12 Geology, Soils, Contaminated Land and Groundwater

This chapter identifies and describes the existing geology, soils, contaminated land and hydrogeology 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.

Geological Sites of Special Scientific Interest present within the study area have been assessed, and it has been identified that impacts will be negligible and therefore no mitigation is required for superficial and solid geology, with the exception of peat deposits that would be excavated. The re-use of these peat deposits will be maximised, where feasible.

Impacts on aquifers within the superficial and bedrock deposits and associated receptors have been assessed. This identifies that two Private Water Supplies should be monitored during the construction phase. Residual impacts on the hydrogeology of the northern part of Blar nam Fiadh peat bog is assessed as Slight/Moderate significance. However, the more healthy part of the Blar nam Fiadh peat bog located to the south of the railway, is unaffected by the proposed Scheme.

Further detailed assessment is required on indirect dewatering impacts on some surface water receptors. Potential indirect dewatering impact on nearby infrastructure and properties have been assessed as generally Negligible/Slight, with the exception of a few areas that need to be assessed in more detail. Post implementation of mitigation measures, residual impacts on properties and infrastructure are expected to be Slight to Negligible/Slight.

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

12.1 Introduction

12.1.1 This chapter presents the results of the geology, groundwater and contaminated land assessment undertaken as part of the Design Manual for Roads and Bridges (DMRB) Stage 3 Environmental Impact Assessment (EIA) for the A96 Dualling Inverness to Nairn (including Nairn Bypass) (hereafter referred to as the proposed Scheme).

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

12.1.3 Geological impacts can occur due to excavating or masking exposures of rocks, or due to drift 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 future commercial exploitation of resources. Conversely, previous exploitation of resources can impose constraints on the proposed Scheme; for example, where land has become unstable due to mining or has been contaminated by previous land uses. It is also recognised that rock exposures can deliver environmental benefit, such as improved access to, and exposure of, new areas of geological interest.

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 lead to dewatering and also to contamination of drift and bedrock aquifers.

12.1.5 Similarly, once a new road is opened, runoff from the road surface may contain elevated concentrations of pollutants, such as oils, suspended solids, metals and, in winter, salt and antifreeze agents (e.g. ethylene glycol), which may find their way into the groundwater system. Groundwater flow can also be intercepted or altered by new cuttings and other significant changes to landform.

12.1.6 The assessment is supported by the following appendix which is located in Volume 2: Technical Appendices of this Environmental Statement:

- Appendix A12.1 (Contaminated Land Sources);
- Appendix A12.2 (Peat Assessment);
- Figure 12.2 (Potentially Contaminated Sources);
- Figure 12.2 (Water Supply Locations); and
- Figure 12.3 (Peat Probing Depth).

12.1.7 Further considerations related to geology, soils, contaminated land and hydrogeology assessments are addressed separately within the following chapters:

- Agricultural soils, discussed in Chapter 15 (People and Communities: Community and Private Assets); and
- Flood Risk Assessment, included in Chapter 13 (Road Drainage and the Water Environment).

Legislative and Policy Background

12.1.8 Appendix A18.1 (Planning Policy Context for Environmental Assessment) describes the planning policies and guidance from national to local level which are relevant to geology, soils, contaminated land and groundwater. 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) and a summary overview is provided in Chapter 18 (Policies and Plans), Section 18.4 (Assessment of Compliance).

12.2 Methodology

Approach to the Assessment

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, Transport Scotland, Welsh Assembly Government and The Department for Regional Development Northern Ireland 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, Transport Scotland, Welsh Assembly Government and The Department for Regional Development Northern Ireland 2009).

12.2.2 Consideration of soils includes contaminated land and made ground (included in the assessment of contaminated land), and potential impacts on peat (included in the assessment of drift deposits). Agricultural soils are also considered sensitive and can deteriorate as a result of disturbance during construction. 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.

Study Area

12.2.3 The assessment covers a study area extending to a corridor of 250m from the centre line of the proposed Scheme. For Groundwater Dependant Terrestrial Ecosystems (GWDTE), a study area extending up to 100m from the centre line of the proposed Scheme was used, as per agreement reached by SEPA on other road schemes. Impacts on groundwater abstractions have been assessed to a distance of 850m from the proposed Scheme, corresponding to the minimum study area applied for groundwater abstractions under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (Controlled Activities Regulations (CAR)).

Baseline Data

12.2.4 Baseline conditions cover the following aspects of ground conditions:

- solid and drift geology;
- features of geological and geomorphological importance;
- mineral extraction;
- groundwater environment including PWS; and
- contaminated land.

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

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

- British Geological Survey (BGS) data, including BGS Bedrock and Superficial Geological maps, BGS borehole logs, BGS Hydrogeological and Groundwater Vulnerability maps (BGS 1988a, 1988b) and other relevant BGS publications (BGS 2016)
- Ordnance Survey (OS) historical maps dating back to 1856 for information on former land use, potential contamination and physical hazards and information on PWS
- Scottish Environment Protection Agency (SEPA) River Basin Management Plans (RBMP) Interactive Map (SEPA 2015)
- Scottish Natural Heritage (SNH) designation database (SNH 2016)
- Peat Probing Report for Blar nam Fiadh peat bog (Jacobs 2013)
- results of previous studies conducted by Atkins; Environmental Planning Constraints Preliminary Assessment (Atkins 2010a) and Geotechnical Preliminary Sources Study Report (Atkins 2010b)

12.2.7 A site walkover was conducted on 23 March 2016 and 24 March 2016 to obtain further information on baseline geological, contaminated land and targeted groundwater related features.

12.2.8 An intrusive ground investigation (GI) was conducted by Raeburn Drilling and Geotechnical Limited (Raeburn), between 21 March 2016 and 31 May 2016. The investigation consisted of 107 boreholes and 130 trial pits located along the length of the proposed Scheme. Samples of soils and encountered groundwater were collected and sent to Terra Tek Site Investigation and Laboratory Services for chemical analysis. Sixty-seven boreholes were also completed with groundwater monitoring installations and were used to monitor groundwater levels. Soil infiltrations tests were conducted in 19 trial pits, and falling and rising head tests were conducted in three boreholes to provide permeability estimates across the proposed Scheme. The results presented in the August 2016 Ground Investigation reports (Raeburn 2016a and 2016b) have been taken into account in this assessment.

Impact Assessment

12.2.9 The impacts in relation to geology, hydrogeology and contaminated land have been assessed individually as per the methodologies provided below. The criteria outlined in Tables 12.1 to Table 12.9 are based on those that have been applied to similar schemes in Scotland and are designed to comply with DMRB Stage 3 requirements. Impacts of Slight/Moderate significance and above are considered to be significance levels at which mitigation would be required.

Geology

12.2.10 The sensitivity and magnitude criteria provided in Table 12.1 and Table 12.2 were used to assign sensitivity and magnitude for bedrock and superficial geology, features of geological importance and mineral extraction. The impact significance was then determined in line with Table 12.3.

Table 12.1: Sensitivity Criteria for Geology Assessment

Likelihood	Definition
high	Areas containing unique or rare geological or geomorphological features considered to be of national interest (e.g. Site of Special Scientific Interest (SSSI) and Geological Conservation Review (GCR))
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 identified as SSSI, GCR or RIGS but that may require specific protection in the future. Geological resources of local importance
negligible	Features not currently protected and unlikely to require specific protection in the future. No exploitable geological resources

Table 12.2: Magnitude Criteria for Geology Assessment

Magnitude	Definition
high	Total loss or partial loss (greater than 50%) 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 significant degree
low	Small loss (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 12.3: Matrix for Determination of Impact Significance for Geology Assessment

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

Groundwater

12.2.11 The assessment considers groundwater sensitivity in the context of hydrogeological conditions including groundwater resources. Criteria for the definition of groundwater sensitivity and magnitude are shown in Table 12.4 and Table 12.5. It should be noted that the dewatering zone of influence associated with road cuttings was estimated using the Sichardt method.

12.2.12 Potential groundwater flooding impacts are covered in the Flood Risk Assessment (Appendix 13.2) and are not discussed in this chapter.

12.2.13 The criteria for defining the magnitude of impact on quality and yield of abstractions are based primarily on the type of road profile (e.g. cutting, embankment or transition cutting embankment) facing the abstraction. However, where appropriate, the vulnerability of groundwater flow to sub-surface disruptions is also considered to refine the magnitude of impact.

12.2.14 The impact significance for groundwater aspects was then determined using the matrix as shown in Table 12.3.

Table 12.4: Sensitivity Criteria for Groundwater

Sensitivity	Definition
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 10 or more properties) and/or industrial supply Important sites of nature conservation dependent on groundwater as per importance criteria attributed within Chapter 11 (Habitats and Biodiversity) Surface water features of International / National importance.
medium	Local aquifer(s) is of limited value either because of some quality impairment or because exploitation of local groundwater is not extensive (i.e. private domestic and/or agricultural supply feeding fewer than 10 properties) Local areas of nature conservation known to be sensitive to groundwater impacts as per importance criteria attributed within Chapter 11 (Habitats and Biodiversity) Surface water features of Regional importance.
low	Poor groundwater quality and/or low permeability make exploitation of groundwater unlikely Minor areas of nature conservation with a degree of groundwater dependency as per importance criteria attributed within Chapter 11 (Habitats and Biodiversity) Surface water features of Authority area importance.
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 Surface water features of less than Authority area importance.

Table 12.5: Magnitude Criteria for Groundwater

Magnitude	Definition
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 Dewatering effects create significant differential settlement effects on existing infrastructure and buildings
medium	Changes to the local groundwater regime are predicted to have a slight impact on resource use Minor impacts on local ecology may result Dewatering effects create moderate differential settlement effects on existing infrastructure and buildings
low	Changes to groundwater quality, levels or yields do not represent a risk to existing resource use or ecology Dewatering effects create minor differential settlement effects on existing infrastructure and buildings
negligible	Very slight change from groundwater baseline conditions approximating to a 'no change' situation Dewatering effects create no or no noticeable differential settlement effects on existing infrastructure and buildings

Contaminated Land

12.2.15 In line with industry standards, the assessment focused on the potential for impacts on receptors as a consequence of encountering contaminated land, using a conceptual site model (CSM) developed for the proposed Scheme. A receptor can be a person (including construction workers), the water environment, flora, fauna or building/structures. The CSM represents a network of relationships between potential sources of contamination 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 the Scottish Government's Statutory Guidance: Edition 2 (Scottish Executive 2006) which incorporates the Contaminated Land (Scotland) Regulations 2000 (amended in 2005) and Part IIA of the Environment Protection Act 1990. The pollutant pathways (PP) and type of receptors used within the assessment are provided in Table 12.6, with individual references for linkages (i.e. PP1 to PP22).

