8 Geology, Contaminated Land and Groundwater

This chapter identifies and describes the existing geology, contaminated land and groundwater within the study area. It assesses the potential impacts of the proposed scheme on these features and outlines measures for avoiding or mitigating these impacts where possible.

No geological Sites of Special Scientific Interest (SSSI) are present within the study area, and no mitigation is required for the superficial and solid geology.

Two biological SSSIs (Cairnleith Moss and Mill Dam) are located within the study area. Both SSSIs and an unnamed pond have been assessed as Groundwater Dependent Terrestrial Ecosystems (GWDTEs) but are assessed as not being at risk from a hydrogeological point of view, and residual impacts are considered as being Negligible to Slight. The River Tay SAC was also assessed and is not considered to be at risk from hydrogeological change.

Several potential sources of contamination have been identified within the study area (including made ground, backfilled quarries, former landfills, rail, former mining and industrial facilities). A number of potential contaminated land issues were identified, which will require mitigation measures during construction. The residual impacts on contaminated land are expected to be of Low to Very Low significance.

The superficial aquifer of medium sensitivity and the bedrock aquifer of high sensitivity have been assessed, with moderate to high yield potential. A number of private water supplies (PWS), springs and wells are sourced from these aquifers. The residual impact on the aquifers and on groundwater receptors including abstractions has been assessed as of Negligible to Slight significance, taking account of the proposed mitigating measures during construction and operation.

8.1 Introduction

8.1.1 Road schemes can have potentially adverse impacts on the geology, land contamination and groundwater, as summarised below.

8.1.2 Excavating or masking exposures of rocks or superficial geological deposits of particular scientific interest can represent an adverse impact 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. Another potential issue is that ground conditions can also impose constraints on a proposed road scheme; for example, where land has become unstable due to mining or has been contaminated by previous land uses.

8.1.3 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. Similarly, once a new road is opened, runoff from the 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.

8.1.4 Construction works involving excavation can lead to dewatering and also to contamination of drift and bedrock aquifers.

8.1.5 This chapter presents the following:

- baseline conditions within the study area relating to solid and drift geology, mineral extraction, contaminated land, groundwater and location of private water supplies;
- potential impacts of the proposed scheme with regard to the identified baseline conditions;
- mitigation measures in order to prevent, reduce or offset the potential adverse impacts of the proposed scheme; and
- a summary of the residual impacts taking into account proposed mitigation.

8.1.6 This assessment has been undertaken using the guidance contained in DMRB Volume 11 Section 3 Part 11 'Geology and Soils' (Highways Agency et al., 1993), taking into account updated

guidance on contaminated land risk assessment where appropriate, and DMRB Volume 11 Section 3 Part 10 HD 45/09 'Road drainage and the Water Environment' (Highways Agency et al., 2009).

8.1.7 Surface water resources and supplies are separately assessed and reported in Chapter 9 (Road Drainage and the Water Environment).

8.2 Approach and Methods

8.2.1 The assessment covers a study area which, in terms of distance from the centreline of the proposed scheme, is specific to each assessment category as follows:

- 250m study area for geology and contaminated land.
- 850m study area for groundwater resources and abstractions including private water supplies (PWS). This is based on requirements of the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR) for groundwater abstractions.

8.2.2 The assessment has been undertaken for the following aspects of ground conditions:

- solid and drift geology;
- features of geological and geomorphological importance;
- mineral extraction and reserves;
- contaminated land, water and gas issues;
- groundwater environment; and
- groundwater abstractions including PWS.

8.2.3 The assessment includes consideration of impacts on peat deposits as part of the assessment of drift geology. Agricultural soils are also considered sensitive and can deteriorate as a result of disturbance during construction, and their subsequent storage/reuse. Measures to address this issue are considered in the context of short-term and long-term impacts on agricultural land capability in Chapter 7 (Community and Private Assets). Other soils are not considered sensitive to impacts from this type of development so were scoped out of the assessment.

Baseline Conditions

8.2.4 Baseline conditions were determined through a desk-based assessment and consultation with statutory and non-statutory bodies, and the results of a programme of Ground Investigation (GI).

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

- Previous assessments:
  - M9/A9 Edinburgh-Stirling-Thurso Trunk Road, Bankfoot Junction Improvement Project, Geotechnical Interpretative Report (Scotland Transerv, 2008);
  - A9 Dualling: Luncarty to Pass of Birnam, Geotechnical Preliminary Sources Study Report (Atkins, 2008);
  - A9 Dualling: Luncarty to Pass of Birnam Stage 2 Engineering Report (Atkins, 2009a); and
  - A9 Dualling: Luncarty to Pass of Birnam, Stage 2 Environmental Assessment Report (Atkins, 2009b).
- Envirocheck reports:
- Ordnance Survey (OS) historical maps dating back to 1856 for information on former land use, any potential contamination and physical hazards, and information on PWS.
- Online SEPA Interactive River Basin Management Plan (RBMP) information (http://gis.sepa.org.uk/rbmp/).

- Macaulay Institute Soil Survey of Scotland 1979, Perth & Arbroath, Sheet 48/49, 1:63,360 Scale.
- British Geological Survey (BGS) maps and relevant publications:
  - 1:50,000 Scale Geological Map, Perth, Sheets 048/W, Perth (Solid and Drift Editions);
  - 1:625,000 Scale Hydrogeological Map of Scotland;
  - 1:625,000 Scale Groundwater Vulnerability Map of Scotland;
  - 'Baseline Scotland : the Lower Devonian aquifer of Strathmore' CR/06/250N (SEPA & BGS, 2006); and
  - 'A preliminary study of the sand and gravel deposits of Strathmore' (BGS, 1983).
- BGS GeoIndex website (www.mapapps2.bgs.ac.uk/geoindex/home.html).
- Scottish Natural Heritage (SNH) designation database (SNH, 2013).
- Geological Conservation Review (GCR) database (JNCC, 2013).

Field Surveys

8.2.6 No field surveys have been undertaken as part of the EIA process. However, as set out below, a programme of GI has been undertaken primarily to inform the engineering design, the results of which have informed the assessment.

Ground Investigations (GI)

8.2.7 The factual GI report (A9 Dualling: Luncarty to Pass of Birnam Ground Investigation Factual Report) provides information for a total number of 641 exploratory hole logs comprising 268 boreholes, 294 trial pits and trial trenches, 32 cone penetration tests, 2 window sample holes and 45 peat probes. A total of 164 exploratory holes encountered bedrock and provided information regarding rockhead elevation levels. Groundwater level monitoring data were available from 76 observation boreholes.

8.2.8 The available exploratory holes provided a good coverage for the majority of the route.

Consultations

8.2.9 Consultations were undertaken with a number of statutory and non-statutory bodies to inform the assessment of geological and hydrogeological impacts and to identify contaminated land. These included requests for the following:

- BGS for information regarding the nature of geology and hydrogeology in the near vicinity of the proposed scheme;
- Perth & Kinross Council for information on former contaminated land use, Environment Protection Act 1990 Part IIA (contaminated land) determinations, private and public water supplies, licensed fuel storage and any additional relevant information; and
- SEPA and SNH for information on the location and extent of environmental or historical sensitivities and licences in the vicinity of the proposed scheme and to establish any future development constraints (note: no data were provided by SEPA of relevance to this assessment).

