12 Geology, Soils, Contaminated Land and Groundwater

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

Baseline conditions were established through desk-based assessment, consultation and a phase of ground investigation. This process established that no designated Geological Receptors or Geological Conservation Review (GCR) sites were identified within the study area; superficial deposits were primarily composed of alluvium, tidal deposits, raised marine deposits, glaciofluvial deposits and Glacial Till. The underlying bedrock was composed of Old Red Sandstone and several potential sources of contamination were identified within the study area (including Made Ground, the A9 Perth – Inverness Trunk Road and A96 Aberdeen – Inverness Trunk Road (hereafter referred to as the A96), the Highland Main Line Railway and small scale industrial/economic activities). In addition, private water supplies (PWS) and surface water features (SWF) have been 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 on geology, soils and mineral resources is expected to be Neutral. Potential Moderate to Moderate/Low significance of impact was identified for a number of contaminated land source and/or pathways, which was reduced to Low after implementation of mitigation measures during construction.

The impact on groundwater flow is expected to be Slight to Neutral for groundwater within superficial deposits and bedrock respectively. The impact on groundwater quality is expected to be Slight to Moderate/Large but this is reduced to Slight to Neutral after mitigation measures. Potential differential settlement has not been identified as an issue on existing infrastructure and buildings. Although PWS are present within the study area, none are anticipated to be impacted by the proposed scheme and only Neutral significance of impact is expected on surface water features from indirect groundwater dewatering.

In conclusion, no significant residual impacts are anticipated for receptors within the study area after the implementation of the proposed mitigation in the context of the EIA Regulations.

12.1 Introduction

12.1.1 This chapter presents the Design Manual for Roads and Bridges (DMRB) Stage 3 Environmental Impact Assessment (EIA) of the A9/A96 Inshes to Smithton scheme (hereafter referred to as the proposed scheme) in relation to the impacts on geology, soils contaminated land and groundwater.

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

12.1.3 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 in the area. Impacts can also include restrictions on existing or potential commercial exploitation of resources, and conversely previous exploitation of resources can impose constraints for a 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.

12.1.4 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 aquifers and degrade water quality. Construction work can also lead to dewatering and also to contamination of superficial and bedrock aquifers.

12.1.5 During operation, runoff from the road surface may contain elevated concentrations of pollutants, such as oils, suspended solids, metals and, in winter, salt and engine coolants (e.g. ethylene glycol) 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.

12.1.6 This chapter is supported by Figure 12.1, which shows the areas of potentially contaminated land, the location of groundwater abstractions and areas where existing cuttings are widened or where a new cutting is proposed (below 1m) as part of the proposed scheme.

Legislative and Policy Background

12.1.7 Appendix A18.1 (Planning Policy Context for Environmental Assessment) describes the planning policies and guidance from national to local level which are relevant to this chapter. An assessment of the compliance of the proposed scheme against all development plan policies relevant to this environmental topic is reported in Appendix A18.2 (Assessment of Development Plan Policy Compliance) with a summary overview provided in Section 18.4 (Assessment of Compliance) of Chapter 18 (Policy and Plans).

12.2 Methodology

Scope and Guidance

12.2.1 This assessment has been undertaken using the guidance contained in DMRB Volume 11, Section 3, Part 11, Geology and Soils (Highways Agency, Scottish Office Development Department, The Welsh Office and The Department of Environment Northern Ireland, 1993) (hereafter referred to as DMRB Geology and Soils) taking into account guidance on contaminated land risk assessment where appropriate (paragraph 12.2.15) and DMRB, Volume 11, Section 3, Part 10, HD45/09 Road Drainage and the Water Environment (Highways Agency, Transport Scotland, Welsh Assembly Government and The Department for Regional Development Northern Ireland, 2009) (hereafter referred to as HD45/09).

12.2.2 Consideration of soils includes contaminated land and Made Ground (included in the assessment of contaminated land). Agricultural soil quality is considered as part of the assessment reported in Chapter 15 (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.

12.2.3 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 17 (Materials).

Study Area

12.2.4 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) a study area extending up to 100m was used and extended where required for the dewatering impact assessment. Impacts on groundwater abstractions have been assessed to a distance of 850m from the outermost edge of the proposed scheme as corresponding to the minimum study area applied for groundwater abstractions under The Water Environment (Controlled Activities) (Scotland) (Regulations) 2011 (Controlled Activities Regulations (CAR)) and based on 'Regulatory Method (WAT-RM-11) Abstraction from Groundwater. V6' (Scottish Environment Protection Agency (SEPA) 2017).

Determination of Baseline Conditions

12.2.5 Baseline conditions cover the following aspects:

- bedrock and superficial geology;
- features of geological and geomorphological importance;
- mineral extraction;
- groundwater environment including abstractions; and
- contaminated land.

12.2.6 Baseline conditions were determined through a desk-based assessment, consultation with statutory and non-statutory bodies and landowners and ground investigations.

<u>Desk-based Assessment</u>

12.2.7 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), the BGS Geoviewer and BGS UK Hydrogeology viewer.
- BGS (1988b) Groundwater Vulnerability Map of Scotland, Scale 1:625,000.
- Macaulay Institute for Soil Research, Soil Survey of Scotland Map, Sheet 5, Eastern Scotland, 1981.
- UK Soil Observatory Soils map viewer (2018).
- Ordnance Survey (OS) historical maps for information on former land use, any potential contamination and physical hazards and information on private water supplies (PWS).
- SEPA Water Classification Hub (SEPA 2017) - https://www.sepa.org.uk/data-visualisation/water-classification-hub/
- SEPA Water Environment Hub (SEPA 2014) - https://www.sepa.org.uk/data-visualisation/water-environment-hub/
- Scott Wilson (2009) Inverness trunk link Road – Geotechnical Report. S100739.
- Scottish Natural Heritage (SNH) designation database (SNH 2014) - https://gateway.snh.gov.uk/natural-spaces/index.jsp.
- Scotland's Environment Web - https://www.environment.gov.scot/ (Scottish Government 2015)
- Previous assessments:
  - A96 Dualling Inverness to Nairn (including Nairn Bypass): DMRB Stage 2 Scheme Assessment Report (Jacobs 2014) (on behalf of Transport Scotland)
  - A96 Dualling Inverness to Nairn (including Nairn Bypass): DMRB Stage 3 Assessment Report (Jacobs 2016) (on behalf of Transport Scotland)
  - A9/A96 Inshes to Smithton DMRB Stage 2 Scheme Assessment Report (Jacobs 2017).
  - A9/A96 Inshes to Smithton Geotechnical Preliminary Sources Study (Jacobs 2017a).
  - Inverness Trunk Link Road Ground Investigation – Enhanced Factual Report on Ground Investigation (GI) (Soil Mechanics 2008)
  - A9/A96 Inshes to Smithton – Detailed Ground Investigation. Report No 17-1483, September 2018 (Causeway Geotechnical Ltd (CGL) 2018).