12.2.16 Historical sources of contaminated land have been identified in the baseline information.

Table 12.6: Potential Pollutant Pathways and Receptors

Pollutant Pathway	Receptor	Pathway
Construction		
PP1	Human Health (Construction)	Ingestion, inhalation and dermal contact with soils, soil dust, deep and shallow groundwater and surface water.
PP2		Migration of ground gases into shallow pits or site buildings.
PP3	Off-site Receptors (local residents and transient traffic (foot, road and rail traffic)).	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 drift 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 Water	Migration of shallow groundwater through drift 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 risk assessment has been undertaken.

12.2.18 The output of the generic quantitative assessment cannot be reported in terms of 'sensitivity'. Instead, it is reported as the 'likelihood' of a complete pollutant linkage being present, which is defined in CIRIA 552: Contaminated Land Risk Assessment – A guide to good practise (CIRIA 2001) and summarised in Table 12.7. The magnitude, or 'consequence', of the effect of contaminated land on likely receptors is outlined in Table 12.8 and overall risk, taking account of both likelihood and consequence, is identified with reference to the matrix in Table 12.9.

Table 12.7: Likelihood Criteria for Contaminated Land Assessment

Likelihood	Definition
high	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 the long term.
low	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 12.8: Magnitude (Consequence) Criteria for Contaminated Land Assessment

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
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 effects to human health Easily reparable damage to buildings, structures and services

Table 12.9: Matrix for Determination of Generic Qualitative Risk Assessment for Contaminated Land

Likelihood / Consequence	Unlikely	Low	Likely	High
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

Mitigation

12.2.19 Potential mitigation measures have been considered during this assessment and take into account best practice, legislation, guidance and professional experience.

12.2.20 As described in Chapter 1 (Introduction) and Chapter 5 (Overview of the Assessment Process) the mitigation commitments and monitoring frameworks identified in the Strategic Environmental Assessments (SEAs) for the Strategic Transport Projects Review (STPR) (Jacobs, Faber Maunsell, Grant Thompson and Tribal Consulting 2008) and A96 Dualling Programme (CH2M 2015 and 2016) have also been taken into consideration in relation to the mitigation proposals.

12.2.21 The mitigation commitments relevant to Geology, Contaminated Land and Hydrogeology detailed within the STPR SEA include:

- The development of interventions should, wherever practicable, avoid crossing or adversely affecting geologically designated sites or valuable soil resources including geological SSSI's and Regionally Important Geological Sites;
- Consultation at the local level to avoid fragmentation of agricultural resources; and
- For discharges to groundwater, pollution control and containment measures should be designed and installed as necessary to ensure compliance of discharges with the Groundwater regulations.

12.2.22 The mitigation commitments relevant to Geology, Contaminated Land and Hydrogeology detailed within the A96 Dualling Programme SEA include:

- Seek to avoid nationally and locally designated geological and geodiversity sites;
- Where avoidance is not possible for the nationally and locally designated sites mitigation to be proposed at project EIA level in consultation with SNH;
- Seek to avoid areas of prime agricultural land and high carbon content soils in route alignment development as far as possible and to minimise fragmentation of fields and farm units;
- Where avoidance is not possible local level peat ecology, hydrogeology and geotechnical surveys will be required to determine locally appropriate solutions which minimise the potential effects of drainage and desiccation, and inform suitable restoration and management plans, including consideration of appropriate re-use or disposal options;
- Adherence to construction best practice to avoid adverse effects on soils such as from contamination, and retention of topsoil seedbanks where appropriate for use in site landscaping; wherever possible, seek appropriate reuse of waste soil;
- Farm accommodation works to be reviewed in more detail when specific alignments can be considered to minimise severance and fragmentation of farm units; and
- Provision of agricultural accommodation works such as vehicle underpasses.

12.2.23 The specific mitigation measures in relation to the proposed Scheme are discussed in Section 12.5 (Mitigation).

Consultation

12.2.24 Consultations have been undertaken with a number of statutory and non-statutory bodies in order to assess geological and hydrogeological impacts and contaminated land issues. These included the following:

- The Highland Council and The Moray Council for information on former contaminated land use, Part IIA determinations, PWS, licensed fuel storage and any additional relevant information;
- SEPA for information on licensed groundwater abstractions on former and current contaminated land use;
- SNH for information on the location and extent of environmental or historical sensitivities in the vicinity of the proposed Scheme and to establish any future development constraints; and
- private property/landowners to identify presence of PWS and obtain information on water source location and type, water storage, treatment and intended use.

12.2.25 Further information on the consultation process is provided in Chapter 5 (Overview of the Assessment Process) of this report.

Limitations

12.2.26 The accuracy and level of detail of documented sources is key to the assessment. For example, the identification of potential contamination sources relies on the accuracy of historical mapping.

12.2.27 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.

12.2.28 Geological and hydrogeological information obtained from the 2016 GI have 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.

12.3 Baseline Description and Evaluation

Geology

Bedrock Geology

12.3.1 Bedrock geology in the study area is generally composed of the Middle Old Red Sandstone. This group is predominantly represented by the Hillhead Sandstone Formation, which is recorded as comprising red and grey quartzose sandstone with interbeds of micaceous siltstone and silty mudstone.

12.3.2 Bedrock geology in the proposed Scheme is generally composed of the following:

- Hillhead Sandstone Formation of the Middle Old Red Sandstone underlies the majority of this section.
- Forres Sandstone Group belongs to the Upper Old Red Sandstone Formation and is present in the northern and eastern limits of the study area. The Forres Sandstone Group is characterised by red sandstone and rare siltstone.
- Auldearn Granite Pluton is located to the south of Auldearn and Househill.

12.3.3 Ground investigation data available substantiate the BGS published data with bedrock predominantly composed of red grey sandstone with frequent mudstone bands. The 2016 GI information suggests that bedrock is typically deep across the study area, with the majority of records indicating depth to bedrock of 10m below ground level (bgl) or more, with a maximum confirmed depth of 36mbgl. Minimum depth to bedrock was reported as 0.5mbgl near Culblair.

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

Superficial Geology

12.3.5 Superficial deposits include made ground, peat, alluvium, a variety of Flandrian and Late Devensian Raised Marine deposits, and Late Devensian glaciomarine and glacial deposits.

12.3.6 Made ground is expected to be locally derived and generally limited to areas of existing road or railway embankment, or the infill of historical quarries and pits. Made ground was encountered in two boreholes constructed as part of the 2016 GI. A 5.75m thick deposit composed of gravel with some brick, occasional tarmac, pottery, slag, concrete and ash was identified 50m distant from the existing A96 within an identified infilled pit (GE022). A 3.2m thick deposit was encountered in a borehole constructed within the footprint of Blackcastle Quarry. In addition, eight trial pits encountered made ground with thicknesses ranging from 0.8m to 3.7m. The material encountered was generally described as silty, clayey sand. However, concrete, cement, plastic, wood and metal wires were recorded in three of the eight trial pits. These areas of made ground have been reviewed and incorporated into the description of contaminated land sources in Appendix A12.1 (Contaminated Land Sources).

12.3.7 As per the definitions in Table 12.1, made ground is considered to be of negligible sensitivity.

12.3.8 Desk-based information indicates three grouped extensive areas of peat within and to the north of the Kildrummie Kames SSSI, as shown on Figure 12.2c. These include the Kildrummie Kames area itself, Blar nam Fiadh and a potential extended area of peat identified from BGS information

(referred to in this report as BGS peat area). Historical BGS borehole logs and an earlier Jacobs Peat Probing Report (Jacobs 2013) indicate that the thickness of peat is expected to be variable, with depths of over 5mbgl being recorded, within the Blar nam Fiadh Peat Bog.

12.3.9 Additional peat probing was undertaken as part of the 2016 GI within and adjacent to the BGS peat area between chainages ch15,500 and ch17,100, with the resultant contoured peat depths shown in Figure 12.3 in study areas A to E. Details on the 2016 peat probing are provided in Appendix A12.2 (Peat Assessment). It should be noted that the gaps between these study areas reflect the absence of peat; the 2016 GI info suggests in particular that there is a discontinuity in peat deposits in the BGS peat area. The depths of peat are quite variable over the mapped area, ranging from 0.2mbgl to 4.4mbgl. A site walkover conducted during March 2016 did not observe any obvious surficial peat deposits within the BGS peat area. The Kildrummie Kames SSSI, in closest proximity to the proposed Scheme, and the BGS peat area were observed to comprise predominantly improved farmland, in particular the southern part up to ch15,900 (study area A and part of study area B). For these reasons, residual peat deposits present in the study areas A and B are considered to be highly degraded and of low value. Any wet areas showing signs of persistent water-logging or boggy development were observed only in topographic lows. As per definitions in Table 12.1, the Kildrummie Kames peat bog is considered to have high sensitivity, the Blar nam Fiadh peat bog is considered to have a medium sensitivity and the BGS peat area is considered to have low sensitivity.

12.3.10 Limited peat deposits are also present in two localised areas, as detailed in Appendix A12.2 (Peat Assessment).

12.3.11 Alluvial deposits comprise two distinct types: fluvial deposits underlying river and burn flood plains; and lacustrine deposits which are found within enclosed basins. Fluvial deposits are generally described as river gravel overlain by thinly laminated silty sand, while the lacustrine deposits typically comprise fine- to medium-grained humic sand, silt and clay. Alluvium deposits generally form relatively small areas throughout the study area. As per definitions in Table 12.1, alluvial deposits are considered to be of negligible sensitivity.