Impact Assessment

8.2.10 In accordance with the general approach set out in Chapter 5 (Overview of Assessment Process) and as described below, the significance of impacts on geology/geomorphology and contaminated land has been assessed taking into account receptor sensitivity and impact magnitude.

8.2.11 Section 8.4 (Potential Impacts) assesses potential impacts that could occur without mitigation and Section 8.6 (Residual Impacts) presents residual impacts likely to be present following mitigation.

Solid and Drift Geology

8.2.12 For the purposes of this assessment, the sensitivity of geological features of interest within the study area is defined for drift geology, solid geology and features of geological interest. Assessment was undertaken by applying the sensitivity and magnitude criteria given in Tables 8.1 and 8.2. The significance of impact was then determined using Table 8.3.

Table 8.1: Sensitivity Criteria - Geological Features

Sensitivity	Description
High	Areas containing unique or rare geological or geomorphological features considered to be of national interest (e.g. SSSIs).
Medium	Areas containing features of designated regional importance considered worthy of protection for their educational, research, historic or aesthetic importance (e.g. Regionally Important Geological Sites (RIGS)). Geological resources of national / regional importance.
Low	Features not currently protected but that may require specific protection in the future (e.g. GCR). Geological resources of local importance.
Negligible	Features not currently protected and unlikely to require specific protection in the future. No exploitable geological resources.

Table 8.2: Magnitude Criteria - Geology

Magnitude	Description
High	Partial (greater than 50%) or total loss of a site, or where there would be complete severance of a site such as to affect the value of the site.
Medium	Loss of part (between approximately 15% and 50%) of a site, 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.
Low	Small effect on a site (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.
Negligible	Very slight change from baseline condition. Change hardly discernible, approximating to 'no change' conditions.

Table 8.3: Matrix for Determination of Impact Significance – Geology

Sensitivity / Magnitude	Negligible	Low	Medium	High
High	Slight	Moderate	Moderate/ Substantial	Substantial
Medium	Negligible/ Slight	Slight/Moderate	Moderate	Moderate/Substantial
Low	Negligible	Negligible/Slight	Slight/Moderate	Moderate
Negligible	Negligible	Negligible	Negligible/Slight	Slight

Mineral Extraction

8.2.13 Specific criteria were not defined for the assessment of mineral extraction as these aspects primarily represent engineering considerations for the proposed scheme construction, and their extent, nature and required mitigation will be assessed by specific GI undertaken by the contractor during detailed design. However, the occurrence and proposed management of these aspects has been considered, assessed qualitatively and presented as part of this assessment.

Contaminated Land

8.2.14 Current DMRB guidance (Volume 11 Section 3 Part 11 Geology & Soils) refers to the identification of affected contaminated land and the determination of appropriate mitigation measures.

8.2.15 In line with industry norms, the assessment focused on the potential for impacts on receptors (including construction workers) 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 from 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 the Statutory Guidance (Scottish Executive, 2006).

8.2.16 Potential impacts are discussed in terms of likelihood (Table 8.4) and magnitude/consequence (Table 8.5). The Generic Qualitative Assessment is then undertaken based on the Table 8.6 matrix. 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, in which case a generic qualitative risk assessment is then undertaken.

Table 8.4: Likelihood Criteria – Contaminated Land

Likelihood	Definition
High likelihood	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	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	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	Complete pollution linkage but it is improbable that an event would occur even in the very long-term.

Table 8.5: Magnitude (Consequence) Criteria – Contaminated Land

Consequence	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.
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.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings/structures/services or the environment.
Minor	Harm (not necessarily significant), which may result in financial loss or require expenditure to resolve. Non-permanent health affects to human health. Easily reparable damage to buildings, structures and services.

Table 8.6: Matrix for Determination of Generic Qualitative Risk Assessment: 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

Groundwater

8.2.17 The assessment considered groundwater sensitivity in the context of hydrogeological conditions including groundwater resources. Criteria for the definition of groundwater sensitivity are reported in Table 8.7. Criteria for the definition of magnitude of impact on groundwater resources are reported in Table 8.8.

8.2.18 Criteria for the definition of the magnitude of impact on PWS yield and quality are based primarily on the type of road profile (e.g. cutting, embankment or transition cutting-embankment) facing the PWS. However, where appropriate, the vulnerability of groundwater flow to sub-surface disruptions was also considered to refine the magnitude of impact.

8.2.19 The significance of an impact was then determined using the same matrix as for geology/geomorphology as shown in Table 8.9.

Table 8.7: Sensitivity Criteria - Groundwater

Sensitivity	Description
High	Local aquifer(s) constitutes a valuable resource because of its high quality and yield, or extensive exploitation for public, private domestic and/or agricultural (i.e. feeding ten or more properties) and/or industrial supply. Designated sites of nature conservation dependent on groundwater.
Medium	Local aquifer(s) are of limited value either because of quality impairment or because exploitation of local groundwater is not extensive (i.e. private domestic and/or agricultural supply to less than 10 properties). Local areas of nature conservation known to be sensitive to groundwater impacts.
Low	Poor groundwater quality and/or low permeability make exploitation of groundwater unlikely Changes to groundwater not expected to have an impact on local ecology.
Negligible	Very poor groundwater quality and/or very low permeability make exploitation of groundwater unfeasible. No known past or existing exploitation of this water body. Changes to groundwater are irrelevant to local ecology.

Table 8.8: Magnitude Criteria - Groundwater

Magnitude	Description
High	Major permanent or long-term change to groundwater quality or available yield. Existing resource use is irreparably impacted upon. Changes to quality or water table level would have an impact upon local ecology.
Medium	Changes to the local groundwater regime are predicted to have a slight impact on resource use. Minor impacts on local ecology may result.
Low	Changes to groundwater quality, levels or yields do not represent a risk to existing resource use or ecology.
Negligible	Very slight change from groundwater baseline conditions approximating to a 'no change' situation.

Table 8.9: Matrix for Determination of Impact Significance – Groundwater

Sensitivity / Magnitude	Negligible	Low	Medium	High
High	Slight	Moderate	Moderate/ Substantial	Substantial
Medium	Negligible/Slight	Slight/Moderate	Moderate	Moderate/Substantial
Low	Negligible	Negligible/Slight	Slight/Moderate	Moderate
Negligible	Negligible	Negligible	Negligible/Slight	Slight

Limitations to Assessment

8.2.20 Limitations to this assessment are identified as follows:

- The identification of potential contamination sources relies on the accuracy of historical mapping and the GI. Any potential contamination source not encountered during the GI or identified through desk-based assessment and consultation is not reported.
- The listing of wells and springs is based on information received from consultation with Perth & Kinross Council, land owner consultation, and historical and current OS maps. Any wells and springs not notified by the council or landowners, not identified during consultation undertaken during the current study or not recorded on OS maps are not assessed or reported in the ES.
- Although some information on PWS is presented within this chapter, it should be noted that detailed consultation, risk assessment and mitigation design may continue as part of the pre-construction activities for the proposed scheme. As such the exact location and technical characteristics of some springs and wells is not determined at this stage.