Consultation

12.2.8 Written consultation has been undertaken with a number of statutory and non-statutory bodies. This includes the following:

- information on licensed groundwater abstractions (via The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)) and on former and current contaminated land use from SEPA;
- information on the location and extent of environmental sensitivities in the vicinity of the proposed scheme and to establish any future development constraints from SNH; and
- information on former and current contaminated land use, Private Water Supplies (PWS) licensed fuel storage and any additional relevant information from The Highland Council.

12.2.9 Further information on the consultation process is provided in Chapter 6 (Consultation and Scoping).

Ground Investigation

12.2.10 An intrusive ground investigation (GI) designed by Jacobs, was undertaken by Causeway Geotech Ltd. between 20 March 2018 and 11 May 2018. The investigation consisted of 29 boreholes and 62 trial pits along the length of the proposed scheme and within the wider study area. Groundwater monitoring installations were completed for 24 boreholes. Samples of soils and encountered groundwater were collected and sent to Chemtest Laboratory for chemical analysis. Five rounds of groundwater monitoring were undertaken between May 2018 and November 2018. A total of ten soil samples and 29 groundwater samples underwent contamination testing.

Impact Assessment

12.2.11 Potential impacts in relation to geology, hydrogeology and contaminated land were assessed individually as per the methodologies provided below. The criteria outlined in Tables 12.1 to 12.3 and 12.5 to 12.10 are based on those that have been applied to similar schemes in Scotland and are designed to comply with DMRB guidance. The overall impact of the proposed scheme is then determined through a combination of these impacts.

Geology

12.2.12 The sensitivity and magnitude criteria in Table 12.1 and Table 12.2 were used for bedrock and superficial geology (including soils) features of geological importance and mineral extraction. The impact significance was then determined using Table 12.3.

Table 12.1: 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. Presence of low quality topsoil or soils (typically indicated by Land Capability for Agriculture Class 5 and Class 6). 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. Presence of very low quality topsoil or soils (typically indicated by Land Capability for Agriculture Class 7). 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 12.2: 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 12.3: 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

12.2.13 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). Impacts and opportunities are considered by applying professional judgment with context of the assessment categories set out in Table 12.1 and Table 12.2.

12.2.14 Impacts on geology and soil of Slight/Moderate significance and above are considered to be significant in the context of the Environmental Impact Assessment (EIA) Regulations (The Roads (Scotland) Act 1984 (Environmental Impact Assessment) Regulations 2017), and the level at which mitigation would be proposed.

Contaminated Land

12.2.15 In line with standard industry best practice, 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 buildings/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.

12.2.16 The pollutant pathways and receptors used within the assessment are provided in Table 12.4, with individual references assigned for linkages, PP1 to PP22.

Table 12.4: 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.

Pollutant Pathway	Receptor	Pathway
PP3	Off-site Receptors (Local residents and transient traffic (foot, road and rail traffic) in the 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.

12.2.17 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 Assessment has been undertaken.

12.2.18 Potential impacts are discussed in terms of likelihood (Table 12.5) and magnitude/consequence (Table 12.6). The Generic Qualitative Assessment is then undertaken based on the matrix shown in Table 12.7.

12.2.19 The estimation of quantities of materials to be disposed off-site is provided in Chapter 17 (Materials).

Table 12.5: 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 12.6: 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 effects to human health. No appreciable pollution. Easily repairable effects or damage to ecological systems. Easily reparable damage to buildings/structures/SM/services.

Table 12.7: Risk Assessment Criteria - 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

12.2.20 Impacts in terms of contaminated land exposure of Moderate/Low significance and above are considered to be significant in the context of the EIA Regulations, and the level at which mitigation would be proposed. These are highlighted in bold in Table 12.7.

Groundwater

12.2.21 The assessment of the magnitude of impact on the quality and level of groundwater is based primarily on the type of road profile (e.g. cutting, embankment or transition cutting-embankment) facing the receptor. 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. The assessment is undertaken within the context of the Water Framework Directive (WFD) (2000/60/EC) and the Groundwater Directive (2006/118/EC).

12.2.22 Potential groundwater flooding impacts are considered in Appendix A13.1 (Flood Risk Assessment) and are not discussed in this chapter.

12.2.23 Criteria for the definition of groundwater sensitivity and magnitude are reported in Tables 12.8 and 12.9. These consider groundwater sensitivity in the context of hydrogeological conditions, including groundwater resources and ecological receptors with potential groundwater dependency.

12.2.24 Sensitivity criteria attributed for surface water receptors (SWF) correspond to the importance criteria for aquatic habitats as provided in Chapter 11 (Ecology and Nature Conservation). Definitions of 'Importance' of aquatic habitats provided in Chapter 11 (Ecology and Nature Conservation) are considered a good representation of the sensitivity of water features to potential groundwater dewatering impacts.

12.2.25 The impact significance for groundwater aspects was then determined using the matrix shown in Table 12.10.

Table 12.8: 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 11.4 (Chapter 11: 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 (refer to Chapter 11: Ecology and Nature Conservation).
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 11.4 (Chapter 11: 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 (refer to Chapter 11: Ecology and Nature Conservation).
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 11.4 (Chapter 11 Ecology and Nature Conservation). Surface water features with some but limited hydrologic importance to sensitive or protected ecosystems of authority area importance (refer to Chapter 11: Ecology and Nature Conservation).
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 (refer to Chapter 11: Ecology and Nature Conservation).