12.3.12 Raised marine deposits are located within the north-west portion of the study area (in close proximity to the Moray Firth coastline) and include undifferentiated shoreface and beach deposits, and tidal flat deposits. The raised shoreface and beach deposits comprise mainly medium sand and well-rounded shingle. The tidal flat deposits comprise fine-grained sand, silty clay and clayey silt which typically infill broader depressions and glacial kettleholes. As per definitions in Table 12.1, these deposits are considered to be of negligible sensitivity.

12.3.13 Glaciomarine deposits of the Alturlie Gravels Formation and Raised Tidal Flat deposits are predominantly located in the centre of the study area, north of Culloden and extending to Delnies, west of Nairn. The Alturlie Gravels Formation is recorded as likely to include blown sand, beach gravel and silt in addition to sand and gravel. The Raised Tidal Flat deposits constitute fine-grained sand, silty clay and clayey silt, which typically infill broader depressions and glacial kettleholes. As per definitions in Table 12.1, these deposits are considered to be of negligible sensitivity.

12.3.14 Glacial deposits are located throughout the study area, to the south of the proposed Scheme and within the central area surrounding Nairn. These include glaciofluvial sheet and ice contact deposits, till and hummocky glacial deposits. These deposits comprise predominantly poorly sorted mixed deposits of clay, silt, sand and gravel. As per definitions in Table 12.1, these deposits are considered to be of negligible sensitivity.

12.3.15 Available GI data indicate that superficial deposits are predominantly composed of sands and gravels with varying silt and cobble contents, which is broadly consistent with the descriptions of the superficial units as provided above. The thickness of these units varies from a minimum of 2.15m near Morayston to over 36m north of Balloch.

Designated Geological Receptors

12.3.16 The Kildrummie Kames SSSI affords statutory protection to an assemblage of landforms which are collectively known as the Kildrummie Kames (also known as Flemington Kames or more correctly

Flemington Eskers (Auton 1992)). The Kildrummie Kames represents probably the best preserved (and one of the longest) examples of a system of large braided eskers in Britain. The assemblage of landforms which comprise the Kildrummie Kames SSSI consists of up to eight braided eskers (5 to 10m high) with intervening kettleholes (often filled with peat and waterlogged silt and sand), kames and outwash terraces. The Kildrummie Kames SSSI is shown on Figure 12.2c.

12.3.17 The site has largely escaped large-scale modifications, such as sand and gravel extraction, and demonstrates a series of well defined, glacially derived landforms. However, the area to the west of the esker features, and in closest proximity to the proposed Scheme, is now predominantly improved farmland. Significant wet areas are generally confined to topographic low points.

12.3.18 The landforms in the vicinity of Meikle Kildrummie are of particular importance, as the esker system ends abruptly to the south-west of this point. From here, the landscape to the east is dominated by outwash deposits. Since the landform assemblage was first described (Jamieson 1866), there have been a range of interpretations as to the mode of their formation (summarised in Auton 1992).

12.3.19 The area between Meikle Kildrummie and Howford is dominated by a large linear, relatively broad and flat topped, ridge with a west-east orientation. This feature is classed as a kame (ice contact deposit) (Auton 1992), with the lower lying land surrounding the ridge described as terraced glaciofluvial sand and gravel deposits, derived from glacial outwash. Firth (1984) (summarised in Gordon and Auton 1993) suggests the ridge was formed in an open crevasse which formed when a sub-glacial ice tunnel (part of the tunnel system in which the eskers to the west of Meikle Kildrummie were deposited) collapsed.

12.3.20 The area is considered to be of importance for the following reasons:

- the landform assemblage is one of the finest and largest examples of a braided esker system in Britain;
- the assemblage is largely intact and unmodified by sand and gravel extraction;
- the surface morphology of the landforms is particularly clear; and
- the landform assemblage continues to provide important opportunities for further research into esker formation and glacier hydrology.

12.3.21 As per the definitions in Table 12.1, the Kildrummie Kames SSSI area (including the Meikle Kildrummie and Howford areas) is considered to be of high sensitivity.

12.3.22 No other designated geological receptors or GCR sites are present within the study area. Other SSSIs are present within the study area and these are described in Chapter 11 (Habitats and Biodiversity).

Mineral Extraction

12.3.23 Twenty one active and disused quarries, primarily associated with sand and gravel quarrying (refer to sites recorded as ‘mineral extraction’ in Appendix A12.1: Contaminated Land Sources) were identified within the study area. Notably, a large active quarry, Blackcastle Quarry (GE57) is located on the proposed Scheme alignment to the west of Nairn.

12.3.24 The review of BGS Mineral Resources publications did not indicate any specific future mineral resource other than suggesting that the area has general mineral resource potential.

12.3.25 Due to the history of the study area where local sand and gravel exploitation are known to have taken place, the potential for future sand and gravel exploitation is expected to remain as a local natural resource and as such is considered to be of low sensitivity.

Hydrogeology

12.3.26 The sandstone bedrock underlying the majority of the study area (Middle Old Red Sandstone) is classified as a moderately productive aquifer, locally yielding small amounts of groundwater. The

sandstone bedrock underlying the eastern end of the study area is classified as a moderately productive, regionally important aquifer, with moderate yields. To the south of Auldearn, intrusive rocks are present (Auldearn Granite Pluton) and characterised as a low productivity aquifer, generally without groundwater except at shallow depth.

12.3.27 Late Devensian sand and gravel superficial deposits across the study area are classified as a locally important aquifer, in which intergranular flow is significant. Areas of alluvium around the River Nairn and the Quaternary coastal deposits to the west constitute a concealed aquifer of limited or local potential.

12.3.28 The SEPA RBMP classification from 2008 is 'Good' with 'High' confidence for both the groundwater quality and quantity.

12.3.29 The BGS Groundwater Vulnerability Map (BGS 1988b) indicates that the superficial deposits within the study area are moderately permeable, with intermediate leaching potential (i.e. moderate ability to attenuate diffuse pollution). In addition, the Baseline Scotland: groundwater chemistry of the Old Red Sandstone aquifers of the Moray Firth area (BGS 2010) confirms that groundwater in both superficial and bedrock aquifers are highly vulnerable to contamination from surface activities.

12.3.30 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 predominantly towards the coast, to the north-west.

12.3.31 The hydrogeological characteristics and sensitivity (as per definitions in Table 12.8) of drift and bedrock units within the study area are summarised in Table 12.10.

Table 12.10: Hydrogeological Characteristics and Sensitivity 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 and gravel.	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	medium
	Alturie Gravels Formation and Raised Tidal Flat Deposits	Silt, clay and fine –grained sand with lenses of gravel.	Local groundwater potential.	medium
	Raised Marine Deposits	Glaciomarine sand and gravel.	Local groundwater potential.	medium
	Glacial Deposits (Till)	Heterogeneous deposits.	Poor groundwater potential due to generally low and variable permeability.	low
	Peat	Decomposed organic deposits.	Very poor groundwater potential due to compacted nature, low permeability and limited spatial extent.	low (from a water resource point of view)
Bedrock	Upper Old Red Sandstone	Principally sandstone with siltstones and conglomerates.	Moderately productive aquifer, regional groundwater potential.	high
	Middle Old Red Sandstone	Principally sandstone with siltstones and mudstones.	Moderately productive aquifer, local groundwater potential.	medium
	Auldearn Granite Pluton	Granite.	Poor groundwater potential except through fractures.	low

Abstractions

12.3.32 Twenty-six potential groundwater abstractions were identified during the DMRB Stage 2 assessment. During DMRB Stage 3 an additional 11 groundwater abstractions have been identified following consultation with SEPA and landowners. However, not all potential groundwater abstractions are currently active. The information is summarised in Table 12.11 and the active

PWS are shown in Figure 12.2. None of the potential abstractions are believed likely to constitute very large yielding supplies.

12.3.33 Where the status of these groundwater supplies is confirmed as active or unclear, the abstractions are considered to be of medium sensitivity as per definitions shown in Table 12.8. Where the PWS are inactive or abandoned, these redundant PWS are not further considered as a receptor.

12.3.34 A survey took place in relation to PWS GE125 but no PWS infrastructure was observed. Animals were noted to drink from troughs connected to a buried supply pipe running along the side of a minor road. Consultation with the landowners indicated that the supply is sourced from a deep borehole (100m deep) and the water is used for irrigation purposes. The supply is 20 years old and can produce 1000 gallons an hour.

Table 12.11: Identified Licensed and Unlicensed Abstractions within the Study Area

Ref	Feature Type	Chainage	Source	SEPA Response	The Highland Council Response	Landowner Response
GE102	Spring	ch1700	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE103	Spring	ch8600	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE104	Well	ch9600	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE105	Spring	ch10700	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE106	Well	ch12500	DMRB Stage 2 Assessment	n/a	n/a	Active
GE107	Well	ch14100	DMRB Stage 2 Assessment	n/a	n/a	Non Active PWS
GE108	Well	ch14100	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE109	Well	ch15500	DMRB Stage 2 Assessment	n/a	n/a	Active
GE110	Well/Spring	ch16900	DMRB Stage 2 Assessment	n/a	n/a	Abandoned
GE111	Spring	ch18000	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE112	Well	ch17950	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE113	Well	ch18750	DMRB Stage 2 Assessment	n/a	n/a	Abandoned
GE114	Spring	ch21000	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE115	Well	ch22400	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE116	Well	ch23400	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE117	Well	ch23700	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE118	Well	ch23800	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE119	Spring	ch25900	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE120	Well	ch27300	DMRB Stage 2 Assessment	n/a	n/a	Abandoned
GE121	Well	ch27800	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE122	Well	ch27900	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE123	Well	ch28100	DMRB Stage 2 Assessment	n/a	n/a	No PWS

Ref	Feature Type	Chainage	Source	SEPA Response	The Highland Council Response	Landowner Response
GE124	Well	ch28400	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE125	Well	ch30000	DMRB Stage 2 Assessment and The Highland Council consultation	n/a	n/a	Active
GE132	Water Tower	ch23000	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE133	Well	ch30100	DMRB Stage 2 Assessment	n/a	n/a	No PWS
GE401	Licensed abstraction	ch20300	SEPA consultation	Active	n/a	n/a
GE402	Licensed abstraction	ch20400	SEPA consultation	Active	n/a	n/a
GE403	Licensed abstraction	ch18900	SEPA consultation	Active	n/a	n/a
GE404	Licensed abstraction	ch3200	SEPA consultation	Active	n/a	n/a
GE405	Licensed abstraction	ch26800	SEPA consultation	Active	n/a	n/a
GE406	PWS	ch24400	The Highland Council consultation	n/a	Active	n/a
GE407	PWS	ch4900	Landowner consultation	n/a	n/a	Active
GE409	PWS	ch9400	Landowner consultation	n/a	n/a	No PWS
GE411	Well	ch18200	Consultation with Blackcastle Quarry operator	n/a	n/a	Active Small volumes of groundwater are abstracted for washing purposes
GE412	PWS	ch18600	Blackcastle Quarry planning application	n/a	n/a	Future abstraction to dewater the new proposed quarry extension
GE426	Spring	ch16100	Landowner consultation	n/a	n/a	No active PWS

Groundwater Monitoring

12.3.35 Information reported by Atkins (2010b) and initial consultation with SEPA in 2011 suggests that the depth below ground of groundwater varies considerably in the area, from approximately 1mbgl to 8.5mbgl.