8.3 Baseline Conditions

A9 Dualling: Strategic Environmental Assessment (SEA)

8.3.1 As noted in Chapter 2 (Need for the Proposed Scheme), an SEA of the wider programme of proposed dualling of the A9 from Perth to Inverness has also been undertaken. The outcomes of the SEA, including responses from consultees and strategic considerations for the geological and soil environment, have been taken into account in this assessment.

Geological Setting

8.3.2 No geological SSSIs, RIGS or other designated sites of geological value have been identified in the area, and no other features of special importance to geology have been identified.

Soils

8.3.3 The soils underlying the site were assessed using the Macaulay Institute Soil Survey of Scotland 1979, Perth & Arbroath (Sheets 48-49, 1:63,360 scale). This indicated that the site is underlain by several types of soils, predominantly comprising podzols, forest soils and non-calcareous gleys. Alluvial soils of undifferentiated drainage were also indicated along the Shochie Burn and Ordie Burn. Table 8.10 summarises the published soil geology along the proposed scheme.

Table 8.10: Published Soils Information

Approximate Chainage (m)	Soil type and description
ch0-600	Freely drained Corby Podzols of the Corby association, developed from gravel derived mainly from Highland rocks.
ch600-900	Alluvium of undifferentiated drainage.
ch900-1200	Freely drained Corby Podzols of the Corby association, developed from gravel derived mainly from Highland rocks.
ch1200-1800	Alluvium of undifferentiated drainage.
ch1800-3600	Freely drained Corby Podzols of the Corby association, developed from gravel derived mainly from Highland rocks.
ch3600-6000	Freely drained Vinyl Podzols of the Forfar Association, developed from till derived from Old Red Sandstone.
ch6000-7400	Freely drained Snaigow Brown Forest Soils of the Gourdie Association, developed from till derived from Highland Schists.
ch7400-7900	Imperfectly drained Gourdie Brown Forest Soils of the Gourdie Association, developed from till derived from Highland Schists.

Approximate Chainage (m)	Soil type and description
ch7900-8000	Poorly drained Cairnleith non-calcareous gleys of the Gourdie Association, developed from till derived from Highland Schists.
ch8000-8600	Imperfectly drained Obney Podzols of the Strichen Association, developed from till derived from schists and schistose grits.
ch8600-8800	Poorly drained Anniegathel non-calcareous gleys of the Strichen Association, developed from till derived from schists and schistose grits.
ch8800-8950	Freely drained Strichen podzols of the Strichen Association, developed from till derived from schists and schistose grits.
ch8950-9100	Poorly drained Anniegathel non-calcareous gleys of the Strichen Association, developed from till derived from schists and schistose grits.
ch9100-9450	Imperfectly drained Obney Podzols of the Strichen Association, developed from till derived from schists and schistose grits.

8.3.4 Based on tests undertaken during the 2013 GI, soil infiltration rates are recorded to range between 1.3E-03m/s and 9.1E-06m/s, confirming a heterogeneous composition of soils along the A9.

Superficial Geology

8.3.5 The BGS drift map and the BGS memoir '*A preliminary study of the sand and gravel deposits of Strathmore'* (BGS, 1983) indicates that superficial deposits in the study area mostly comprise alluvium (mixture of clay, silt, sand and gravel), glaciofluvial sheet deposits (mixture of gravel, sand and silt) and glacial till.

8.3.6 The BGS information suggests that the study area is dominated by alluvium and glaciofluvial sheet deposits in its southern portion, and glacial till in its northern portion. In the central part, alluvium and glaciofluvial sheet deposits seem to be present to the west of the proposed scheme and glacial till to the east. Localised areas of peat deposits are also indicated to the east of the proposed scheme associated with Cairnleith Moss.

8.3.7 Historical GI from the BGS reported in the A9 Dualling: Luncarty to Pass of Birnam Stage 2 Engineering Report (Atkins 2009a) confirms the presence of fluvio-glacial and glacial deposits along the proposed scheme, with localised made ground in three locations (ch3450, ch3775, ch5200) and peat deposits at three other locations (ch4500, ch6330, ch8630). The peat deposits reported historically are expected to have been removed for the construction of the existing A9.

8.3.8 The 2013 GI records support the published and historical information. Heterogeneous superficial deposits were encountered in the majority of the exploratory holes, predominantly composed of various sequences of clay, silt, sand and gravel. Made ground deposits, associated with the existing A9 were encountered at 231 locations. The average thickness of the superficial deposits is in the region of 6.8 m, with the maximum thickness recorded 28.4m, and the minimum encountered thickness being 0.2m. Localised peat deposits were recorded from seven exploratory holes as shown on Figure 8.1 and described as follows:

- slightly gravelly amorphous peat recorded in two boreholes in between layers of alluvium deposits to the east of ch2760 (1 and 0.5m thick);
- spongy fibrous mottled peat of 1.6m thick recorded at one trial pit location along ch4460 and a thin layer (0.3 m) of fibrous and pseudo fibrous peat encountered between alluvium and glaciofluvial deposits at ch4440. A targeted peat probing exercise has confirmed that peat deposits are very local, extending approximately 10 to 20m around the trial pit location;
- black plastic pseudo fibrous peat 0.15 m thick encountered at ch7200;
- a very thin layer (0.05m) of pseudo fibrous peat recorded between glaciofluvial deposits at ch8200 and an area of topsoil with occasional pockets of peat deposits between ch8200 and ch7900; and
- a thin layer (0.3m) of black plastic peat encountered at ch8600.

Solid Geology

8.3.9 The solid geology underlying the study area is characterised by Lower Devonian Old Red Sandstone. The entire study area lies to the south of the Highland Boundary Fault.

8.3.10 The Scone Formation, belonging to the Arbuthnott-Garvock Group, is indicated at the very southern tip of the study and up to Luncarty. The Scone Formation is described as a fine-to coarse-grained, commonly cross-bedded sandstone with subsidiary siltstone, mudstone, conglomerate, with sparse andesitic lava flows and some calcareous beds with concretionary limestones towards the top.

8.3.11 The rest of the study area belongs to the Strathmore Group, and the following included sedimentary formations are present below drift deposits from south to north:

- Cromlix Mudstone Formation (siltstones and mudstones with fine-grained silty sandstones and sandy siltstones, which lithologies may be locally interbedded with thin lenses of medium to coarse-grained pebbly sandstone) between Luncarty and the location where Ordie Burn crosses the proposed scheme;
- Teith Standstone (cross-bedded sandstone, locally interbedded with siltstone and mudstone intercalations) from where Ordie Burn crosses the proposed scheme and Muir Thorn; and
- Craighall Conglomerate (well-rounded pebble and boulder (up to 0.6m diameter) conglomerate, of andesitic lava, locally quartzite and other lithologies of 'Highland' origin, interbedded with andesite, basaltic andesite and basalt lava members, together with minor sandstone, siltstone and mudstone beds) to the north of Muir Thorn.

8.3.12 A few dykes of the Central Scotland Late Carboniferous Tholeiitic Dyke Swarm are also indicated on the BGS map running in a general east – west direction.

8.3.13 The northern part of the study area is getting close to the Highland Boundary Fault and a number of faults running South-west to North-east are indicated within the study area.