Table 12.9: 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.

Magnitude	Description
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 12.10: 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

12.2.26 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

12.2.27 The exact abstraction locations of PWS are not currently known. Figure 12.1, however, shows indicative locations based on OS maps and consultation with The Highland Council. Detailed consultation with landowners in relation to PWS has not taken place and, therefore, there may be PWS which are present but have not yet been identified. The assessment is reliant on the accuracy of the information provided during consultation.

12.2.28 Geological and hydrogeological information obtained from the GI has been used for this assessment. In areas where no data was available, the nearest geological and hydrogeological information was extrapolated from the wider available dataset.

12.2.29 Seven rounds of groundwater monitoring were undertaken between May 2018 and January 2019. The available data may not reflect the full range of seasonal groundwater level variations that may occur.

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.

12.3 Baseline Conditions

Geology

Designated Geological Receptors

12.3.1 There are no designated geological receptors or Geological Conservation Review (GCR) sites within the study area.

Bedrock Geology

12.3.2 Bedrock geology within the study area is comprised primarily of the Hillhead Sandstone Formation which is described as a red and grey, planar-bedded, quartzose sandstone with interbeds of micaceous siltstone and silty mudstone (BGS Online Geoviewer 2018).

12.3.3 Previous ground investigations (Soil Mechanics 2008; Scott Wilson 2009; Jacobs 2017a) encountered bedrock at various depths across the site. Medium strong red sandstone was recorded at one location at a depth of 22mbgl in the vicinity of the proposed Cradlehall Railway Bridge. To the north of Ashton Farm, possible bedrock was recorded at relatively shallow depths of 2.7mbgl and 5.5mbgl. Boreholes in the north of the study area, at the tie in to the A96, recorded bedrock at deeper depths of 21.3mbgl and 28.3mbgl.

12.3.4 The A9/A96 Inshes to Smithton Detailed Ground Investigation encountered bedrock in 12 boreholes (Causeway Geotech Ltd 2018). Bedrock was identified as sandstone at all locations at depths ranging from 4.50mbgl (BHISD17) to 19.0mbgl (BHISD09) with limestone breccia encountered underlying sandstone at two locations at depths between 22.0mbgl and 25.5mbgl (BHISD24) and 24.85mbgl and 28.5mbgl (BHISD25). In alignment with previous ground investigations, bedrock was recorded at relatively shallow depths in the northern portion of the study area, to the north of Ashton Farm (4.5mbgl in BHISD17). Bedrock was encountered at deeper depths of 16mbgl to 18.5mbgl at the southern end of the route where the B9006 Culloden Road crosses the existing A9 Perth – Inverness Trunk Road and at 15.0mbgl to 19.0mbgl where the proposed scheme crosses the Highland Main Line Railway.

12.3.5 As per definitions in Table 12.1, bedrock present within the study area is considered to be of negligible sensitivity.

Superficial Geology

12.3.6 Superficial deposits within the study area include: alluvium; a variety of Flandrian and late Devensian raised marine deposits; and late Devensian glacial deposits (Causeway Geotech Ltd 2018).

12.3.7 The published geological information indicates that the proposed scheme is predominantly underlain by Quaternary superficial deposits. These include Late Devensian glacial deposits comprising Glaciofluvial Deposits, Glacial Till and Raised Tidal flat deposits, as well as Flandrian Alluvium. A small area of Glaciomarine Deposits is recorded in the vicinity of the proposed scheme close to the tie-in to the A96.

12.3.8 The Glacial Till Deposits comprise Hummocky Glacial Deposits of the Smithton Suite and are indicated to underlie the proposed scheme to the south of the Highland Main Line Railway (Jacobs 2017a). The Hummocky Glacial Deposits are described as dense clayey gravel and sandy gravel diamicton, mainly sandstone, with many boulders. A subglacial Till is also thought to underlie the younger Quaternary deposits across the area. The subglacial Till is described as stiff, matrix supported, stony sandy diamicton (Jacobs 2017a).

12.3.9 Glaciofluvial Sheet Deposits are described as comprising sand and gravel and are indicated to be present in the area adjacent to the Highland Main Line Railway and to the south of Ashton Farm (Jacobs 2017a).

12.3.10 Raised Marine Tidal Flat Deposits are recorded in the northern portion of the study area, to the north of Ashton Farm (Jacobs 2017a). These deposits are described as mainly pale olive-grey clayey silts, including some fresh water alluvium.

12.3.11 Raised Marine Shoreface Deposits are recorded at the north end of the A9 where widening is proposed and also at the northern extent of the proposed scheme. These are recorded to comprise sand, gravel and shingle.

12.3.12 A small area of Glaciomarine Deposits is recorded at the tie-in at Smithton, these deposits are described as interbedded pebbly silt and clay, fine sand, matrix-rich gravel and diamicton. A glacial meltwater channel is indicated at the southern extent of the proposed scheme immediately south of the proposed Cradlehall Roundabout.

12.3.13 The Flandrian Alluvium is recorded in several areas in the vicinity of the proposed route and is typically associated with watercourses (Jacobs 2017a). The Alluvium is described as comprising gravel, sand, silt and clay.

12.3.14 As per definitions in Table 12.1, these deposits are considered to be of negligible sensitivity.

Made Ground

12.3.15 Made Ground is expected to be locally derived and generally limited to areas of existing road or railway embankment. It is likely that Made Ground will be encountered in the vicinity of the existing Highland Main Line Railway and at the A96 Smithton Junction where the proposed scheme ties in to the A96. Areas of Made Ground have been identified at the Smithton roundabout where the Cairnlaw Burn is culverted beneath C1032 Barn Church Road (Jacobs 2017a).

12.3.16 As per definitions in Table 12.1, these deposits are considered to be of negligible sensitivity.

Mineral Extraction

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

12.3.18 Although quarrying, sand and gravel extraction is present in the region, no current or historical activity has been identified within the study area. The nature of superficial deposits however does not exclude the future potential for small scale mineral exploitation.

12.3.19 As per definitions in Table 12.1, these deposits are considered to be of low sensitivity.

Contaminated Land

12.3.20 A total of 22 potential contamination sources have been identified within 250m of the proposed scheme and are detailed in Table 12.11 below and locations shown on Figure 12.1.