12.3.36 Groundwater level data from the 2016 GI was collected during the period 13 April to 23 August 2016 and confirms a high level of variability with depth to groundwater ranging between ground level (at Tornagrain Wood ch10200) and 22mbgl (near Balloch ch5050) and typically in the region of 4mbgl. This equates to groundwater piezometric levels of 51.02m AOD (Blackcastle Quarry ch17900) to 1.63m AOD (near Stratton ch1700) across the study area. The greatest range in groundwater level recorded in a single borehole was 4.12m during this short period of time.

12.3.37 Falling head permeability tests were conducted on eight boreholes and returned permeability estimates ranging between 1.05×10^{-8}m/s and 7.08×10^{-6}m/s.

Groundwater Quality

12.3.38 Baseline Scotland: groundwater chemistry of the Old Red Sandstone aquifers of the Moray Firth area (BGS 2010) describes the groundwater in the Old Red Sandstone as generally moderately mineralised, with calcium as a dominant cation and bicarbonate as a dominant anion, and with nitrate concentrations ranging from 0.05mg/l to 8mg/l. The study area does not lie within a Nitrate

Vulnerable Zone (NVZ), however, agricultural inputs are likely considering the predominant land use. Water quality in this aquifer is expected to be suitable as a drinking water supply.

12.3.39 Consultation with SEPA has indicated that there are 73 discharge consents within the study area, primarily associated with the discharge of effluent to soakaways (refer to Appendix A12.1: Contaminated Land Sources). In addition, there are three Pollution Prevention Control permits in place and six Waste Management Licences. The locations of these are shown on Figure 12.1.

12.3.40 The groundwater sample chemical analysis results from the 2016 GI have been compared against resource protection values (RPVs) as defined within SEPA Position Statement WAT-PS-10-01 (SEPA, 2014). This screening exercise has identified predominantly marginal and isolated exceedances for arsenic, chloride, total cyanide, mercury, vanadium, phenols, polycyclic aromatic hydrocarbons and total petroleum hydrocarbons across the proposed scheme. Elevated concentrations of cadmium, ammoniacal nitrogen and nitrate (occasionally with nitrite exceedances) are more common throughout the proposed scheme.

Ecological Receptors with Potential Groundwater Component

12.3.41 Two areas where peat bog is present have been identified within the Kildrummie Kames SSSI area, Kildrummie Kames peat bog and Blar nam Fiadh. These are considered to be partially fed by groundwater flow and of high (Kildrummie Kames) and medium (Blar nam Fiadh) sensitivity.

12.3.42 An area of marshy grassland associated with semi-natural woodland is present near Mosside on the western outskirts of Nairn. This area is also thought to be groundwater dependent and is considered to be of low sensitivity.

12.3.43 Based on the ecological information available in Chapter 11 (Habitats and Biodiversity), there are no confirmed GWDTE sites present within the study area. Other marshy grassland areas noted in Chapter 11 (Habitat and Biodiversity) identified in the Phase 1 habitat survey are considered to be dominantly surface water fed and/or outside the study area and are not further assessed in this chapter.

12.3.44 A description of the Longman and Castle Stuart Bays SSSI and Inner Moray Firth Special Protection Area (SPA) and Ramsar is provided in Chapter 11 (Habitats and Biodiversity).

12.3.45 The location of these sites is provided on Figure 12.2.

Surface Water Features (SWFs)

12.3.46 A number of SWFs are present within the study area and are detailed in Chapter 13 (Road Drainage and the Water Environment). Loch Flemington is located within the Kildrummie Kames SSSI area, west of the western extent of the Kildrummie Kames peat bog, and is a SPA. This feature is therefore considered to be of high sensitivity and is considered likely to be in continuity with groundwater. Further characterisation of this designated site can be found in Chapter 11 (Habitats and Biodiversity) and Chapter 13 (Road Drainage and the Water Environment) of this report.

Contaminated Land

12.3.47 One hundred and eighty-five potentially contaminated land sources have been identified within the 250m study area. Details of the identified contamination sources are provided in Appendix A12.1 (Contaminated Land Sources) and are shown on Figure 12.1.

12.3.48 The 2016 GI identified five areas where made ground was proven to be present. Two areas (GE417 and GE418) are in close proximity to Smithton Junction (GE10) and may be associated with the existing A96. The other three areas correspond with previously identified potentially contaminated sites: GE22 (Pit 2), GE57 (Blackcastle Quarry) and GE101 (a disused quarry). A sulphurous odour and putrescible material was observed within the made ground area at GE22.

12.3.49 The soil sample chemical analysis results from the 2016 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 potential exposure pathways to end users given the proposed use as a road; however, potential pathways remain, including for maintenance workers. Therefore the soil sample chemical analysis results have also been compared against GAC suitable for public spaces (park) and commercial/industrial end uses. The aim of the assessment is to identify any contaminants that exceed the GACs and may be considered as Contaminants of Potential Concern.

12.3.50 A soil organic matter concentration of 6% has been used (Laboratory results ranged from 0.2 to 8.1%). The following hierarchy of GACs has been used to screen soil sample analysis results:

- Jacobs derived GACs based on CLEA 1.06, Soil Guideline Values (SGVs) and Toxicity reports published by the Environment Agency (EA);
- Suitable for Use Limits (S4ULs) for Human Health Risk Assessment, Land Quality Management / 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).

12.3.51 The results of the soil sample chemical analysis screening showed no exceedance in relation to S4ULs and C4SLs developed for public spaces nor for Jacobs derived GACs for commercial/industrial end use. Three contaminants had concentrations in excess of the Jacobs derived residential GACs. One soil sample associated with Blackcastle Quarry (GE57) contained a 410mg/kg concentration of lead which is in excess of the residential GAC (310mg/kg) but far below the C4SL for public space 2 (1300mg/kg) and the commercial industrial GAC (2330mg/kg). One soil sample associated with Pit 2 (GE22) contained a 55mg/kg concentration of beryllium which is above the residential GAC (38mg/kg) but far below the S4UL for public space (park) (63mg/kg) and the commercial industrial GAC (378mg/kg). Another soil sample which is also associated with Pit 2 (GE22) contained a 1.63mg/kg concentration of benzo(a)pyrene which is marginally above the residential GAC (1mg/kg) but below the S4UL for public space (park) (13mg/kg) and the commercial industrial GAC (14mg/kg).

12.3.52 Ground gas monitoring has been undertaken within 125 monitoring boreholes across the proposed Scheme as part of the 2016 GI. Ground gas concentrations could pose a potential risk to human receptors 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 and carbon dioxide, carbon monoxide and hydrogen sulphide, and depleted oxygen 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)).

12.3.53 Recorded methane concentrations were below the recommended safety threshold of 20% of the lower explosive limit for methane (1% v/v) with the exception of two occurrences where a peak value of 6% v/v was recorded in isolation. Both locations are associated with GE22 (Pit 2) where putrescible material was observed and the likely source for the methane.

12.3.54 Carbon dioxide concentrations exceed the long term exposure limit (0.5% v/v) in 86 boreholes, 58 of which also exceed the short term occupational exposure limit (1.5% v/v). Carbon monoxide concentrations are above the long term exposure limit (30ppm) in 36 boreholes, 23 of which also exceed the short term exposure limit (200ppm).

12.3.55 Oxygen concentrations below the 19%v/v limit set by the Mines and Quarries Act were recorded in 97 locations, 25 of which contained very low oxygen concentrations (below 16%v/v).

12.3.56 Hydrogen sulphide concentrations were predominantly below the monitoring equipment's level of detection (1ppm). However 13 locations have recorded hydrogen sulphide concentrations above the long term exposure limit (5ppm), 9 of which also exceed the short term exposure limit (10ppm). Six locations have marginal exceedances with the elevated concentrations recorded on only one occasion. Higher concentrations are observed at the remaining seven locations with no obvious source for the hydrogen sulphide gas reported within the borehole logs nor are any in proximity to an identified contaminated land source. There may be some influence from the BGS peat area for three locations which are located between 50 and 150m to either the north or the west of the BGS peat area.

12.4 Potential Impacts

12.4.1 The potential impacts are assessed prior to the implementation of mitigation. Potential mitigations 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 removal of excavated material or dewatering due to road cuttings) would extend through to the operational phase. Where differences in impacts are predicted between the construction and operational phases, these impacts have been assessed for each in turn.

12.4.3 There are a variety of ways in which road development schemes can impact on geological and hydrogeological features and resources, such as:

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

12.4.4 A key aspect of the impact assessment is to identify areas of temporary or permanent excavations. Information on proposed excavated areas is provided in Table 12.12 and permanent excavations are shown on Figures 12.1 and 12.2. It should be noted that only cuttings deeper than 1m are included.