8.3.14 The 2013 GI encountered bedrock at 164 locations, and confirmed the presence of the various sedimentary formations beneath the proposed scheme. The bedrock strata was predominantly composed of sandstones and mudstones, and commonly described as thinly to moderately laminated and bedded lithologies with occasional layers of siltstones and conglomerates. The upper horizon of the bedrock strata was commonly weathered to various degrees.

Mineral Extraction

8.3.15 A search of the BGS Mining Plan Portal indicates that no sub-surface mining plans are kept for the study area, which suggests the area is unlikely to be influenced by any recorded historic deep mining activities. The nearest recorded mining plans are for Birnam Slate Quarries, 1.75km from the proposed scheme.

8.3.16 Historical maps indicate that there have been seven historic quarries, gravel or sand pits within 250m of the route indicating that the sand and gravel deposits have been exploited in this area in the past.

8.3.17 One of the pits, Gowrie Gravel Pit (source 19 in Appendix 8.1), is reported in Envirocheck reports as still in operation.

8.3.18 BGS mineral publication '*A preliminary study of the sand and gravel deposits of Strathmore'* (BGS, 1983) indicates extensive exploitable deposits of sand and gravel underlying the study area from the southern end up to around ch6200.

Contaminated Land

8.3.19 Potential contamination sources within 850m of the study area are described and referenced in Appendix A8.1 (Potential Historical and Current Contamination Sources). These potential sources are also shown on Figure 8.1. As stated above, there were several areas of made ground noted by the historic ground investigations that have been included in these figures and are referred to in Appendix A8.1. It should be noted that the subsequent assessment of contaminated land related impacts is limited to a distance of 250m from the proposed scheme.

8.3.20 Consultation has been undertaken with Perth & Kinross Council regarding contaminated land. The Council has indicated 16 potential contaminated land areas and three Petroleum Register Localities. These Potentially Contaminated Land sources are also included in Appendix A8.1.

8.3.21 The soil sample chemical analysis results from the 2013 ground investigations 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 potential exposure pathways to end users given the proposed use as a road, however, potential pathways remain, including for maintenance workers. The aim of the assessment is to identify any contaminants that exceed the GACs and may be considered as Contaminants of Potential Concern (COPCs).

8.3.22 A soil organic matter (SOM) concentration of 6% has been assumed. The following hierarchy of GACs has been used to screen soil sample analysis results:

- Soil Guideline Values (SGVs) published by the Environment Agency (EA);
- Land Quality Management (LQM) / Chartered Institute of Environmental Health (CIEH), 2nd Edition; and
- Soil Generic Assessment Criteria for Human Health Risk Assessment, Contaminated Land: Applications in Real Environments (CL:AIRE) (2010).

8.3.23 The results of chemical analysis screening against the residential GACs is summarised as follows:

- one GAC exceedence for metals (vanadium) in one location (source reference 45);
- asbestos identified in one location (source reference 67);
- several GAC exceedences for polynuclear aromatic hydrocarbon (PAH) congeners, including benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, chrysene, dibenzo(ah)anthracene, naphthalene and indeno(1.2.3-cd)pyrene, all associated with source reference 67; and
- the screening against residential criteria indicates that potential risks to construction workers are likely to be present associated with source reference 67.

8.3.24 Up to ten rounds of ground gas monitoring have been undertaken within 59 monitoring boreholes since completion of the 2013 GI. Preliminary gas risk assessments have been undertaken in accordance with current UK guidance based on the available data for the following potential receptors:

- risks to workers (Construction, Landscaping, Maintenance); and
- risks associated with confined spaces (Maintenance Workers in particular).

8.3.25 Methane has been detected in twelve locations, with the majority of these showing concentrations of 3.1% volume/volume (v/v) or below. One location (BH5920/2A) has shown consistently high concentrations of up to 36.5% v/v. Carbon dioxide was detected in 51 of 59 locations, with generally relatively low concentrations (up to 8.5% v/v); although one particularly elevated concentration (17% v/v) was identified at BH5920/2A. Depleted oxygen concentrations (below 19% v/v) were identified in 26 locations, with a lowest value of 0.2% v/v. Flow rates were mostly undetectable, with some low flows up to 0.4l/hr encountered; one elevated flow rate of 22.3l/hr was recorded however it is not clear whether this is an accurate result. Low concentrations (up to

28.1ppm) of carbon monoxide were detected in eight locations, and low concentrations of hydrogen sulphide (up to 1.1ppm) were detected in two locations.

8.3.26 A preliminary assessment of the risks posed to the final development from ground gas has been undertaken based on current UK guidance, CIRIA C665: Assessing Risks Posed by Hazardous Ground Gases to Buildings (CIRIA 2007) to determine the significance of the ground gas regime.

8.3.27 The proposed development layouts include new road, bridges, retaining walls and drainage systems. The site area is therefore considered to be classified as an office / commercial / industrial development. CIRIA C665 advocates initially using the highest gas levels and flows recorded at the site irrespective of their location within the site to calculate borehole gas volume flows. However, one location (BH5950/2A) appears to exhibit significantly different characteristics to all other locations and as such will be treated separately.

8.3.28 The overall 'worst-case' Gas Screening Value (GSV) calculated for the study area (excluding BH5950/2A) is 0.034 which provides a Characteristic Situation of CS1 indicating a low hazard potential. The location with high methane concentration provides a 'worst-case' GSV of 0.15, which in conjunction with the methane concentrations provides a Characteristic Situation of CS3 or CS4 indicating a moderate to high hazard potential.

8.3.29 Ground gas concentrations could pose a potential risk to site construction and workers working below ground and/or within confined spaces. Ground gas concentrations were compared to GAC's considered appropriate for the protection of construction and maintenance workers from the following UK guidance for methane, carbon dioxide and depleted oxygen, carbon monoxide and hydrogen sulphide respectively:

- NHBC 2007, Guidance On Evaluation Of Development Proposals On Sites Where Methane And Carbon Dioxide Are Present, Report Edition No.: 04, March 2007;
- Health and Safety Executive (HSE), 'EH40/2005 Workplace Exposure Limits':2011; and
- Mines and Quarries Act 1954, 27 (Section 55(2)(b)).

8.3.30 Recorded methane concentrations in three locations are above the recommended safety threshold of 20% of the lower explosive limit for methane of 1%. Carbon dioxide concentrations exceed the short term (15 minutes) occupational exposure limit (0.5% v/v) and the long term (8 hour) exposure limit (1.5% v/v) in many locations. Depleted concentrations of oxygen were also recorded below the Mines and Quarries Act value of 19%v/v. Carbon monoxide concentrations are below the long term (8 hour) and short term (15 minute) exposure limits of 30ppm and 200ppm respectively. Hydrogen sulphide concentrations are below the long term (8 hour) and short term (15 minute) exposure limits of 6ppm and 12ppm respectively.

8.3.31 The review of the gas data information, in terms of rounds of monitoring available and results obtained, has been used to develop the gas mitigation measures described in Table 8.15.

Hydrogeology

8.3.32 Information on the groundwater characteristics of the study area was obtained from BGS and SEPA publications, from previous environmental reports and relevant GI information.