Table 12.11: Potentially Contaminated Land Sources

ID	Land Use	Source of Information	Dates Present	Location	Comments
GC01	Canstore, Homebase	The Highland Council	Current	Inverness Retail and Business Park	Potential land contamination associated with contemporary land use. Information from The Highland Council (ref IN-GAR-1272). Data retrieved from Trading Standards File I314.
GC04	Highland Main Line Railway	OS maps	1906 to present	Crosses proposed scheme at Cradlehall	Made Ground associated with the Highland Main Line Railway - crosses the proposed scheme at Cradlehall.
GC05*	Inverness to Lossiemouth Fuel Pipeline	A96 DMRB Stage 2 assessment (Jacobs 2014)	Current	North-west of Smithton, north end of study area	Pipeline which runs along the A96 Inverness - Aberdeen Trunk Road at the northern end of the study area.

ID	Land Use	Source of Information	Dates Present	Location	Comments
GC06	Stratton Farm Petrol Tank	The Highland Council	Current	North-west of Smithton	Information from The Highland Council (ref IN-GAR-1065). Data retrieved from Trading Standards File BP331.
GC07	Smithton Junction – Made Ground	A96 DMRB Stage 2 assessment (Jacobs 2014)	1971 to present	North-west of Smithton	Made Ground located to the south-east of Smithton Junction roundabout
GC08	Existing A9	OS maps	1981 to present	Crosses proposed scheme at Inshes	Made Ground associated with the A9 Inverness - Perth Trunk Road.
GC09	Existing A96	OS maps	1971 to present	Within 250m of proposed scheme at Smithton Junction	Made Ground associated with the A96 Inverness - Aberdeen Trunk Road.
GC11	Smithy	OS maps	1874 to 1907	Inshes	Potential land contamination associated with historical land use.
GC12	Filling Station, Tesco	A96 DMRB Stage 2 assessment (Jacobs 2014)/ SEPA	Current	Inshes Retail Park	Potential land/groundwater contamination (CAR Licence - PPC - ID:33) PPC/N/0060058 Information from The Highland Council (ref IN-GAR-1245). Data retrieved from Trading Standards File I254.
GC14	Sewage Treatment Effluent (STE) discharge	SEPA	Current	Castlehill House, Inshes, Inverness	STE to land, potential land/groundwater contamination CAR/R/1115826
GC15	Pollution Prevention and Control	SEPA	Current	Beechwood Park, Inverness	Lifescan, Inverness Medical Ltd No further details available. PPC/B/1003237
GC17	Pollution Control – Sheep Dip	SEPA	Current	Ashton Farm, Inverness	JA Munro & Sons, GWR-BH1Sheep Dip Licence CAR/R/1007680. Surrendered in 2006.
GC22	STE discharge	SEPA	Current	The Brambles, Stratton, Inverness	STE to soakaway, Stratton, Inverness CAR/R/1065258
GC23	Waste Management	SEPA	Current	Culloden Road, Inverness	Inverness Campus Paragraph 19 exemption for use of waste for construction of roadway WML/XC/1109174
GC24	Waste Management	SEPA	Current	Stratton Farm, Inverness	Stratton Farm, Inverness No further details available WMX/N/0036120
GC25	Waste Management	SEPA	Current	Benview Pet Cemetery, Inverness	Benview Pet Cemetery Potential land/groundwater contamination WML/N/0050004
GC29	Sheep Wash	The Highland Council	1964 - 1984	South-east of Inverness College	Information from The Highland Council (ref IN-SHP-1017).

ID	Land Use	Source of Information	Dates Present	Location	Comments
GC30	Smithton Junction – Made Ground	A96 DMRB Stage 3 Assessment (Jacobs, 2017b)	Current	A96 tie in. South east of the Smithton Junction	The recent A96 Dualling Preliminary and Detailed Ground Investigations recorded an area of Made Ground at the proposed tie-in to the A96 Dualling scheme adjacent to C1032 Barn Church Road. Chemical analysis results for samples taken in two trial pits where Made Ground was recorded have been assessed with all determinands recorded at low levels
GC31	Pollution Control	SEPA	Current	Stoneyfield House	Stoneyfield House CSO CAR/L/1026128
GC32	Pollution Control	SEPA	Current	Inverness Campus	Inverness Campus, Southern System SuDS Outfall to U/T of Scretan Burn CAR/S/1098390
GC33	B9006 Culloden Road Embankment - Made Ground	A9/A96 Ground Investigation 2018	Current	B9006 Culloden Road	A9/A96 Ground Investigation recorded areas of Made Ground at three locations associated with embankments at B9006 Culloden Road to a maximum depth of 8.9mbgl.
GC34	Made Ground located to south-east of Inverness Retail and Business Park	A9/A96 Ground Investigation 2018	Current	South-east of Inverness Retail and Business Park	Area of Made Ground to south-east of Inverness Retail and Business Park to a maximum depth of 3mbgl.

* Feature is considered confidential and is not depicted on figures attached to this report.

12.3.21 The GI identified Made Ground in nine locations. Three of these locations are associated with the existing A9 Perth – Inverness Trunk Road, three with the embankment at B9006 Culloden Road, at the tie-in to A96 Smithton Junction and two are associated with a previously unidentified area of Made Ground located to the south-east of Inverness Retail and Business Park. Made Ground was primarily comprised of sands and gravels of varying lithologies. Pottery fragments were noted in one location associated with the area of Made Ground located to the south-east of Inverness Retail and Business Park. No olfactory evidence of contamination was noted within any of the Made Ground deposits.

12.3.22 The soil chemical analysis results from the 2018 GI have been compared against Generic Assessment Criteria (GAC) suitable for a residential end use to assess the potential risks to construction workers, which is considered to be a conservative approach. There will be limited exposure pathways to end users, given the proposed end use as a road; however potential pathways remain, including, those for maintenance workers. As a result, the soils sample chemical analysis results have also been compared against GAC suitable for public spaces (park) and commercial 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.

12.3.23 The following hierarchy of GACs has been used to screen soil sample analysis results:

- Suitable for Use Limits (S4ULs) for Human Health Risk Assessment, Land Quality Management / 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).