Table 12.12: Cutting Depths

Name	Approximate Chainage	Approximate Maximum Excavation Depth (mbgl)	Local Maximum Recorded Groundwater Level (mbgl)	Likelihood to Intercept Bedrock	Likelihood to Intercept Groundwater
C2	ch4900 to 5000	3.05	4.33	low	low
C3	ch4900 to 5050	3.18	5.0	low	low
C4	ch5030 to 5060	2.85	4.10	low	low
C5	ch5050 to 5180	3.05	Dry	low	low
C6	ch5600 to 5850	4.18	Dry	low	low
C9	ch8180 to 8420	3.90	1.10	low	likely
C10	ch9690 to 9990	2.05	Dry	low	Low
C11	ch10300 to 10920	2.84	6.13	low	low
C16	ch13730 to 14200	2.10	4.90♦	low	low
C17	ch13730 to 13840	1.61	4.90	low	low

Name	Approximate Chainage	Approximate Maximum Excavation Depth (mbgl)	Local Maximum Recorded Groundwater Level (mbgl)	Likelihood to Intercept Bedrock	Likelihood to Intercept Groundwater
C18	ch14060 to 14340	1.00	14.44	low	low
C19	ch14650 to 15500	6.58	3.20	low	likely
C21	ch17050 to 17680	10.03	10.15 or 0.92♦	low	likely
C24	ch18260 to 18410	2.9	0.96	low	likely
C26	ch21500 to 22200	5.59	4.02	low	likely
C29	ch23500 to 25400	10.38	3.10 - 5	likely	likely
C31	ch25860 to 25940	1.94	5.4♦	low	low
C32	ch26000 to 26110	4.62	10.71	low	low
C33	ch27460 to 28360	7.20	5.30	likely	likely
C34	ch28890 to 29570	6.30	Ground level	low	likely
C35	ch29760 to 30880	9.13	1.3	low	likely
C36	ch1580 to 1700	1.34	12.49♦	low	low
C37	ch10300 to 10600	5.28	3.6	low	low
C38	ch10730 to 10900	4.18	dry	low	low
C39	ch17720 to 17900	5.78	1.2	low	likely
CS2	ch110 to 210	1.18	8.68	low	low
CS4	ch100 to 500	5.86	6.50	low	low
CS5	ch0 to 400	5.09	12.54♦	low	low
CS6	ch60 to 430	7.54	1.62	likely	likely
CS7	ch0 to 240	6.34	1.62♦	likely	likely
CS8	ch0 to 40	4.14	0.69♦	likely	likely
CV02	ch1250	4.69	7.8	low	low
CV04	ch2280	6.40	8.3	low	low
CV05	ch2535	2.06	8.76♦	low	low
CV06	ch3230	3.11	3.7♦	low	low
CV07	ch4745	3.40	2.5♦	low	likely
CV08	ch6320	1.28	6	low	low
CV09	ch7525	7.01	1.17	likely	likely
CV13	ch10200	1.71	0	low	likely
CV14	ch10550	2.71	2.0♦	low	likely
CV16	ch12700	1.63	3♦	low	low
CV17	ch17010	3.38	10.15♦	low	low
CV18	ch19610	1.97	1.24	low	likely
CV19	ch23405	1.75	3♦	low	low
CV20	ch26695	1.49	0.69♦	low	likely
CV22	ch11390	1.82	0.40♦	low	likely
CP01	ch1350 to ch1450	6.07	3♦	low	likely
CP02	ch1150 to ch1200	7.24	3-7♦	low	likely
CP03	ch1200 to ch1300	7.27	3-7	low	likely
CP04	ch1550 to ch1700	6.85	12.49♦	low	low
CP05	ch2000 to ch2250	5.72	1	low	likely
CP06	ch2300 to ch2400	4.60	1♦	low	likely
CP07	ch2800 to ch3000	3.28	3.19	low	possibly
CP08	ch4800 to ch5000	4.09	3-5	low	possibly
CP10	ch8500 to ch8600	2.15	4.71	low	low
CP12	ch10050 to ch10300	2.07	0	low	likely
CP13	ch10700 to ch10920	2.47	6.13	low	low
CP14	ch12670 to ch12960	2.53	0.69♦	low	likely
CP15	ch15650 to ch15800	3.16	4.81♦	low	low
CP16	ch16800 -to ch17000	1.41	1.66♦	low	low
CP17	ch17000 to ch17130	10.56	8.68	low	likely

Name	Approximate Chainage	Approximate Maximum Excavation Depth (mbgl)	Local Maximum Recorded Groundwater Level (mbgl)	Likelihood to Intercept Bedrock	Likelihood to Intercept Groundwater
CP18	ch19800 to ch19950	1.70	1.24	low	likely
CP19	ch22130 to ch22270	6.63	2.8	likely	likely
CP21	ch25700 to ch25800	5.76	5.4♦	low	likely
CP22	ch26600 to ch26850	6.03	0.69♦	likely	likely
CP23	ch28650 to ch28870	4.72	1.27	low	likely
CP24	ch23300 to ch23500	5.93	3.17	low	likely
CP25	ch26600 to ch26850	4.59	0.69♦	likely	likely
CT1	ch40 to ch165	1.40	4.1	low	low
CT2	ch0 to ch70	1.30	14.4	low	low
CT3	ch60 to ch120	1.70	3.2	low	low
CT4	ch60 to ch130	1.65	10.15	low	low
CT5	ch250 to ch280	1.60	4.02	low	low
CT6	ch100 to ch265	2.4	12.54	low	low
♦ Groundwater level from nearby monitoring point, not from within cutting footprint					

Geology

Bedrock Geology

12.4.5 Table 12.12 indicates that bedrock is likely to be intercepted by nine of the proposed cuttings. This is expected to represent a low magnitude of impact because of the widespread presence of these deposits, resulting in an overall impact significance of Negligible.

12.4.6 The use of blasting to excavate bedrock in places cannot be ruled out at this stage. There are three major mechanisms where rock blasting can impact on rock structure:

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

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

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

12.4.9 On this basis the overall significance of potential impacts from blasting operations on solid geology is considered as Negligible.

Superficial Geology

12.4.10 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 these superficial deposits as a result of the construction activities is considered to be of low magnitude for all superficial deposits, with the exception of peat. This is because of the widespread presence of these deposits (excluding peat) elsewhere in the region and in the country. As a result, the overall impact significance is Negligible during both construction and operation phases.

12.4.11 Given the areas of expected peat deposits, the proposed Scheme has been designed to minimise direct interaction with peat and to minimise by 43% the volume of peat that would need to be removed as a result. In particular, the volumes of peat to excavate were minimised in the area of the Gollanfield Railway Bridge where a piled load transfer platform is being proposed to support the eastern embankment (ch16,290 to ch16,390). However, some direct interaction with peat is expected within the BGS peat area (included to varying degrees within study areas A to D) and potentially within Blar nam Fiadh (which borders study area E). It should be noted that the peat identified in study areas A and B is very degraded and would have limited re-use potential across the site. The estimated volumes expected to be removed for each study area are provided in Table 12.13. The location of the peat probing study areas are defined within Figure 12.3.

Table 12.13: Estimate of Peat Volumes to be Excavated during Construction of the Proposed Scheme

Study Area	Area Under Design Footprint (m^2)	Average Peat Depth (m)	Estimated Volume (m^3)	Estimated Volume Catotelm (m^3)	Estimated Volume Accrotelm (m^3)	Estimated Volume Degraded Peat (m3)
A	9,150	0.18	1,500	0	0	1500
B	12,285	0.19	2,500	0	0	2,500
C	4,246	1.11	6,500	2,250	4,250	0
D	7,910	1.13	23,500	8,500	15,000	0
E	9,994	0.45	5,000	4,750	250	0

12.4.12 The BGS peat area (low sensitivity) would be directly impacted by the proposed Scheme during both the construction and operation phases. However, as these excavations are located on the periphery of the BGS peat area and would result in extraction of only a small percentage of the total peat volume, they are likely to represent a low magnitude of impact and result in an overall impact significance of Negligible/Slight.

12.4.13 There is potential that Blar nam Fiadh (medium sensitivity) would be directly impacted by the proposed Scheme which borders the northern edge of Blar nam Fiadh as shown on Figure 12.3. Peat deposits have been encountered within study area E to the north of Blar nam Fiadh and perhaps a marginal area of the Blar nam Fiadh will be directly impacted by the proposed Scheme during both the construction and operation phases. This is likely to result in a localised minimal impact to Blar nam Fiadh resulting in an overall impact significance of Negligible/Slight.

12.4.14 Appendix A12.2 (Peat Assessment) also identifies two areas of isolated peat and concludes that approximatively 1,500m^3 of material are present. It should be noted that the peat in these localised areas has been found within alluvial material and as such it is likely that the peat will be removed along with the soft alluvial material and not as a distinct horizon. This is expected to have a negligible impact on the geological deposits, resulting in an overall impact of Negligible significance.

12.4.15 Chapter 17 (Materials) takes into account these estimated volumes and also covers potential impacts on carbon losses as a result of peat excavations.

Designated Geological Receptors

12.4.16 None of the identified designated geological receptors are considered likely to be directly or indirectly impacted by the construction of the proposed Scheme.

Mineral Extraction

12.4.17 Mineral extraction has occurred historically within the study area and a number of active quarries have also been identified. Due to the relatively wide spread occurrence of these deposits within the study area, sand and gravel resources have been assigned low sensitivity. The impact magnitude of the construction of the proposed Scheme on these resources is deemed to be negligible, resulting in an impact significance of Negligible.

12.4.18 The proposed Scheme would pass through a previously worked area of the existing Blackcastle Quarry, but would not directly impact current areas of mineral extraction.

Groundwater

12.4.19 The Sichardt method was used to estimate the zone of dewatering influence around each of the cuttings considered likely to intercept groundwater, using permeability estimates derived from permeability tests from the 2016 GI, along with cutting dimensions and drawdown estimates. The likely impacts on receptors within this zone were then assessed and are presented below.

12.4.20 The same zone of dewatering influence is also used to determine potential indirect contaminated land impacts as a result of contaminated groundwater mobilisation.

Groundwater Flow

12.4.21 Table 12.12 indicates that 37 cuttings (13 proposed road cuttings, 17 proposed SUDS cuttings and 7 proposed culvert cuttings) have the potential to intercept groundwater within the superficial deposits. This is expected to create a local dewatering effect within the superficial deposits (low to medium sensitivity) around these locations, assessed as being potentially of medium magnitude. This results in an overall potential impact significance of Slight/Moderate to Moderate.