8.3.33 SEPA's Interactive River Basin Management Plan (RBMP) classification from 2008 of relevant groundwater bodies is provided in Table 8.11. The entire study area is classified as a Nitrate Vulnerable Zone. Nitrate vulnerability is explained by the combination of permeable aquifers with low superficial protection (hence vulnerable to surface pollution) and widespread farming practice within the hydrogeological catchments.

8.3.34 The vulnerability of the aquifers is confirmed by the BGS Groundwater Vulnerability Map which indicates that the full study area is highly permeable, with soils of high to intermediate leaching potential (i.e. with limited to moderate ability to attenuate diffuse pollution).

Table 8.11: SEPA RBMP classification on relevant groundwater bodies

Area	SEPA identified groundwater bodies : quality status / quantity status
Most of proposed scheme except extreme north	Perth bedrock and localised sand and gravel aquifers : Good / Good
Around Ordie Burn	Ordie Burn Valley Sand and Gravel Aquifer : Poor (nitrate contamination from farming activities) / Good
Northern extent of proposed scheme	Vale of Strathmore bedrock and extensive sand and gravel aquifers : Good / Poor (under abstraction pressure)

8.3.35 The BGS Hydrogeological Map identified three aquifer categories:

- River alluvium aquifer defined as concealed aquifers of limited potential or local potential;
- Sand and gravel aquifer characterised by significant intergranular flow and of local importance; and
- Lower and Middle Old Red Sandstone classified as a locally important aquifer where flow is dominantly in fissures and other discontinuities.

8.3.36 A baseline characterisation report, *'Baseline Scotland: the lower Devonian aquifer of Strathmore – CR/06/250N'* (SEPA & BGS, 2006), has been produced to characterise the groundwater chemistry of the Lower Devonian aquifer. As part of this study, the physical characteristics of the aquifer were also reviewed and confirmed the information on the BGS Hydrogeological Map in determining that fracture permeability dominates the aquifer flow, even in the sandstone formations where intergranular permeability is relatively high and anisotropic.

8.3.37 This report also suggests that the Teith Sandstone and the Scone Formation are of potentially high productivity and the Cromlix Mudstone of potentially moderate productivity. Normal operating yields in the Lower Devonian aquifer as a whole range from 5 to 15 litres per second (l/s), with maximum of up to 28 l/s recorded.

8.3.38 Groundwater flow within the superficial deposits is likely to follow surface topography, towards the local surface water watercourses. The direction of flow of any bedrock groundwater is not known.

8.3.39 Hydrogeological characteristics of drift and bedrock units are summarised in Table 8.12.

Table 8.12: Hydrogeological characteristics of drift and bedrock units

Geological Unit		Geological Characteristic	Hydrogeological characteristic	Hydrogeological sensitivity
Drift	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
	Glaciofluvial deposits	Sand and gravel with silt	Local groundwater potential.	Medium
	Glacial till	Heterogeneous deposits	Poor groundwater potential due to generally low and variable permeable nature.	Low
	Peat	Decomposed organic deposits	Very poor groundwater potential due to compacted nature, low permeability and limited spatial extent.	Low

Geological Unit		Geological Characteristic	Hydrogeological characteristic	Hydrogeological sensitivity
Bedrock	Lower Devonian aquifer (all formations belonging to Old Red Sandstone present in study area)	Principally sandstones and mudstones with notable successions of conglomerates, shales and siltstones, but also igneous intrusions	Moderate to high groundwater potential.	High
	Central Scotland Late Carboniferous Tholeiitic Dyke Swarm	Intrusive Permo-Carboniferous quartz-dolerite and tholeiite	Poor groundwater potential due to generally low permeable nature and limited areal extent.	Low

Abstraction and Discharge Consents

8.3.40 The Envirocheck reports do not indicate the presence of any groundwater abstractions within the study area. However, consultations undertaken with landowners during the EIA have indicated the presence of one PWS source along the proposed scheme feeding two properties: one at Tophead Farm (west of ch2800) and the other at Gellybanks Farm (west of ch8450), both of which are indicated on Figure 8.1. However, due to the distance between these properties, there is some doubt as to whether the Gellybanks Farm supplied by the PWS is actually another farm by the same name to the southwest of Tophead Farm. The supply is described as feeding from a spring-capture tank system. The exact spring location is unknown but understood to be distant from the proposed scheme further to the west and located outside the study area. This PWS is of medium sensitivity.

8.3.41 A review of the current OS map also suggests the presence of three springs (refer to Figure 8.1), all located along surface water features and therefore expected to feed into these burns, and two wells located at the edge of the 850m offset boundary (refer to Figure 8.1). However, consultation with land owners has not indicated any private water usage of these springs and these are not classified as PWS abstractions.

8.3.42 As per the Envirocheck reports, there are no discharge consents within the study area and no pollution incidents have been recorded within 1km of the site.

Groundwater Monitoring

8.3.43 Groundwater monitoring information from the 2013 GI was available from 76 observation boreholes. Five boreholes are screened into bedrock and 14 boreholes are screened through both bedrock and drift, while the remaining boreholes are screened in drift deposits. The monitoring data was limited to the period between April and November 2013, however it confirms the presence of shallow groundwater within the superficial deposits. Groundwater levels range from 0.3 to 17.4 below ground level mBGL, with the average groundwater level being 3.3 mBGL beneath the proposed scheme.

Groundwater Quality

8.3.44 The baseline characterisation report (SEPA & BGS, 2006) indicated the following characteristics of the Lower Devonian aquifer:

- neutral to slightly alkaline pH;
- oxygenated conditions;
- nitrate concentrations often high with an interquartile range of 2.6 to 11.7mg/l as NO_3-N;
- phosphorous typically less than 0.1mg/l (90 percentile value) and with a median of 0.03mg/l;

- uranium concentration of up to 15.4µg/l – however uranium concentrations in groundwater are similar to concentrations recorded in surface waters, and also similar to concentrations in other UK red-bed sandstones (i.e. natural signature of the aquifer); and
- occasional exceedances of drinking standards for nitrite and fluoride.

8.3.45 Groundwater chemical testing data were not available as part of the factual 2013 GI report.

Groundwater Dependent Terrestrial Ecosystems (GWDTE)

8.3.46 The following potential GWDTEs have been identified with the study area due to the assemblage of vegetation at each location, and their locations are shown on Figure 8.1:

- Cairnleith Moss SSSI, approximately 300m east of the route. The site is designated for its extensive area of lagg fen which surrounds a raised bog, and the extent of flushed pasture.
- Mill Dam SSSI, towards the northern end of the study area. The site is designated for its species-rich basin fen and also supports a number of uncommon local species.
- An unnamed pond at Muir of Thorn, 490m west of the proposed scheme (Figure 8.1).

8.3.47 Further characterisation of these designated sites can be found in Chapter 10 (Ecology and Nature Conservation).

Surface Water Receptors

8.3.48 The River Tay is designated as a SAC for the protection of fish, otter and vegetation. The SAC includes the Ordie Burn and its tributaries, the Garry Burn and the Shochie Burn. These surface water systems are expected to have a groundwater baseflow component.

8.3.49 Further characterisation of the SAC is provided in Chapter 10 (Ecology and Nature Conservation) and potential impacts are also considered in Chapter 9 (Road Drainage and the Water Environment).