12.3.24 The results of the soil sample chemical analysis screening showed no exceedance in relation to S4ULs and C4SLs developed for public spaces, commercial land use or residential land use. It is noted that there were concentrations of hydrocarbons recorded in soils samples obtained from three locations (BHISD22 at 1mbgl, BHISD23 at 1mbgl and 2mbgl), however these were again below the screening threshold.

12.3.25 Ground gas monitoring has been carried out comprising up to 5 rounds at up to 23 locations. 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)).

12.3.26 The minimum concentration of methane necessary to support its combustion in air is defined as the Lower Explosive Limit (LEL) of 5%v/v. The maximum concentration of methane that will burn in air is defined as the Upper Explosive Limit (UEL) of 17%v/v. The range between the LEL and UEL is known as the flammable range for methane.

12.3.27 Concentrations of methane were not recorded above either 25% of the LEL (1%v/v) or 100% of the LEL (5%v/v) at any of the monitored locations.

12.3.28 Hydrogen sulphide was not recorded at any of the monitored locations during any of the monitoring rounds.

12.3.29 Carbon dioxide has been recorded in excess of the occupational exposure limits both for the long term (8 hour) Workplace Exposure Limit (WEL) (0.5% vol) and short term (15 mins) WEL (1.5% vol) at 3 of 23 locations monitored across the route area. A maximum concentration of 2.2% was recorded at BHISD01 which is screened within natural sand and silt and located adjacent to the existing A9 Perth – Inverness Trunk Road.

12.3.30 Depleted oxygen values below the 19% limit from the Mines and Quarries (1954) were recorded in 4 locations.

12.3.31 Carbon monoxide concentrations exceed the long term WEL (20ppm) and the short term WEL (100pm) at one monitoring location, located to the south-east of Inverness Retail and Business Park, with a maximum concentration of 278ppm recorded. This borehole is screened within natural gravels. Made Ground was recorded at this location, however no other source is noted in the vicinity. It is noted that this exceedance was recorded during one round only, with all other rounds recording peak carbon monoxide concentrations of 1 to 2ppm.

Hydrogeology

12.3.32 BGS hydrogeological maps indicate that the study area is underlain by Middle Old Red Sandstone, a moderately productive aquifer comprised of fine to medium grained sandstones, in places flaggy, with siltstones, mudstones, conglomerates and interbedded lavas. Locally it yields small amounts of groundwater and is represented in this region by the Hillhead Sandstone Formation and the Inshes Flagstone Formation. Nearer the coast, the study area is underlain by Quaternary sands and gravels of glaciofluvial origin, which form terraced and gently sloping and moundy terrain. Groundwater potential is dependent on the thickness of the saturated deposits but can yield up to 10 to 15l/s.

12.3.33 The SEPA Water Environment Hub details the site to be within the area of the Inverness and Ardersier Coastal groundwater area which was classified in 2014 as having a 'Good' water quality and overall classification of 'Good'.

12.3.34 Groundwater flow within the superficial deposits is likely to follow surface topography towards the local surface watercourses. The direction of flow of any bedrock groundwater is unconfirmed, but is expected to be generally to the north-west, towards the coast.

12.3.35 The hydrogeological characteristics of superficial and bedrock units are summarised in Table 12.12.

Table 12.12: Hydrogeological Characteristics of Superficial and Bedrock Units

Geological Unit		Geological Characteristic	Hydrogeological Characteristic	Sensitivity
Superficial	Made Ground	Composed of clay, sand and gravel (predominantly engineered fill).	Very poor groundwater potential due to surface/close surface location and possible low permeable nature.	Low
	Alluvial Deposits	Composed of variable sediments including clay, silt, sand, gravel and peat.	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	Medium
	Raised Tidal Flat Deposits	Silt, clay and fine–grained sand with lenses of gravel.	Local groundwater potential.	Medium
	Raised Marine (Including Ardersier Silts Formation)	Glaciomarine sand and gravel.	Local groundwater potential.	Medium
	Glaciofluvial Sheet Deposits	Sands and gravel, with local lenses of silt	Local groundwater potential.	Medium
	Glacial Deposits (Till)	Heterogeneous deposits.	Poor groundwater potential due to generally low and variable permeable nature.	Low
	Hummocky Glacial Deposits	Complex deposits composed of rock debris, clayey till and poorly to well-stratified sand and gravel.	Poor groundwater potential due to generally low and variable permeable nature.	Low
Bedrock	Middle Old Red Sandstone (Inshes Flagstone Formation and Hillhead Sandstone Formation)	Principally sandstone and mudstones with notable successions of conglomerates, shales and siltstones but also igneous intrusions.	Moderate groundwater potential.	High

Groundwater Flow

12.3.36 Groundwater monitoring was undertaken as part of the East Beechwood Masterplan GI in 2008 (Jacobs 2017a). The minimum depth to groundwater, 0.43m, was recorded in one borehole located adjacent to a tributary of the Scretan Burn. It is anticipated that groundwater will be close to the existing ground surface within the surrounding area of both the Cairnlaw Burn and the Scretan Burn.

12.3.37 In addition, a period of daily groundwater level monitoring was carried out in five boreholes with monitoring installations in the superficial deposits between August and December 2008 (Soil Mechanics 2008). Three were located in the south, one in the centre and one in the north of the study area. Groundwater generally ranged between 0.3mbgl and 2.9mbgl during this period, with a range of level variation of around 0.5m.

12.3.38 This is supported by groundwater monitoring undertaken in 24 boreholes (Causeway Geotech Ltd 2018) for seven rounds undertaken between May 2018 and January 2019. Groundwater ranged in depth from 0.35mbgl adjacent to U1058 Caulfield Road North and 0.57mbgl adjacent to the Scretan Burn to 9.26mbgl located towards the north of the proposed scheme.

Groundwater Abstractions

12.3.39 Two licensed groundwater abstractions, one known PWS and two further potential PWSs have been identified within an extended 850m study area. These are shown on Figures 12.1 and are summarised

in Table 12.13. As it is unclear what the status of these supplies are, all PWS have been provisionally assessed to be of medium sensitivity, as per definitions shown in Table 12.8.

