured in a Peat Management Plan that will be developed by the Contractor (**Mitigation Item SMC-G10)**.

10.5.6 Risk assessments will be undertaken before explosives can be used on site to minimise or control the impact of blasting on bedrock geology (**Mitigation Item SMC-G15**).

Contaminated Land

10.5.7 Direct interaction is expected between construction of the proposed scheme and areas of potentially contaminated land. This interaction could lead to direct and indirect impacts to human health and the water environment which have been predicted to range from moderate to moderate/low significance. The standard mitigation items described below would be implemented to negate or minimise the predicted impacts and to minimise the contact with any potentially contaminated soil or groundwater.

10.5.8 Prior to construction, consultation will be undertaken with the relevant local authorities and SEPA regarding works in relation to land affected by contamination to support the obligations set out in 'Planning Advice Note 33: Development of Contaminated Land' (Scottish Government, 2000). Any remedial action undertaken in relation to land affected by contamination will be carried out under the appropriate remediation licencing (**Mitigation Item SMC-G1**).

10.5.9 Prior to construction and where potential contamination has been identified, further site investigations sufficient to determine the extent and type of contaminants present will be undertaken as necessary to inform identification of appropriate construction methods and any additional mitigation (**Mitigation Item SMC-G2**).

10.5.10 Prior to construction, appropriate health and safety and waste management procedures for working with potentially contaminated soils will be established. Waste management procedures will take account of inter alia: Waste Management Licence Regulations 1994 (as amended by Waste management licensing Amendment (Scotland) Regulations 2003), HSE Guideline Note MS13 Asbestos 1988 and the Health and Safety Commission Approved Code of Practice and Guidance Note. These procedures will be implemented as appropriate during construction (**Mitigation Item SMC-G3**).

10.5.11 Risks to construction and maintenance staff working with/near contaminated land will be mitigated by the implementation of Mitigation Item SMC-G3 in combination with the adoption of appropriate systems of work, including personal protective equipment (PPE) as a last resort. In the event that unrecorded contamination is encountered, works should be stopped and the working procedures reassessed to confirm the working methods remain appropriate (**Mitigation Item SMC-G4**).

10.5.12 Appropriate training of personnel involved in earthworks activities to implement a watching brief to identify potential presence of previously unidentified contamination (**Mitigation Item SMC-G5**).

10.5.13 Where required, landowner consultation and site visits will be undertaken to confirm the location and network of septic tanks. Where septic tanks are located within the land made available (LMA) they will be relocated and/or rebuilt subject to discussion and agreement with the affected landowner(s) (**Mitigation Item SMC-G6**).

10.5.14 To prevent cross contamination and pollution from piling works undertaken in areas of land affected by contamination, the Contractor will develop a Piling Risk Assessment and adhere to appropriate guidance including the 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention, National Groundwater and Contaminated Land Centre Report NC/99/77' (**Mitigation Item SMC-G7**).

10.5.15 To maximise the reuse of site-won materials on-site (and minimise the need for disposal of waste in line with the principles of the "Waste Hierarchy") whilst ensuring that no risks are posed to human health nor the water environment a soil reuse assessment will be undertaken prior to construction. The soil reuse assessment will identify any potential risks posed to both human health and the water environment from potentially contaminated soils reused throughout the scheme (**Mitigation Item SMC-G9**).

10.5.16 If excavated soils are deemed unsuitable for reuse they will be assessed in line with the 'Waste Classification: Guidance on the Classification and Assessment of Waste' (Technical Guidance WM3) (Natural Resources Wales, SEPA, Northern Ireland Environment Agency, Environment Agency, May 2015) prior to disposal to determine whether they are hazardous or non-hazardous. This will establish the most appropriate and cost effective waste stream for the waste materials (**Mitigation Item SMC-G8**).

10.5.17 Where concrete materials are proposed to be used, appropriate guidance such as 'Building Research Establishment (BRE) SD1:2005' and 'British Standard (BS) BS8500' should be followed to ensure that ground conditions are appropriate for the use of concrete at each given location (**Mitigation Item SMC-G11**).

10.5.18 Where potential pollutant pathways for ground gas have been identified, a ground gas monitoring programme will be developed prior to construction in adherence to 'CIRIA 665 Assessing Risks Posed by Hazardous Ground Gases to Buildings'. This will include an assessment of gassing issues following receipt of additional ground gas monitoring results at selected boreholes. Appropriate working methods will be developed and adopted during below ground site construction works (including piling works and excavations). This should include as a minimum, gas monitoring undertaken prior to any entry into excavations, confined spaces or below ground structures and use of PPE as a last resort. If significant ground gas issues are identified during construction, further post construction monitoring will be undertaken and/or appropriate gas protection measures will be incorporated into the final design (**Mitigation Item SMC-G12**).

Groundwater Quality

10.5.19 Unless it can be demonstrated by the Contractor via a Quantitative Risk Assessment that no water quality impacts will occur due to leaching from SuDS retention ponds and detention basins, operational SuDS features will be lined. Any potential water quality impacts due to leaching from SuDS features will be addressed through the CAR process (**Mitigation Item SMC-G13**).

10.5.20 Storage of excavated soils and made ground will be minimised on site (spatially and in duration) and all storage areas will be appropriately lined, with adequate drainage management in place. This is to ensure that no polluted water percolates into the ground or contaminated run-off is generated (**Mitigation Item SMC-G14**).