8.4 Potential Impacts

8.4.1 This section discusses the potential impacts (i.e. those that could occur in the absence of mitigation) to geological and hydrogeological features and potential contamination from road construction and/or operational activities. Mitigation to avoid or reduce these potential impacts is identified and described in Section 8.5 (Mitigation).

8.4.2 A key aspect of the assessment of impacts is to identify areas of temporary or permanent excavations. Information on proposed excavated areas and the associated geological and hydrogeological settings are provided in Table 8.13.

8.4.3 It should be noted that no new road cutting is created, and that all cuttings listed in Table 8.13 relate to widening of existing cuttings, which will have a much lesser effect on groundwater baseline conditions.

Table 8.13: Excavation Areas

Design Cutting			Average Drift thickness (m)	Monitored average groundwater level (mbgl)	Excavation Reaches Bedrock/ Groundwater	Material excavated
Name	Approx. Chainage	Maximum Road Level Excavation (mbgl)				
Cutting 1	ch0-540	6.7	>12	2.5	No/ Yes	Granular made ground and cohesive natural deposits predominantly comprising clay with variable silt, sand and gravel content.

Design Cutting			Average Drift thickness (m)	Monitored average groundwater level (mbgl)	Excavation Reaches Bedrock/ Groundwater	Material excavated
Name	**Approx. Chainage**	**Maximum Road Level Excavation (mbgl)**				
Cutting 2	ch820-1600	7.4	20.5	2.8	No/ Yes	Granular made ground and cohesive natural deposits predominantly comprising clay with variable silt, sand and gravel content.
Cutting 3	ch1760-1980	2.4	9.5	4.6	No/ No	Heterogeneous made ground and natural deposits composed of sand, gravel, silt, clay.
Cutting 4	ch2430-2550	1.8	>8	3.6	No/ No	Heterogeneous natural deposits composed of sand, gravel and clay.
Cutting 5	ch2800-3050	6.3	19	8.5	No/ No	Granular made ground and heterogeneous natural deposits composed of sand, gravel, clay and silt.
Cutting 6	ch3120-3250	3.7	>6	8	No/ No	Heterogeneous natural deposits composed of sand, gravel and clay.
Cutting 7	ch3570-3800	3.7 (local high ground)	7.2	1.7	No/ Likely	Heterogeneous made ground and natural deposits composed of sand, gravel and clay.
Cutting 8	ch3900-4390	6.2	>10	Artesian	No/ Yes	Heterogeneous made ground and natural deposits composed of sand, gravel and clay.
Cutting 9	ch4500-5670	9.8	4.7	Artesian	Yes/ Yes	Heterogeneous made ground and natural deposits composed of sand, gravel and clay. Sedimentary bedrock composed of sandstones and mudstones.
Cutting 10	ch5940-6980	10.1 (13.3 at local high ground)	4.3	3.3	Yes/ Yes	Heterogeneous made ground and natural deposits composed of sand, gravel, silt and clay. Sedimentary bedrock composed of sandstones and mudstones.
Cutting 11	ch7600-7900	4.2	6.5	2.3	No/ Likely	Heterogeneous made ground and natural deposits composed of sand, gravel, silt and clay.
Cutting 12	ch8790-8920	1	>10	1.5	No/ Unlikely	Heterogeneous made ground and natural deposits composed of sand, gravel, silt and clay. Sedimentary bedrock composed of sandstones, mudstones and siltstones.
Luncarty Link Road Cutting	ch550-630	1.4	24.5	3.1	No/ No	Heterogeneous made ground and natural deposits composed of sand, gravel, silt and clay.
Bankfoot North Side Road	ch0-245	3.8	3.2	5.4	Likely/ Unlikely	Heterogeneous made ground and natural deposits composed of sand, gravel, cobbles, silt and clay.

Geology

8.4.4 This section discusses the potential impacts on geology and mineral extraction/resources. The construction and operational impacts are assessed together, as the majority of the construction impacts (such as excavation and removal of material) would extend to the operational phase.

Soils

8.4.5 Assessment of the value of local soils is limited to their agricultural capacity, and this aspect is covered in Chapter 7 (Community and Private Assets). Cut/fill balance estimates are discussed in Chapter 17 (Materials).

8.4.6 Potential impacts on peat deposits are included in the assessment of superficial deposits and potential impacts on made ground are included in the assessment of contaminated land.

Superficial Deposits

8.4.7 Information presented in Table 8.13 indicates that drift deposits will be affected by the proposed construction and associated earthworks along the majority of the proposed scheme. Excavation depths are likely to reach the base of the superficial deposits in three cutting areas.

8.4.8 The 2013 GI encountered highly localised peat deposits in seven exploratory holes:

- Peat located to the east of ch2700 is indicated to be amorphous in nature and is unlikely to be intercepted by the proposed scheme.
- A proposed section of embankment trapped in between two cuttings slightly encroaches onto the peat located along ch4440 and ch4460 and a small area of peat is likely to be intercepted by the proposed scheme at this location. Given their poor engineering properties, it is likely that these localised deposits will be removed from site if they cannot be reused.
- The very thin peat deposits recorded at ch7200 (0.15m thick) and ch8600 (0.05m thick) are within the corridor of proposed embankments, while the thin peat deposits at ch8200 and nearby topsoil with occasional peat pockets are not expected to be intercepted by the proposed scheme. The very localised deposits present at ch7200 and ch8600 are likely to be removed from site if they cannot be reused.

8.4.9 The potential volumes of peat deposits intercepted by the proposed scheme and which may require to be excavated are localised and minimal. The predominant contribution to the total volumes is excavation of deposits around ch4440 and ch4460. Based on an average peat thickness of 1m, volumes of 103m^3 of acrotelmic peat and 155m^3 of catotelmic peat are estimated to be excavated.

8.4.10 The sensitivity of all superficial deposits is negligible. The excavation of peat deposits is expected to be minimal. The magnitude of potential impact is anticipated to be low, resulting in a potential impact of Negligible significance.

Solid Geology

8.4.11 Bedrock (negligible sensitivity) is likely to be excavated in four cutting areas as per Table 8.13. The potential impact is assessed to be of low magnitude and Negligible significance.

Mineral Extraction

8.4.12 Exploitable sand and gravel deposits of low sensitivity, given their extensive occurrence, are expected to be present beneath the route. The potential impact on sand and gravel resources is expected to be of low magnitude and of Negligible/Slight significance.

Impact of Blasting

8.4.13 It is expected that the strength of the rock is such that excavation may be undertaken using conventional excavation/ripping techniques as opposed to blasting. Consequently, no blasting impact assessment is required.

Hydrogeology

8.4.14 Table 8.13 indicates that groundwater is likely to be intercepted by several of the proposed excavations within the study area.

Groundwater Quality

8.4.15 Impacts on groundwater quality in relation to historical and current land uses are assessed in the contaminated land section.

8.4.16 In the event of accidental spillage during construction or operational phases, potential contamination may migrate through the upper unsaturated zone reaching the shallow drift aquifer and impair groundwater quality, unless appropriate measures for control of discharge and drainage are taken.