Table 12.13: Groundwater Abstractions

ID	Type	Source of Information	Location (distance from route)	Comments
GA01	Licensed groundwater abstraction	SEPA	Raigmore Hospital, Inverness (<250m)	CAR/S/1116312
GA02	Licensed groundwater abstraction	SEPA	Gleneircht, North-west of Culloden / North of Smithton (<850m)	Identified as a Registration, assumed to be an abstraction 10 to 50 m^3/day CAR/R/1141869
GA03	PWS	Consultation	South of Inshes / south-east end of study area (<850m)	No further details available
GA04	Wells and Springs	OS maps	Stratton (<500m)	Spring, no further details available. Unknown if in use
GA05	Wells and Springs	OS maps	West of Raigmore Hospital, Inverness (<850m)	King Duncan's Well (historical) Unknown if in use

Groundwater Quality

12.3.40 Groundwater chemistry of the Old Red Sandstone aquifers of the Moray Firth area (BGS 2010), is generally moderately mineralised, with calcium as a dominant cation, bicarbonate as a dominant anion and with samples taken suggesting nitrate concentrations ranging from 0.05mg/l to 8mg/l. All groundwater bodies are designated Drinking Water Protected Areas. The study area does not lie within a Nitrate Vulnerable Zone.

12.3.41 Groundwater analysis results obtained during the 2018/2019 groundwater monitoring regime have been compared against relevant Resource Protection Values (RPVs) stated in Position Statement (WAT-PS-10-01) Assigning Groundwater Assessment Criteria for Pollutant Inputs (Version v3.0 Aug 2014). The screening shows that nickel, selenium and ammoniacal nitrogen were recorded at concentrations marginally in excess of the relevant freshwater RPV in both the Made Ground and natural soils across the route area but these were not attributed to any single source.

Ecological Receptors with Potential Groundwater Component

12.3.42 No ecological receptors with potential groundwater component have been identified within the study area.

Surface Water Features

12.3.43 A number of surface water features are present within the study area. These are detailed in Chapter 13 (Road Drainage and the Water Environment) of this report and are shown on Figure 13.1. The same sensitivity criteria attributed for quality and flow parameters within Chapter 13 (Road Drainage and the Water Environment) have been used in this chapter.

12.4 Potential Impacts

Introduction

12.4.1 The potential impacts reported in this section are assessed in line with approach set out in Section 12.2 (Methodology). Potential impacts are assessed prior to the implementation of mitigation. Mitigation measures are then identified and described in Section 12.5 (Mitigation).

12.4.2 Construction and operational phases have been considered together as the majority of construction effects (such as the removal of excavated material or dewatering due to proposed cuttings) would extend

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.

12.4.3 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 are not reproduced elsewhere in the area;
- constraint/limitation to existing or potential 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 dependent terrestrial ecosystems;
- surface runoff from the operational road 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; and
- excavation or exposure of new or previously unidentified potential sources of contamination which can result in the creation of new pollutant linkages.

12.4.4 The location of potential impacts refers to the 'links' of the proposed scheme as detailed in Chapter 4 (The Proposed Scheme) and shown on Figure 4.1. For ease of reference these include:

- Culloden Road to Cradlehall Roundabout (Link 1 – ch0 to ch306);
- Cradlehall Roundabout to Eastfield Way Roundabout (Link 2 - ch0 to ch644);
- Eastfield Way Roundabout to Inverness Retail and Business Park (Link 3 – ch0 to ch693);
- Eastfield Way Roundabout to Smithton Junction (Link 4 – ch0 to ch1113);
- Cradlehall Roundabout to Inverness Campus (Link 5 – ch0 to ch289); and
- Castlehill Road Tie-in (Link 6 - ch0 to ch208).

12.4.5 A key aspect of the impact assessment is to identify areas of excavation. Information on the proposed excavated areas is provided in Table 12.14 and locations are shown on Figure 12.1. 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 'Existing Cutting (Widened') and new proposed cuttings (labelled as 'Cutting'). Groundwater level and depth to bedrock data from the 2018 GI and monitoring work have been assessed and interpolated as far as possible across the footprint of the proposed scheme. On this basis, twelve of the proposed cuttings have potential to interact with groundwater, with only a temporary effect associated with the Sustainable Drainage System (SuDS) all of which are proposed to be lined (refer to **Mitigation Item G-12**).

Table 12.14: Cutting Depths

Name	Approximate Chainage	Approximate Maximum Excavation Depth (mbgl)	Likelihood to Intercept Bedrock	Local Maximum Groundwater Level (mbgl)	Likelihood to Intercept Groundwater
Cutting 1 (C1)	Link 4 ch600 to ch760	1.7	Unlikely	1.5	Likely
Cutting 2 (C2)	Link 4 ch1000 to ch1100	6.6	Low	1.67	Likely
Cutting 3 (C3)	Link 3 Park ch0 to ch40	1.5	Unlikely	0.7	Likely

Name	Approximate Chainage	Approximate Maximum Excavation Depth (mbgl)	Likelihood to Intercept Bedrock	Local Maximum Groundwater Level (mbgl)	Likelihood to Intercept Groundwater
Cutting Drainage 1 (CD1)	Link 5 ch60 to ch260	1.88	Unlikely	1.46	Likely
Cutting Drainage 3 (CD3)	Link 4 ch240to ch340	1.6	Unlikely	1.08	Likely
Cutting Drainage 4 (CD4)	Link 4 ch400 to ch500	1.6	Unlikely	1.08	Likely
Cutting Drainage 6 (CD6)	Link 5 ch520 to ch560	1.3	Unlikely	1.08	Likely
Cutting Drainage 7 (CD7)	Link 3 Park ch150 to ch280	1.2m in the eastern part; 2.6m in the western part	Unlikely	0.7	Likely
Cutting SuDS 1 (CSuDS1)	East of Cradlehall Roundabout	1.40	Unlikely	0.94	Likely
Cutting SuDS 2 (CSuDS2)	Link 3 (north-east of ch90 to ch150)	3.00	Unlikely	0.7	Likely
Cutting 3 (CSuDS3)	North of Eastfield Way Roundabout	1.5	Unlikely	0.93	Likely
Cutting 4 (CSuDS4)	Link 5 (west of ch750 to ch850)	2.3	Unlikely	1.46	Likely
Widening 1 (W1)	A9 southbound lane gain / lane drop ch300 to ch440	1.9	Unlikely	3.40	Low
Widening 2 (W2)	A9 southbound lane gain / lane drop ch560 to ch740	1.55	Unlikely	1.92	Low

Geology

Designated Geological Receptors

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

Superficial Geology

12.4.7 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 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.