Associated Disciplines/Chapters

10.5.21 In addition to the mitigation measures identified with respect to geology, soils, contaminated land and groundwater, standard mitigation items from both Chapter 11: Road Drainage and the Water Environment and Chapter 16: Air Quality will offer additional protection. Standard Mitigation items designed to protect the Surface Water Environment (W1, W3, W4, W6 to W10 and W12) will also protect groundwater receptors while air quality mitigation measures will avoid the creation of a statutory nuisance associated with dust and air pollution when working with contaminated land.

Specific Mitigation

Geotechnical Hazards

10.5.22 Upon completion of the landslide risk assessment associated with alluvial or river terrace deposits highlighted in paragraph 10.4.15, any mitigation required will be incorporated into the detailed design by the Contractor (**Mitigation Item P04-G16**).

10.5.23 The same applies to risk of future instability associated with slopes located above the proposed new earthworks (paragraph 10.4.15), for which protection measures may be required, e.g. catch fences along the crest of new cuttings. This is particularly likely to the north of Pitlochry where the re-alignment of the A9 cuts into the existing hill-side where scree and loose blocks of rock have been noted. However, the requirements for such protection measures would be determined by the Contractor during detailed design (**Mitigation Item P04-G17**).

10.5.24 Detailed GI to be completed between September 2017 and March 2018 will inform a stability assessment of the proposed rock slopes and will provide an indication of remedial measures that may be required following construction, which is envisaged to require blasting techniques. Such measures might include scaling of the rock slopes to remove rock debris and blocks considered to be at risk of potential failure from the face, and the installation of rock dowel or bolts to stabilise specific blocks of concern. On completion of construction of the new rock slopes, the cut face will be inspected by a suitably qualified and experienced engineering geologist to assess the stability and to add any further remedial measures required (**Mitigation Item P04-G18**).

10.5.25 Measures to enhance the potential benefit of proposed new rock cuttings have been discussed with the BGS and SNH in relation to the Killiecrankie to Glen Garry section to the north and are also relevant for rock cuttings in the Pitlochry to Killiecrankie section. These measures will include:

- 'signature' blocks of rock excavated during the formation of new cuts to be taken off site and used for educational purposes (**Mitigation Item P04-G19**); and
- providing the BGS and SNH with the opportunity to survey and document the new rock exposures during and immediately following construction for the purposes of updating their geological mapping records (**Mitigation Item P04-G20**).

Contaminated Land

10.5.26 Additional groundwater quality investigations will be undertaken in areas of cuttings intercepting the water table, where necessary. This will be the basis for a risk assessment to be carried out, including assessment of risks from migration of groundwater. Where required, water treatment will be put in place prior to discharge (**Mitigation Item P04-G21**).

Groundwater Flow

10.5.27 Seventeen cuttings and widenings and three SuDS detention basins are expected to intercept groundwater as per Table 10.13. The potential volume of groundwater drainage would be considered in the context of potential groundwater abstraction CAR licences prior to works commencing (**Mitigation Item P04-G22**).

10.5.28 Additional GI will be undertaken in vicinity of cuttings C1, C3, C4, CS1 and CS7 to confirm the conclusions of the initial settlement assessment (**Mitigation item P04-G23**). In the eventuality of some properties being confirmed as at potential risk, appropriate measures including condition surveys and monitoring of buildings and groundwater level changes may be required.

Groundwater Quality

10.5.29 Groundwater intercepted by cuttings may need to be treated prior to being discharged, as there was evidence of elevated cadmium, mercury, selenium, ammoniacal nitrogen and hydrocarbons in some sampled boreholes (**Mitigation Item P04-G24**).

Abstractions

10.5.30 PWS identified as potentially at risk (PK-PWS11 and PK-PWS12) will be monitored. Should a potential significant adverse impact on a PWS be confirmed, an alternative source of water will be provided. To this effect, the Contractor will be required to prepare a supply-specific monitoring plan and mitigation strategy in communication with affected land owners and in consultation with SEPA (**Mitigation Item P04-G25**).

10.5.31 PWS pipe networks identified as being at potential risk (PK-PWS4 and PK-PWS5) will be protected during construction by the Contractor. This will be achieved by the Contractor confirming the exact location of the pipeline by digging and incorporating protective measures to ensure that the infrastructure does not get damaged during construction and in the long term by the proposed scheme (**Mitigation Item P04-G26**).

10.6 Residual Impacts

10.6.1 Residual impacts on geology are expected to be of Neutral significance, with potential beneficial effects as a result of the exposure of new rock cuttings.

10.6.2 The implementation of mitigation measures in relation to contaminated land issues and direct/indirect impacts is expected to reduce potential impacts to a residual impact of Low significance during the construction phase and Very Low significance during the operational phase.

10.6.3 Localised residual impacts of Slight significance are expected on groundwater flow within bedrock and **Moderate** to **Moderate/Large** significance on groundwater flow within superficial deposits of medium and high sensitivity (respectively).

10.6.4 Residual impacts on differential settlement are assessed as Neutral.

10.6.5 The implementation of mitigation measures in relation to the protection of the water environment against pollution incident is expected to reduce the potential impacts on groundwater quality and associated receptors to a residual impact of Slight and Neutral significance (respectively).

10.6.6 After implementation of mitigation measures, residual impacts on PWS identified at potential risk are expected to reduce to Neutral.

10.6.7 Residual impacts on surface water receptors from indirect dewatering are expected to be Neutral to Slight.

10.7 Statement of Significance

10.7.1 With the proposed scheme in place, and taking into account mitigation measures as described in Section 10.5 (Mitigation), a **Moderate** to **Moderate/Large** significance on groundwater flow within glacial till and glaciofluvial deposits/alluvium/river terrace deposits respectively are anticipated.

10.7.2 All other impacts on geology, contaminated land and groundwater are not predicted to be significant in the context of the EIA Regulations.

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