8.4.17 The potential impact from accidental spillages is considered to be of medium magnitude with regard to both the superficial aquifers (low sensitivity in glacial till and medium sensitivity in alluvium and glaciofluvial deposits) and bedrock aquifers (high sensitivity of the Lower Devonian Aquifer) given the highly vulnerable nature of all aquifers to surface pollution described in the baseline. Therefore the potential impact on groundwater quality is assessed as of Slight/Moderate significance on groundwater in glacial till, of Moderate significance on alluvium and glaciofluvial and of Moderate/Substantial significance on the Lower Devonian Aquifer.

8.4.18 Potential impacts of accidental spillages on surface waters are discussed in Chapter 9 (Road Drainage and the Water Environment).

8.4.19 During the operational phase, there is a potential risk that, in the absence of a lining system, pollutant may percolate and migrate to the underlying aquifers at SUDS locations. Given the highly vulnerable nature of all aquifers to surface pollution described in the baseline, and given that this would be a long term impact, the potential impact is considered to be of high magnitude. This would result in an impact of Moderate significance on groundwater in glacial till, of Moderate/Substantial significance on alluvium and glaciofluvial and of Substantial significance on the Lower Devonian Aquifer.

Groundwater Flow

8.4.20 Local groundwater flow direction and gradient can be affected in areas of excavations that reach and extend below groundwater levels.

8.4.21 Information presented in Table 8.13 indicates that groundwater is likely to be intercepted in seven cutting areas. Consequently, the potential magnitude of impact is anticipated to be negligible to low, and the potential significance on the superficial aquifers is assessed as Negligible to Slight. Impact on individual groundwater receptors are discussed separately below.

8.4.22 The construction of embankments may result in localised compaction of superficial deposits. However, in groundwater flow terms, this would result in localised impacts of negligible magnitude. The overall potential impact of compaction from embankments on groundwater is assessed as being of Negligible significance.

Private Water Supplies (PWS)

8.4.23 Information available at the time of reporting suggests that all sources of potentially active PWS are located well away from the proposed scheme. It should be noted that Gellybanks Farm, which is understood to be fed from a distant source but where an uncertainty remains on the exact source location, is within 250m of the proposed Cutting 12. However, Cutting 12 is assessed as unlikely to intercept groundwater.

8.4.24 On this basis, no impacts are predicted on PWS.

Groundwater Impacts on Surface Water Receptors

8.4.25 The lowering of groundwater levels or the dewatering of shallow aquifers can affect nearby surface water features (e.g. rivers, burns or ponds) that interact with groundwater by entirely or partially losing their baseflow component.

8.4.26 Shochie Burn, and Ordie Burn are both crossed by the proposed scheme and are adjacent to proposed cutting widening works, and Garry Burn runs parallel to the A9 (adjacent to three cutting areas). Given that the superficial aquifer is expected to be in hydraulic continuity with these

watercourses, their proximity to the proposed excavation areas and how that compares to the wider burn catchment, potential impacts are identified as being of Negligible significance on Shochie Burn and Ordie Burn, and of Negligible/Slight significance on Garry Burn.

Groundwater Dependent Terrestrial Ecosystems (GWDTE)

8.4.27 Cairnleith Moss SSSI is considered to be of high sensitivity. It lies 300m east of the A9 and 430m from the nearest cutting areas (Cutting 13 and Cutting 14), so no direct impact is expected although the catchment may be very slightly disturbed during construction. Consequently, based on the information available at the time of writing, the potential impact on the hydrogeological component of Cairnleith Moss is assessed as of Slight significance.

8.4.28 Mill Dam SSSI is also considered to be of high sensitivity. No cutting is proposed in the vicinity of the site, with the nearest cutting located about 1.5km away. No direct or indirect impact is expected on the hydrogeology of this site.

8.4.29 The unnamed pond at Muir of Thorn (refer to unnamed pond shown on Figure 8.1) is located 490m west of the A9 and 530m of the nearest excavation area. Given its proximity to the proposed works, the potential impact is assessed as of Negligible significance.

Contaminated Land

8.4.30 A number of potential pollution sources, exposure and migration pathways have been identified for the site along with potential receptors that may be at risk and these are discussed below.

Sources

8.4.31 Historical sources have been identified in the baseline information. All identified sources can be viewed on Figure 8.1.

Pathways and Receptors

8.4.32 The pollutant pathways and receptors are provided in Table 8.14, with individual references for linkages, PP1 to PP22.

Table 8.14: Potential Pollutant and 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, recreational users of the environment (e.g. walkers, cyclists, anglers etc)	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 (including Ordie Burn, Shochie Burn, River Tay)	Migration of contaminated shallow groundwater through drift deposits or made ground.
PP8		Run-off 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.

Pollutant Pathway	Receptor	Pathway
PP11	Ecological Receptors 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 water	Migration of shallow groundwater through drift deposits or made ground.
PP19		Run-off 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.

Conceptual Site Model Assessment

8.4.33 A Conceptual Site Model (CSM) assessment has been undertaken to determine the potential risk from the sources to each receptor.

8.4.34 Given the nature of the proposed scheme, there are two potential ways in which the development could impact on contaminated land:

- Direct interaction between the proposed scheme and potentially contaminated land sites (i.e. within the proposed scheme footprint and within its immediate vicinity); and
- Indirect disturbance of potentially contaminated land sites as a result of the proposed scheme via the interception in excavated areas of gas or water associated with potentially contaminated land sites.

8.4.35 Direct interaction may occur with the following potentially contaminated land sources shown in Appendix A8.1:

- Site 1 - Perth to Inverness Railway (adjacent);
- Site 9 - Sand and Gravel Pit (within footprint);
- Site 10 - Mill Lade 1 with Mill Dam (adjacent);
- Site 15 - Mill Lade 3 (adjacent);
- Site 18 - Gravel Pit 1 (adjacent);
- Site 20 - Bankfoot Branch Railway line & Terminus (within footprint);
- Site 25 - Newmill (house (mill?) / farm with sheep wash (adjacent);

- Site 26 - Historic made ground (within footprint);
- Site 27 - Smithy 3 (adjacent);
- Site 28 - Webvr Graphics (adjacent);
- Site 31 - Bankfoot sewage works (adjacent);
- Site 36 - Hilton quarry (adjacent);
- Site 37 - Historic made ground (within footprint);
- Site 38 - Motor museum (adjacent);
- Site 41 - Works (adjacent);
- Site 43 - Recycling depot (adjacent);
- Site 45 - Bankfoot Branch Railway Terminus (within footprint);
- Site 58 - Historical made ground encountered along the road, associated with existing embankment, road junction and other areas;
- Site 59 - Historic made ground (within footprint);
- Site 60 - Historic made ground (within footprint); and
- Site 67 - Made ground with recorded exceedances (within footprint).

8.4.36 Direct interaction with the potentially soil contaminated land sources listed above and indirect release of gas have the potential to affect human receptors via pollutant pathways PP1, PP2, PP3, PP12 and PP13 (high likelihood and potential medium consequence). The potential significance of impact is estimated to be Moderate.