12.4.8 No peat has been identified at this stage in the study area. Potential excavation of peat cannot be ruled out at this stage but would be expected to be localised and minimal, also generating a minor magnitude of impact. This results in an overall impact significance of Neutral during both the construction and operation phases.

Made Ground

12.4.9 Made Ground 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 these deposits as a result of construction activities is considered of negligible magnitude. This therefore results in an overall impact of Neutral significance during both construction and operation phases.

Mineral Extraction

12.4.10 There is no evidence of previous mineral extraction from the superficial deposits within the study area, and there is limited 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.

Bedrock Geology

12.4.11 Table 12.14 indicates a low to unlikely likelihood of bedrock being impacted by the proposed scheme. Because of the widespread presence of these bedrock deposits elsewhere in the region and country the potential percentage loss is minimal and any impact on these deposits is expected to be of negligible magnitude. This therefore results in an overall impact of Neutral significance during both construction and operation phases.

Contaminated Land

12.4.12 A number of potential pollutant 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.

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

Construction Phase – Direct Disturbance

12.4.14 Direct disturbance of seven potential contaminated land sources has the potential to impact on human receptors as summarised in Table 12.15.

Table 12.15: Potential Direct Contaminated Land Impacts During Construction

Source Ref	Source Name	Pollutant Pathway	Consequence	Likelihood	Impact Significance
GC04	Highland Main Line Railway	PP1 and PP3	Mild	Likely	Moderate/Low
GC08	Existing A9	PP1 and PP3	Mild	Likely	Moderate/Low
GC17	Sheep Dip Licence (surrendered in 2006)	PP1 and PP3	Mild	Likely	Moderate/Low
GC30	Smithton Junction - Made Ground	PP1 and PP3	Mild	Likely	Moderate/Low
GC33	B9006 Culloden Road Embankment – Made Ground	PP1 and PP3	Mild	Likely	Moderate/Low
GC34	Made Ground to south-east of Inverness Retail and Business Park	PP1 and PP3	Mild	Likely	Moderate/Low
n/a	Made Ground removed and temporarily stored	PP1 and PP3	Medium	Likely	Moderate

Construction Phase – Indirect Disturbance

12.4.15 Indirect disturbance may occur where proposed cuttings intercept groundwater, as they could draw contaminated groundwater towards the cutting which then needs to be discharged (PP10). Table 12.14 indicates that 12 cuttings have the potential to intercept groundwater. However, only four of these are considered likely to interact with potential contamination sources. The risk assessment for the cuttings drawing in contaminated groundwater which then needs to be discharged (PP10) or that may lead to contamination of surface water (PP7) is presented in Table 12.16.

Table 12.16: Potential Indirect Contaminated Land Impacts during Construction

Cutting	Potential Contamination Sources	Pollutant Pathway	Consequence	Likelihood	Impact Significance
C2	GC30	PP10	mild	Likely	Moderate/Low
CSUDS2	GC34	PP10	mild	Likely	Moderate/Low
C3	GC34	PP10	mild	Likely	Moderate/Low
CD7	GC34	PP10	mild	Likely	Moderate/Low

12.4.16 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 mild, resulting in a potential impact of Moderate/Low significance.

Operation Phase – Direct Disturbance

12.4.17 The same list of potentially contaminated land sources as shown in Table 12.15 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.

12.4.18 Potential impact significance for all sources, other than Made Ground, is therefore proportional to, but one level lower than that shown in Table 12.15. Potential pollutant pathways during the operation include PP12, PP13, PP14 and PP15. All of the identified potential sources have an impact significance of Low during the operation phase.

Operation Phase – Indirect Disturbance

12.4.19 Groundwater intercepted by proposed cuttings would need to be drained and discharged (PP21). The same potential contaminant sources have 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. Table 12.17 covers potential operational impacts on the receiving water environment.

Table 12.17: Potential Indirect Contaminated Land Impacts during Operation

Cutting	Potential Contamination Sources	Pollutant Pathway	Magnitude	Likelihood	Impact Significance
C2	GC30	PP21	Mild	Low	Low
CSUDS2	GC34	PP21	Mild	Low	Low
C3	GC34	PP21	Mild	Low	Low
CD7	GC34	PP21	Mild	Low	Low

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

Groundwater

Groundwater Flow

12.4.21 Table 12.14 indicates that twelve cuttings have the potential to intercept groundwater within the superficial deposits. This is expected to create a localised dewatering effect within the superficial deposits (low to medium sensitivity) around these locations, assessed as being potentially of minor magnitude. This results in an overall potential impact significance of Slight.

12.4.22 Potential differential settlement has not been identified as an issue on existing infrastructure and buildings.

12.4.23 The construction of embankments may result in localised compaction of superficial deposits, which could affect local groundwater flow. This would result in localised impacts of negligible magnitude for

groundwater flow within the superficial deposits, resulting in a Neutral significance of impact during both construction and operation phases.

12.4.24 No impact is expected on bedrock groundwater as a result of the cuttings and embankments, resulting in a Neutral significance of impact.

Groundwater Quality

12.4.25 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. This may impair groundwater quality, unless appropriate measures for control of discharge and drainage are taken.

12.4.26 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 12.18. Hydrogeological units are groupings of geological units with similar hydrogeological characteristics.

Table 12.18: Potential Impact of Accidental Spillages on Key Hydrogeological Units During Construction and Operation

Hydrogeological Unit	Sensitivity	Magnitude	Significance
Superficial Aquifers – Alluvium, Raised Tidal Flat Deposits, Raised Marine Deposits, Glaciofluvial Sheet Deposits	Medium	Moderate	Moderate
Superficial Aquifers – Made Ground, Glacial Till, Hummocky Glacial Deposits	Low	Moderate	Slight
Bedrock – Middle Old Red Sandstone	High	Moderate	Moderate/Large

12.4.27 Potential impacts of accidental spillages on surface water features are discussed in Chapter 13 (Road Drainage and the Water Environment).