12.4.22 Bedrock is expected to be intercepted in nine cuttings in areas underlain by the Middle Old Red Sandstone Group (medium sensitivity). The magnitude of any potential impact is considered to be low resulting in an overall impact significance of Slight/Moderate.

12.4.23 Where dewatering occurs, there is a potential risk of differential settlement, which could impact nearby infrastructure and properties. All surrounded infrastructure has been attributed a medium sensitivity except where listed buildings are present where a high sensitivity has been attributed. This is considered a conservative approach.

12.4.24 The settlement assessment takes into account the proximity of potential receptors to cuttings likely to intercept groundwater and the degree of groundwater drawdown expected. Potential settlement at these receptors was analysed using the Burland and Burbidge method, which is laid out in Foundation Design and Construction, 7th Edition (Tomlinson, 2001). This method of analysis was selected as the ground conditions throughout the site were generally consistent (i.e. predominately silty sands and gravels). Table 12.14 summarises the potential impacts due to settlement along the proposed Scheme. Table 12.14 indicates that the settlements within the sand and gravels due to the drawdown of groundwater are generally negligible to low in magnitude resulting in an overall impact significance of Negligible/Slight to Slight/Moderate.

Table 12.14: Potential Impacts on Infrastructure and Properties as a Result of Groundwater Dewatering

Cutting ID	Approximate Chainage (m)	Nearby Receptors	Magnitude of Impact	Significance of Impact
C19	ch14650 to ch15500	Isolated residential properties Local access road Railway line	low	Slight/Moderate
C21	ch17050 to ch17680	Isolated residential properties Railway line Blackcastle Quarry Local access road	low	Slight/Moderate
C26	ch21500 to ch22200	Fuel Pipeline Local access road	negligible	Negligible/Slight
C29	ch23500 to ch25400	Isolated residential properties Industrial property Local access road	negligible	Negligible/Slight
C33	ch27460 to ch28360	Local access road	negligible	Negligible/Slight
C34	ch28890 to ch29570	Local access road Isolated residential properties	negligible	Negligible/Slight

Cutting ID	Approximate Chainage (m)	Nearby Receptors	Magnitude of Impact	Significance of Impact
C35	ch29760 to ch30880	Local access road Isolated residential properties	negligible	Negligible/Slight
C39	ch17720 to ch17900	Local access road	negligible	Negligible/Slight
CS6	ch60 to ch430	Local access road Isolated residential properties 7 B listed buildings	negligible	Negligible/Slight to Slight
CS7	ch0 to ch150	Local access road Isolated residential property	negligible	Negligible/Slight
CS8	ch0 to ch40	Local access road	negligible	Negligible/Slight
CV09	ch7525	Isolated residential properties	negligible	Negligible/Slight
CV14	ch10550	Local access road	negligible	Negligible/Slight
CV20	ch26695	Local access road	negligible	Negligible/Slight
CV22	ch11390	Railway line Inverness Airport Isolated properties	negligible	Negligible/Slight
CP01	ch1350 - 1450	Railway line Fuel Pipeline	negligible	Negligible/Slight
CP02	ch1150 - 1200	Local access Road Retail park Isolated property	negligible	Negligible/Slight
CP03	ch1200 – 1300	Local access road Isolated property	negligible	Negligible/Slight
CP07	ch2800 – 3000	Isolated property Local access road	negligible	Negligible/Slight
CP12	ch10050 - 10300	Railway line	negligible	Negligible/Slight
CP14	ch12670 - 12960	Local access road	negligible	Negligible/Slight
CP17	ch17000 - 17300	Local access road Isolated property	negligible	Negligible/Slight
CP19	ch22130 - 22270	Local access road	negligible	Negligible/Slight
CP21	ch25700 - 25800	Local access road	negligible	Negligible/Slight
CP22	ch26600 - 26850	Local access road Isolated property	negligible	Negligible/Slight
CP23	ch28650 - 28870	Isolated properties	low	Slight/Moderate
CP24	ch23300 - 23500	Isolated properties	negligible	Negligible/Slight
CP25	ch26600 - 26850	Isolated property Local access road	negligible	Negligible/Slight

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

12.4.26 Infiltration trenches proposed as part of the proposed Scheme to direct runoff drainage to the subsurface could create localised mounding of groundwater, which could alter local groundwater flow patterns. This is assessed as having an impact magnitude of low, resulting in an overall impact of Slight significance, with the exception of the infiltration trench proposed in the vicinity of Blackcastle Quarry. Permeability test data was used to estimate the maximum distance from the infiltration trench that would be impacted by raised groundwater levels. Based on the Sichardt method, it was estimated that the groundwater mound would extend 450m from the infiltration trench. The currently worked area of the quarry is located approximately 550m away from the infiltration trench and therefore it is considered unlikely that the currently worked area of the quarry would be impacted by raised groundwater levels caused by the infiltration trench.

Groundwater Quality

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

12.4.28 The potential magnitude of impact from accidental spillages is considered to be medium on shallow groundwater present in superficial deposits and low on bedrock. The potential impact assessment from accidental spillages on these aquifers is summarised in Table 12.15,

Table 12.15: Potential Impact of Accidental Spillages on Key Hydrogeological Units during both Construction and Operation Phases

Hydrogeological Unit	Sensitivity	Magnitude	Significance
Superficial – Made ground, glacial till, peat	low	medium	Slight/Moderate
Superficial – Alluvium, Raised marine deposits, Alturie Gravels Formation, Raised tidal flat deposits	medium	medium	Moderate
Bedrock – Upper Old Red Sandstone	high	low	Moderate
Bedrock – Middle Old Red Sandstone	medium	low	Slight/Moderate
Bedrock - Auldearn Granite Pluton	low	low	Negligible/Slight

12.4.29 Potential impacts of accidental spillages on SWFs are discussed in Chapter 13 (Road Drainage and the Water Environment).

12.4.30 As part of the proposed Scheme, infiltration trenches and soakaways are proposed at various locations along the route, which could act as pathways for contamination to enter the water environment. However, the proposed Scheme design would provide two levels of treatment for all drainage, which is considered a satisfactory degree of attenuation before discharging to groundwater. No concerns regarding trench soakaways were raised during discussions with SEPA held on 2 June 2016. Based upon this position the potential impact is therefore expected to be of Negligible significance on groundwater from these structures.

12.4.31 The magnitude of impact of blasting on the overall quality of the bedrock aquifer is considered negligible, because dilution would significantly reduce the risk of contamination. The potential impact is therefore of Negligible significance for groundwater in igneous rock.

Abstractions

12.4.32 A PWS (medium sensitivity) at Wester Hardmuir Farm (GE125) is located to the north of the proposed Scheme, adjacent to Cutting 35. Cutting 35 (Table 12.12) is considered likely to intercept groundwater. However, the PWS is reported to be a 100m deep borehole and therefore no impact is expected on the yield of this supply. The water quality of the supply could, however, be at risk of impact from any pollution incident associated with the proposed Scheme in this vicinity. The potential magnitude of impact on the water quality is low (because of the depth of the supply), resulting in an overall impact significance of Slight/Moderate during the construction phase.

12.4.33 Impacts on abstraction GE411 are assessed as unlikely but cannot be ruled out. For this reason, potential magnitude of impact on GE411 (on yield and quality) is assessed as low, with an impact significance of Slight/Moderate.

12.4.34 None of the other identified active groundwater abstractions are located in proximity to a cutting considered likely to intercept groundwater and therefore no impact is expected on these receptors. None of the other identified abstractions are expected to be impacted by spillage incidents during construction or operation phases.

Ecological Receptors with Potential Groundwater Component

12.4.35 Blar nam Fiadh peat bog (medium sensitivity) is located in the vicinity of Cutting 21, which is likely to intercept groundwater. The portion to the north of the railway line is expected to experience a marginal and localised degree of direct impact from the construction of the proposed Scheme. This area could also be impacted by any pollution incident associated with construction activity. The magnitude of any potential impact is expected to be low, resulting in an overall impact significance of Slight/Moderate during the construction and operation phases.

12.4.36 No impact is expected on the marshy grassland near Mosside.

Groundwater Effects on Surface Water

12.4.37 Potential surface water quality impairment or reduction in baseflow contribution as a result of impact on the groundwater environment have been assessed based on the proximity of SWFs 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. Cuttings proposed with the purpose of burn realignment would not have a dewatering impact on the burns they are designed to redirect and are not considered below.

12.4.38 SWFs are referenced as per the SWF numbering system developed in Chapter 13 (Road Drainage and the Water Environment). The assessment of potential impacts on SWFs as a result of interaction with proposed road cuttings is summarised in Table 12.16.

Table 12.16: Assessment of Cutting Impacts on SWFs

Cutting	SWF	Sensitivity	Magnitude of Impact	Significance of Impact
CP01	SWF02	negligible	medium	Negligible/Slight
CP03	SWF03	medium	negligible	Negligible/Slight
CP05	SWF03	medium	medium	Moderate
CP05	SWF05	negligible	medium	Negligible/Slight
CP06	SWF03	medium	low	Slight/Moderate
CP06	SWF05	negligible	medium	Negligible/Slight
CP06	SWF06	negligible	medium	Negligible/Slight
CP07	SWF06	negligible	negligible	Negligible
CP08	SWF08	negligible	low	Negligible/Slight
CP14	SWF18	negligible	low	Negligible
C21	SWF19	negligible	high	Slight
C21	SWF21	negligible	medium	Negligible/Slight
C29	SWF24	negligible	high	Slight
CS6	SWF26	medium	negligible	Negligible/Slight
C29	SWF27	medium	medium	Moderate
C29	SWF29	low	high	Moderate
CS6	SWF31	low	high	Moderate
C34	SWF33	negligible	medium	Negligible/Slight
C35	SWF34	medium	low	Slight/Moderate
CP23	SWF35	negligible	negligible	Negligible

12.4.39 Loch Flemington is located 450m from the nearest cutting (Cutting 19) considered likely to intercept groundwater, and therefore no impact is expected upon the Loch as a result of the construction of the proposed Scheme.