8.4.37 In addition, soils/made ground from those potentially contaminated land sources may be removed and temporarily stored on site, which may represent a hazard to the water environment via pollutant pathways PP5 to PP9 (likely and mild consequence, resulting in a potential significance of impact of Moderate/Low). The soils/made ground from those potentially contaminated land sources may be proposed for re-use elsewhere along the proposed scheme and also pose a potential long term risk to the water environment (pollutant pathways PP16 to PP20). This is estimated to be of low likelihood and medium consequence, resulting in a potential significance of impact of Moderate/Low.

8.4.38 Indirect impacts may occur in cutting areas likely to intercept groundwater and which could draw contaminated groundwater towards the cutting. As per Table 8.13, seven cutting areas are expected or likely to intercept groundwater. However, the dewatering impact from the cuttings, compared to the baseline condition, are expected to be localised given the proposed works will only widen the existing layout.

8.4.39 Source 67 is associated with soil PAH exceedances and may have resulted in deteriorating the local groundwater quality. Source 67 is located between cuttings 1 and 2; however Shochie Burn separates source 67 from Cutting 2, and therefore the quality of the groundwater intercepted at Cutting 2 is not expected to be influenced by Source 67 (pollutant pathway PP10, PP12 and PP21). However, there is a risk that Source 67 influences the groundwater quality intercepted at Cutting 1. The potential significance of impact is anticipated to be Moderate.

8.4.40 No significant source of pollution is expected to originate from the identified potentially contaminated land sites areas around the remaining cuttings expected / likely to intercept groundwater. The significance of impact is expected to be Low for humans and water receptors during construction and Very Low during the operational phase.

8.4.41 Potential for pollutant linkages PP2 and PP13 are also present, as the presence of high concentration of gas was recorded in at least one location in the baseline information.

8.5 Mitigation

8.5.1 The mitigation measures described below are proposed to avoid or reduce potential impacts on geology, contaminated land and groundwater arising from the proposed scheme.

Geology

8.5.2 A small amount of peat is likely to be extracted. Excavation, storage, and any off-site removal 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 G1**).

8.5.3 No further mitigation is required for geology.

Hydrogeology

8.5.4 SUDS features will be lined unless the contractor confirms agreement with SEPA during the detailed design that this is not necessary to protect the water environment (**Mitigation Item G2**).

8.5.5 Mitigation measures proposed for surface water protection during construction and operation in Chapter 9 (Road Drainage and the Water Environment) will also prevent or reduce the potential for contamination of local groundwater.

8.5.6 Where proposed road cutting widening is likely to intercept groundwater, as per Table 8.13, the contractor will consider potential volumes of groundwater intercepted within the groundwater abstraction CAR context prior to starting the works. To support such assessment, additional GI may be required. A programme of groundwater quality sampling and testing is currently on-going.

Contaminated Land

8.5.7 Mitigation measures in relation to contaminated land are summarised in Table 8.15 (**Mitigation Items G3 to G14)**.

Table 8.15: Contaminated Land Mitigation

Pollutant Pathway	Source reference requiring mitigation*	Mitigation Item No.	Mitigation description
PP1, PP3	1, 6, 10, 18, 20, 25, 26, 27, 28, 31, 36, 37, 38, 41, 43, 58, 59, 60, 65,	G3	Establishment of appropriate health and safety and waste management procedures for working with potentially contaminated soils. Waste management procedures shall include but not be limited to: Waste Management Licence Regulations 1994 (as amended by Waste management licensing Amendment (Scotland) Regulations 2003), HSE Guideline Note MS13 Asbestos 1988, the Health and Safety Commission Approved Code of Practice and Guidance Note.
		G4	The risks to construction workers will be mitigated by the adoption and use of appropriate PPE. The level of PPE protection should be selected on the basis of the completed land contamination section within the Environmental Statement or subsequent assessments.
		G5	Implement a 'watching brief' in order to take account of the fact that there may be isolated pockets of previously unidentified contamination.
PP2, PP13	Whole scheme	G6	Additional site investigation and monitoring to gather additional information on gas issues.
		G7	Assessment of gassing issues in accordance with CIRIA 665 following receipt of ground gas monitoring results.

Pollutant Pathway	Source reference requiring mitigation*	Mitigation Item No.	Mitigation description
		G8	A ground gas monitoring programme, to be produced prior to construction and adhered to during construction
		G9	Appropriate working methods to be developed and adopted by the contractor 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.
PP12	Operational maintenance	G10	Establishment of appropriate health and safety and waste management procedures for working with potentially contaminated soils, developed as part of standard Health and Safety procedures.
PP5 to PP9	Soil leaching	G11	Store excavated made ground material using bunding facilities.
PP16 to PP20	Proposed road embankment.	G12	Re-use criteria to be developed for protecting groundwater, surface waters and any ecological receptors. Material exceeding criteria to be treated contained and / or removed for off-site disposal.
PP10, PP21	Construction and operational phase	G13	Groundwater to be tested prior discharging to a surface water feature.
PP1 to PP11	In the vicinity of potential contaminated land sources.	G14	The local Environmental Health department (Perth & Kinross Council) will be consulted in order to ensure that ground investigation and subsequent remediation (where necessary) is carried out in order to ensure minimal risk to the groundwater environment.

* For source reference requiring mitigation refer to Appendix A8.1 (Potential Historical and Current Contamination Sources)

8.6 Residual Impacts

8.6.1 Residual impacts are those that remain once the measures described in Section 8.5 (Mitigation) have been implemented. If no mitigation measures are proposed then the residual impacts are equivalent to the potential impacts described in Section 8.4 (Potential Impacts).

Solid Geology

8.6.2 Bedrock geology is of negligible sensitivity, with expected low magnitude of impact as limited volumes are expected to be removed. Residual impacts on solid geology remain the same as the potential impacts, and are expected to be of Negligible significance.

Drift Geology (Superficial Deposits)

8.6.3 Drift deposits are of negligible sensitivity. The excavation of peat deposits is expected to be minimal and localised, and with the mitigation measure on excavation, re-use and disposal of these small amounts of peat, the remaining magnitude of impacts is expected to be low. Residual impacts on drift geology are therefore expected to be of Negligible significance.

Mineral Extraction

8.6.4 Exploitable sand and gravel deposits are considered to be of low sensitivity given their extensive occurrence and the impact is expected to be of low magnitude given the small volumes that would be removed. Residual impacts on mineral extraction are therefore expected to be of Negligible/Slight significance.

Contaminated Land

8.6.5 A number of potential source-pathway-receptors have been identified. However, with the implementation of mitigation measures described in Table 8.15, all residual impacts on contaminated land are expected to be of Low to Very low significance.

Hydrogeology

8.6.6 The drift and bedrock aquifer are at potential risk of being affected by accidental spillages; however mitigation measures have been proposed and will reduce the residual impacts to of Slight significance.

8.6.7 Any modifications of groundwater flow are expected to be minor and localised, and no impact is expected on PWS receptors. Residual impacts on aspects such as groundwater baseflow reduction and GWDTE are of Negligible significance in relation of pollution risk to Shochie Burn, Ordie Burn, and unnamed pond at Muir of Thorn; Negligible/Slight significance on Garry Burn; Slight significance on Cairnleith Moss; with none on Mill Dam SSSI.

8.6.8 Overall, all residual impacts on hydrogeology are expected to be of Negligible to Slight significance.

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