Abstractions

12.4.28 Although 5 abstractions were identified within 850m of the scheme, no impacts are anticipated. This is due to the distance of the proposed scheme from these receptors.

Ecological Receptors with Potential Groundwater Component

12.4.29 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

12.4.30 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.

12.4.31 Surface water features are referenced as per the SWF numbering system developed in Chapter 13 (Road Drainage and the Water Environment).

12.4.32 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. The assessment of potential impacts on SWFs as a result of interaction with proposed road cuttings is summarised in Table 12.19. It should be noted that the nearest portion of cutting CD7 to SWF04 is expected to generate a very minor drawdown effect and as result no significant impact is expected on this receptor.

Table 12.19: Potential Impacts on SWFs as a Result of Interaction with Proposed Road Cuttings Prior to SUDS Discharging Into SWFs.

Cutting	SWF	Importance	Magnitude of Potential Impact	Significance of Potential Impact
CD3	Cairnlaw Burn (SWF08)	High	Negligible	Neutral
CD7	Scretan Burn (SWF04)	Medium	Negligible	Neutral
C2	Cairnlaw Burn (SWF08)	High	Minor	Slight / Moderate
C2	Tower Burn (SWF10)	Low	Negligible	Neutral
C3	Beechwood Burn (SWF03)	Low	Negligible	Neutral
CSUDS2 (temporary)	Beechwood Burn (SWF03)	Low	Negligible	Neutral
CSUDS2 (temporary)	Scretan Burn (SWF04)	Medium	Negligible	Neutral
CSUDS3 (temporary)	Indirect Tributary of Scretan Burn (SWF06)	Low	Negligible	Neutral
CSUDS3 (temporary)	Cairnlaw Burn (SWF08)	High	Negligible	Neutral
CSUDS4 (temporary)	Cairnlaw Burn (SWF08)	High	Negligible	Neutral

12.4.33 Based on Table 12.19, cutting C2 is expected to have an indirect dewatering impact on SWF08. However, water dewatered at this location will be discharged from CSUDS4 back up stream into SWF08. As a result of this, the significance of impact on SWF08 is expected to be Neutral.

12.5 Mitigation

12.5.1 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.

Embedded Mitigation

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

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

Standard Mitigation

Geology

12.5.4 Although no peat was identified in the study area, the excavation of peat deposits cannot be ruled out at this stage. Excavation, storage and any off-site removal, if required, will be undertaken with 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 will comply with relevant waste management practices under The Waste Management Licensing (Scotland) Regulations 2011 (Scottish Government 2011) (**Mitigation Item G-10**).

12.5.5 Potential geological impacts are of Neutral significance and therefore mitigation measures are not required.

Contaminated Land

12.5.6 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.

12.5.7 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) if and where relevant. Any remedial action undertaken in relation to land affected by contamination will be carried out under the appropriate remediation licencing (**Mitigation Item G-01**).

12.5.8 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 G-02**).

12.5.9 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 2011, HSE Control of Asbestos Regulations 2012, and the Health and Safety Commission Approved Code of Practice (ACOP) and Guidance Note (2012). These procedures will be implemented as appropriate during construction (**Mitigation Item G-03**).

12.5.10 Risks to construction and maintenance staff working with/near contaminated land will be mitigated by the implementation of Mitigation Item 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 G-04**).

12.5.11 Appropriate training of personnel involved in earthworks activities to enable implementation of a watching brief to identify presence of previously unidentified contamination (**Mitigation Item G-05**).

12.5.12 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 required to construct and operate the proposed scheme (i.e. the Draft Compulsory Purchase Order (CPO) boundary) they will be relocated and/or rebuilt subject to discussion and agreement with the affected landowner(s) (**Mitigation Item G-06**).

12.5.13 To prevent cross contamination and pollution from piling works undertaken in areas of land affected by contamination, the contractor will 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 G-07**).

12.5.14 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 proposed scheme (**Mitigation Item G-08**).

12.5.15 If excavated soils are deemed unsuitable for reuse, a waste strategy will be developed. This should consider on-site treatment as well as waste disposal and soils 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 G-09**).

12.5.16 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 G-11**).

Groundwater Quality

12.5.17 Chapter 13 (Road Drainage and the Water Environment), provides details on anticipated mitigation to address potential impacts on surface waters, including adherence to SEPA Pollution Prevention

Guidelines (PPGs) during construction and operation. It should be noted that SEPA are in the process of replacing the PPGs with Guidance for Pollution Prevention (GPPs) which should be adhered to, as appropriate. In respect of groundwater, these measures would also:

- mitigate against pollution by reducing the potential for pollutant release and preventing any contaminated runoff produced by the works from entering groundwater via the unsaturated zone; and
- protect groundwater receptors against impacts on water quality.

12.5.18 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 ponds, basins or wetland features, operational SuDS features will be lined (**Mitigation Item G-12**).

12.5.19 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 G-13**).

Groundwater Flow and Associated Groundwater Receptors

12.5.20 Groundwater monitoring should continue to be undertaken in order to obtain one year of monitoring on groundwater conditions, especially in cutting areas and where groundwater receptors are present and may be impacted.

12.5.21 This additional monitoring dataset should be used in the context and potential requirement of obtaining groundwater abstraction CAR licencing for these activities (**Mitigation Item G-14**).

Groundwater Effects on Surface Water

12.5.22 No additional mitigation measures are required for this type of receptor.

12.6 Residual Impacts

12.6.1 Residual impacts on geology are expected to be of Neutral significance.

12.6.2 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.

12.6.3 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 for superficial and bedrock groundwater, respectively.

12.6.4 Residual impacts due to differential settlement are assessed as Neutral to Slight.

12.6.5 Residual impacts are expected to be Neutral to Slight on groundwater flow patterns, with no impact expected on associated receptors such as abstractions, surface water features and ecological receptors.

12.7 Statement of Significance

12.7.1 All impacts on geology, soils, contaminated land and groundwater are not predicted to be significant in the context of the EIA Regulations following implementation of mitigation.

12.8 References

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