Contaminated Land

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

12.4.41 There are two potential ways in which construction of the proposed Scheme could impact contaminated land:

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

Construction Phase – Direct Disturbance

12.4.42 Direct disturbance with a number of potentially contaminated land sources has the potential to impact on human receptors as summarised in Table 12.17.

Table 12.17: Potential Direct Contaminated Land Impacts during Construction

Source Ref	Source Name	Pollutant Pathway	Magnitude	Likelihood	Significance
GE06	Aberdeen to Inverness railway line	PP1 & PP3	mild	likely	Moderate/Low
GE07	Inverness to Lossiemouth fuel pipeline	PP1 & PP3	medium	likely	Moderate
GE10	Smithton Junction – made ground	PP1, PP2, PP3 & PP4	mild	likely	Moderate/Low
GE11	Millton mill dam	PP1, PP2, PP3 & PP4	mild	likely	Moderate/Low
GE22	Pit 2	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE34	Gravel pit 2	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE46	Former railway land – Gollanfield Station.	PP1 & PP3	mild	likely	Moderate/Low
GE47	Filling station	PP1 & PP3	medium	likely	Moderate
GE49	Smithy 2	PP1 & PP3	mild	likely	Moderate/Low
GE50	Poultry farm	PP1 & PP3	mild	likely	Moderate/Low
GE56	Gravel pit 7	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE57	Blackcastle Quarry	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE59	Depot	PP1 & PP3	medium	likely	Moderate
GE84	Sand pit 3	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE87	Sand pit 4	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE98	Old sand pit	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE99	Sheep dip 3	PP1 & PP3	mild	likely	Moderate/Low
GE100	Sand pit 5	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE101	Quarry (disused)	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE209	Nairn sewerage network combined sewer outfall	PP1 & PP3	mild	low	Low
GE211	Septic tank discharge to land point	PP1 & PP3	mild	likely	Moderate/Low
GE253	Septic tank discharge to land point	PP1 & PP3	mild	likely	Moderate/Low
GE260	Septic tank discharge to land point	PP1 & PP3	mild	likely	Moderate/Low
GE297	Septic tank	PP1 & PP3	mild	likely	Moderate/Low
GE322	Septic tank	PP1 & PP3	mild	likely	Moderate/Low
GE373	Sand pit	PP1, PP2, PP3 & PP4	medium	likely	Moderate

Source Ref	Source Name	Pollutant Pathway	Magnitude	Likelihood	Significance
GE377	Old gravel pit	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE417	GI encountered made ground	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE418	GI encountered made ground	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE421	GI encountered made ground	PP1, PP2, PP3 & PP4	medium	likely	Moderate
GE426	Septic tank	PP1 & PP3	mild	likely	Moderate/Low
n/a	Made ground removed and temporarily stored	PP1, PP3, PP5 to PP9	medium	likely	Moderate

Construction Phase – Indirect Disturbance

12.4.43 Indirect interactions may occur where cuttings intercept groundwater, as they could draw contaminated groundwater towards the cutting. Table 12.12 indicates that 37 cuttings have the potential to intercept groundwater. 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 12.18.

Table 12.18: Potential Indirect Contaminated Land Impacts during Construction

Cutting	Potential Contamination Sources	Pollutant Pathway	Magnitude	Likelihood	Significance
C9	GE07	PP10	medium	low	Moderate/Low
C19	GE50, GE238, GE399	PP10	mild	likely	Moderate/Low
C21	GE06, GE56, GE57, GE130, GE229, GE268, GE284, GE285, GE309, GE320, GE321, GE322, GE352, GE416	PP10	medium	likely	Moderate
C24	GE57	PP10	medium	likely	Moderate
C26	GE07, GE310	PP10	medium	low	Moderate/Low
C29	GE07, GE78, GE84, GE216, GE253, GE254, GE282, GE283, GE297, GE299, GE301, GE305	PP10	medium	likely	Moderate
C33	GE213, GE214	PP10	mild	likely	Moderate/Low
C34	GE98, GE99, GE295, GE100, GE101, GE206, GE343, GE344, GE345, GE373, GE423	PP10	medium	likely	Moderate
C35	GE98, GE99, GE100, GE101, GE206, GE292, GE294, GE344, GE345, GE373, GE377, GE423	PP10	medium	likely	Moderate
C39	GE57, GE268, GE320, GE416	PP10	medium	likely	Moderate
CS6	GE224	PP10	mild	likely	Moderate/Low
CS7	GE224	PP10	mild	likely	Moderate/Low
CV07	GE07, GE22	PP7	medium	likely	Moderate
CV09	GE204, GE393	PP7	mild	likely	Moderate/Low
CV20	GE209	PP7	mild	likely	Moderate/Low
CV22	GE06, GE39, GE40, GE41, GE328	PP7	medium	likely	Moderate
CP01	GE06, GE07	PP10	medium	low	Moderate/Low
CP02	GE06, GE07	PP10	medium	likely	Moderate
CP03	GE07	PP10	medium	likely	Moderate
CP05	GE07, GE417	PP10	medium	low	Moderate/Low
CP06	GE06, GE07, GE11	PP10	medium	likely	Moderate
CP07	GE07	PP10	medium	low	Moderate/Low

Cutting	Potential Contamination Sources	Pollutant Pathway	Magnitude	Likelihood	Significance
CP08	GE21, GE22	PP10	medium	likely	Moderate
CP12	GE06	PP10	mild	low	Low
CP17	GE229, GE284, GE309	PP10	mild	low	Low
CP22	GE87, GE209	PP10	mild	low	Low
CP24	GE216, GE253, GE254	PP10	mild	low	Low
CP25	GE209, GE300	PP10	mild	low	Low

12.4.44 Construction personnel could be at risk, through pathway PP1, of having direct contact with contaminated groundwater. The potential of this event occurring has been assessed as being likely with an impact magnitude of mild, resulting in a potential impact of Moderate/Low significance.

Operation Phase – Direct Disturbance

12.4.45 The same potentially contaminated land sources, as shown in Table 12.17, also have the potential for direct interaction during the operation phase as during the construction phase but with a reduced likelihood, except for made ground that may potentially be re-used on-site. These impacts are summarised in Table 12.19.

Table 12.19: Potential Direct Contaminated Land Impacts during Operation

Source Ref	Source Name	Pollutant Pathway	Magnitude	Likelihood	Significance
GE06	Aberdeen to Inverness railway line	PP12 & PP14	mild	low	Low
GE07	Inverness to Lossiemouth fuel pipeline	PP12 & PP14	medium	low	Moderate/Low
GE10	Smithton Junction – made ground	PP12, PP13, PP14 & PP15	mild	low	Low
GE11	Millton mill dam	PP12, PP13, PP14 & PP15	Mild	low	Low
GE22	Pit 2	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE34	Gravel pit 2	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE46	Former railway land – Gollanfield Station.	PP12 & PP14	Mild	low	Low
GE47	Filling station	PP12 & PP14	medium	low	Moderate/Low
GE49	Smithy 2	PP12 & PP14	Mild	low	Low
GE50	Poultry farm	PP12 & PP14	Mild	low	Low
GE56	Gravel pit 7	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE57	Blackcastle Quarry	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE59	Depot	PP12 & PP14	medium	low	Moderate/Low
GE84	Sand pit 3	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE87	Sand pit 4	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE98	Old sand pit	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE99	Sheep dip 3	PP12 & PP14	Mild	low	Low
GE100	Sand pit 5	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE101	Quarry (disused)	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE209	Nairn sewerage network combined sewer outfall	PP12 & PP14	Mild	low	Low

Source Ref	Source Name	Pollutant Pathway	Magnitude	Likelihood	Significance
GE211	Septic tank discharge to land point	PP12 & PP14	Mild	low	Low
GE253	Septic tank discharge to land point	PP12 & PP14	Mild	low	Low
GE260	Septic tank discharge to land point	PP12 & PP14	Mild	low	Low
GE297	Septic tank	PP12 & PP14	Mild	low	Low
GE322	Septic tank	PP12 & PP14	Mild	low	Low
GE373	Sand pit	PP12, PP13, PP14 & PP15	medium	low	Moderate
GE377	Old gravel pit	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE417	GI encountered made ground	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE418	GI encountered made ground	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE421	GI encountered made ground	PP12, PP13, PP14 & PP15	medium	low	Moderate/Low
GE426	Septic tank	PP12 & PP14	Mild	low	Low
n/a	Made ground removed and temporarily stored	PP12, PP14, PP16 to PP20	medium	likely	Moderate

Operation Phase – Indirect Disturbance

12.4.46 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 12.20 covers potential operational impacts on the receiving water environment.

Table 12.20: Potential Indirect Contaminated Land Impacts during Operation

Cutting	Sources	Pollutant Pathway	Magnitude	Likelihood	Significance
C9	GE07	PP21	medium	unlikely	Moderate/Low
C19	GE50, GE238, GE399	PP21	mild	low	Low
C21	GE06, GE56, GE57, GE130, GE229, GE268, GE284, GE285, GE309, GE320, GE321, GE322, GE352, GE416	PP21	medium	low	Moderate/Low
C24	GE57	PP21	medium	low	Moderate/Low
C26	GE07, GE310	PP21	medium	unlikely	Low
C29	GE07, GE78, GE84, GE216, GE253, GE254, GE282, GE283, GE297, GE299, GE301, GE305	PP21	medium	low	Moderate/Low
C33	GE213, GE214	PP21	mild	low	Low
C34	GE98, GE99, GE295, GE100, GE101, GE206, GE343, GE344, GE345, GE373, GE423	PP21	medium	low	Moderate/Low
C35	GE98, GE99, GE100, GE101, GE206, GE292, GE294, GE344, GE345, GE373, GE377, GE423,	PP21	medium	low	Moderate/Low
C39	GE57, GE268, GE320, GE416	PP21	medium	low	Moderate/Low

Cutting	Sources	Pollutant Pathway	Magnitude	Likelihood	Significance
CS6	GE224	PP21	mild	low	Low
CS7	GE224	PP21	mild	low	Low
CV07	GE07, GE22	PP18	medium	low	Moderate/Low
CV09	GE204, GE393	PP18	mild	low	Low
CV20	GE209	PP18	mild	low	Low
CV22	GE06, GE39, GE40, GE41, GE328	PP18	medium	low	Moderate/Low
CP01	GE06, GE07	PP21	medium	unlikely	Low
CP02	GE06, GE07	PP21	medium	low	Moderate/Low
CP03	GE07	PP21	medium	low	Moderate/Low
CP05	GE07, GE417	PP21	medium	unlikely	Low
CP06	GE06, GE07, GE11	PP21	medium	low	Moderate/Low
CP07	GE07	PP21	medium	unlikely	Low
CP08	GE21, GE22	PP21	medium	low	Moderate/Low
CP12	GE06	PP21	mild	unlikely	Very Low
CP17	GE229, GE284, GE309	PP21	mild	unlikely	Very Low
CP22	GE87, GE209	PP21	mild	unlikely	Very Low
CP24	GE216, GE253, GE254	PP21	mild	unlikely	Very Low
CP25	GE209, GE300	PP21	mild	unlikely	Very Low

12.4.47 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 medium, resulting in potential impact of Moderate/Low significance.

Cumulative Impacts

12.4.48 An expansion of the Blackcastle Quarry is proposed and the proposed Scheme footprint is adjacent to this future area of mineral extraction. The proposed Scheme would not limit the area of mineral exploitation proposed. The only nearby proposed cutting is Cutting 24, which is expected to intercept groundwater, with the zone of dewatering overlapping with the western edge of this area of quarry expansion. The potential dewatering effect of this cutting would be advantageous to the operation of the expanded quarry, as it is likely to reduce the volumes required to be pumped out by the quarry operator during routine operation. Therefore, no negative cumulative impact is expected on mineral resources and cumulative impact on groundwater resources is Negligible.

12.4.49 Current and future expanded operations at Blackcastle Quarry have the potential to impact the Blar nam Fiadh peat bog area through pollution from a spillage incident or potential reduction in groundwater flow should dewatering be associated with a future expansion. It is likely that only the small area of the feature to the north of the Aberdeen to Inverness Railway Line would be cumulatively impacted. Consequently, overall impacts are likely to be small and any potential cumulative impacts would also be concentrated on this part of the feature.

12.5 Mitigation

12.5.1 Mitigation measures for the proposed Scheme in relation to geology, hydrogeology and contaminated land are detailed below and take into account best practice, legislation, guidance and professional experience. The mitigation commitments identified in the SEAs for the STPR (Jacobs, Faber Maunsell, Grant Thompson and Tribal Consulting 2008) and A96 Dualling programme (Ch2M 2015 and 2016) have also been taken into consideration.

Geology

12.5.2 Geological impacts are Negligible for all deposits with the exception of peat and therefore mitigation measures are only considered for peat and not the remaining geological deposits.

12.5.3 The appointed contractor shall develop a Peat Management Plan which explores the possibility of using engineering methods such as piling or in-situ stabilisation which would seek to reduce the volumes of peat to excavate, in particular in study areas C and D (as per Table 12.13). The Peat Management Plan shall also explore ways of maximising peat re-use, for example via potential enhancement strategies in surrounding peaty areas or re-use for landscaping purposes as part of the detailed design. This Peat Management Plan shall include the identification of temporary storage areas and be developed in consultation with SEPA and other authorities as relevant prior to construction and may need to be supported by additional GI data gathering including additional peat probing as part of detailed GI scheduled in 2017. Groundwater monitoring shall be undertaken to assess construction risk in terms of dewatering and impact on slope stability (**Mitigation Item G1**).

12.5.4 Peat excavation, storage, and any off-site removal required shall be undertaken by the appointed contractor in accordance with '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 G2**).

Hydrogeology

Groundwater Flow

12.5.5 Thirteen proposed road cuttings, seventeen proposed SUDS cuttings and seven proposed culvert cuttings are expected to intercept groundwater. The potential volume of groundwater drainage would be considered in the context of potential groundwater abstraction CAR licences prior to works commencing (**Mitigation Item G3**). This would be done using all available GI data, including detailed GI, scheduled in 2017.

12.5.6 A detailed differential settlement assessment shall be undertaken prior to construction in cutting areas identified in Table 12.14, resulting in a potential Slight/Moderate significance of impact. This assessment shall be supported by additional GI data obtained as part of the detailed GI scheduled in 2017. In the eventuality of some properties being identified at potential risk, appropriate measures including condition surveys and monitoring of buildings and groundwater level changes may be required (**Mitigation Item G4**).

Groundwater Quality

12.5.7 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 appropriate road drainage and runoff treatment. These measures would also mitigate against water pollution risk to groundwater by reducing the potential for pollutant release and reducing the likelihood of any contaminated runoff produced by the works entering groundwater, either directly or via the unsaturated zone. These mitigation measures would also protect groundwater receptors against impacts on water quality during construction.

12.5.8 The appointed contractor shall review areas of groundwater likely to be intercepted by cuttings during construction and implement treatment as required prior to discharge. (**Mitigation Item G5**). There was evidence of elevated toxic metals, phenols, polycyclic aromatic hydrocarbons and total petroleum hydrocarbons in some sampled boreholes. This data would be taken into account by the appointed contractor in the preparation of potential discharge licensing consents in consultation with SEPA.

12.5.9 Infiltration trenches are designed to provide two levels of attenuation to potential contaminated inflows and based on initial consultations with SEPA, no further mitigation measures are required prior to discharge to groundwater.

Abstractions

12.5.10 The PWS GE125 shall be monitored for quality prior and during the construction phase by the appointed contractor (**Mitigation Item G6)**. The quality monitoring prior construction will be required to establish a water quality baseline of this supply.

12.5.11 A groundwater monitoring network shall be established around the Blackcastle Quarry and surrounding road cuttings to verify changes in groundwater levels and ensure that the abstraction GE411 is protected prior and during construction by the appointed contractor (**Mitigation Item G7**).

12.5.12 If PWS are shown to be impacted, alternative or replacement supplies shall be put in place by the appointed contractor (**Mitigation Item G8**).

Groundwater Effects on Surface Water

12.5.13 The appointed contractor shall undertake a detailed assessment of cuttings identified in Table 12.16, using all available GI data, including the awaited full 2016 data set (**Mitigation Item G9**). Additional mitigation measures may need to be put in place prior to construction, such as re-directing abstracted groundwater to the surface water receptor itself or to the relevant catchment if impacts are confirmed.

Contaminated Land

12.5.14 Mitigation measures in relation to contaminated land that shall be implemented by the appointed contractor are summarised in Table 12.21 (**Mitigation Items G10 to G27**).

Table 12.21: Contaminated Land Mitigation

Potential Pathway Receptor	Mitigation Item	Mitigation Measures Required
Construction		
PP1, PP3	G10	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. The appointed contractor shall re-allocate / rebuilt septic tanks directly impacted by the works.
	G11	The risks to construction workers will be mitigated by the adoption and use of appropriate PPE.
	G12	A 'watching brief' shall be implemented during excavation in order to take account of the fact that there may be isolated pockets of previously unidentified contamination..
	Refer to GR1	Control of dust generation will be required through damping-down with clean water during dry and/or windy periods.
	G13	Air quality monitoring, including occupational exposure and ambient air quality monitoring is to be undertaken.
PP2, PP4	G14	Assessment of gassing issues in accordance with CIRIA 665 following receipt of additional ground gas monitoring results at selected boreholes.
	G15	A ground gas monitoring programme, to be produced prior to construction and adhered to during construction.
	G16	Appropriate working methods to be developed and adopted by the appointed contractor during below ground site construction works (including piling works and excavations). This shall 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
PP5	G17	Minimise storage on site (spatially and in duration) and ensure all storage areas are properly lined, and an adequate drainage management in place. This shall ensure that no polluted water percolates into the ground or generate contaminated run-off.
PP6 to PP10	G18	Additional groundwater quality investigations should be undertaken in areas of cuttings intercepting the water table. This should be the basis for a ground improvement risk assessment to be carried out, including assessment of risks from migration of groundwater. Where required, water treatment should be put in place prior to discharge.

Potential Pathway Receptor	Mitigation Item	Mitigation Measures Required
Operational		
PP12	G19	The risks to maintenance workers will be mitigated by the adoption and use of appropriate PPE
PP13, PP15	G20	Ground gas monitoring of confined spaces e.g. service pits, should be undertaken prior to entry.
	G21	If significant ground gas issues identified, further post construction monitoring will be undertaken and/or appropriate gas protection measures will be incorporated into the final design.
PP14	G22	Where risks to end users have been identified, the appointed contractor's detailed design will incorporate measures to prevent wind blown dust e.g. the use of hard standing areas to cap contaminated soils.
	G23	Use of clean cover and vegetation on embankment areas constructed using excavation arisings.
PP16 to PP21	G24	Prior to disposal, soils will be assessed in line with the WM2 document (Environment Agency, 2008) to determine whether they are hazardous or non-hazardous.
	G25	A soil reuse assessment will be undertaken in order to identify any potential risks posed to the Water Environment from potentially contaminated soils used in embankments and associated structures.
	G26	Reference to appropriate guidance in the selection of construction materials such as Building Research Establishment (BRE) SD1:2005 and British Standard (BS) BS8500 where concrete materials are proposed.

12.6 Residual Impacts

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

12.6.2 A residual impact of Slight/Moderate to Moderate significance is expected on groundwater flow. Residual impact on differential settlement is expected to be Slight after implementation of proposed mitigation measures.

12.6.3 Residual impacts on PWS are expected to be Negligible to Slight.

12.6.4 Residual impacts of Slight/Moderate significance are expected on the northern part of the Blar nam Fiadh peat bog hydrogeology. However, the more healthy part of the Blar nam Fiadh peat bog located to the south of the railway would be unaffected by the proposed Scheme.

12.6.5 The implementation of mitigation measures in relation to the protection of the water environment against pollution incidents is expected to reduce the potential impacts on groundwater quality and associated receptors to a residual impact of Slight significance.

12.6.6 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.

12.6.7 Residual impacts on surface water receptors from indirect dewatering of proposed cuttings may vary from Negligible to Moderate.

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