

9. Geology and Soils

9.1 Introduction

9.1.1 The soils and underlying geology are important factors in determining many of the physical attributes of an area, such as the physical appearance of the environment, local flora, water quality and land use. Soils and the underlying bedrocks from which they derive can contain valuable resources, from fertile land for food production and agriculture to economically valuable mineral and water reserves.

9.1.2 Further, proposed infrastructure works can impact on geological or geomorphological features, which are considered valuable in their own right (e.g. for academic or research purposes). Protected designated sites, such as geological or geomorphological Areas of Special Scientific Interest (ASSI) or other sites of geological importance designated as Regionally Important Geological Sites (RIGS), would require measures to be taken to avoid or minimise adverse impacts from construction operations.

9.1.3 This chapter provides an initial assessment of ground contamination and soil quality along the line of the road with respect to the potential impact of the development on contaminants that may be present. The assessment has, where feasible, used the source-pathway-receptor linkage model for the construction phases of the development.

9.1.4 Land contamination can be defined as the presence of substances in, on or under the land that have the potential to cause harm, whether this is to the environment or human health.

9.2 Approach and Methods

9.2.1 The Design Manual for Roads and Bridges (DMRB) Volume 11 Section 3 Part 11, Geology and Soils does not prescribe an actual method for assessing the impact of the Scheme. Therefore the following criteria have been used to assess the impact of the Scheme on the geology and soils using the information that is available at the time of the preparation of this Environmental Statement.

9.2.2 The primary contaminated land guidance is contained within the Contaminated Land Exposure Assessment (CLEA) framework. Within this framework a number of Soil Guideline Values (SGVs) have been published for key contaminants along with toxicological guideline values relating to intake thresholds. The soil guideline values provided by the CLEA model represent intervention values. Soil concentrations of a contaminant above these values might represent an unacceptable risk to the health of the site users.

9.2.3 The CLEA Soil Guideline Values for an "industrial/commercial" end use are the most appropriate for this development and have been used as the basis for the contamination related section of this assessment.

Level of Impacts

9.2.4 The sensitivity of the receptor is scaled on the basis of the relative importance of the receptor as defined in Table 9.1.

Table 9.1: Scale of Importance of Geological Features

Importance	Criteria	Examples
Very High	Attribute with a high quality and rarity, regional or national scale	Geological Areas of Special Scientific Interest (ASSI) Regionally important Geological Site (RIGS); or aquifer within the zone of influence; or supplying ASSI.
High	Attribute with a high quality and rarity, local scale	Other exposed geological features of major or educational value; or mineral reserve allocated on Local Minerals Plan.
Medium	Attribute with medium quality and rarity, local scale.	Other areas of potential mineral resources
Low	Attribute with a low quality and rarity, local scale.	Other areas of superficial geology or geomorphological feature.
Negligible	Attribute with negligible quality and rarity, local scale.	

9.2.5 The presence and sensitivity of contamination receptors at risk from potential land contamination can be assessed by consideration of the following:

- Surrounding land uses, based on mapping and site visits and the occupants of the proposed adjacent sites;
- Proposed end-use, based on the nature of the proposed development;
- Type of construction operations that will be necessary as part of the Scheme;
- Surrounding sites of nature conservation importance; and
- Geology, hydrogeology and hydrology of the site and its surrounding area.

9.2.6 The sensitivity of potential receptors can be described qualitatively according to the categories shown in Table 9.2.

Table 9.2: Descriptive Scale for Sensitivity of Receptors

Qualitative Description (Receptor Sensitivity)	End Users (operational workers / visitors)	Surrounding Land Uses	Construction Workers	Ecological Sites	Built Environment
Low	"Hard" end use (e.g. roads, industrial, car parking)	Industrial area	Minimal disturbance of ground	No sites of significant ecological value close by	Not applicable
Moderate	Landscaping or open space	Open space or commercial area	Limited earthworks	Locally designated ecological sites	Buildings, including services and foundations
High	Residential, allotments, play areas	Residential area	Extensive earthworks, and demolition of buildings	Nationally or internationally designated ecological sites	As above but of high historic value or other sensitivity

- 9.2.7 If a hazard has been identified and potential sensitive receptors are present, then the potential impacts can be determined by considering the pathways whereby the hazard may impact upon the receptors. Table 9.3 indicates the most feasible potential impacts that may generally occur in relation to development sites for different classes of receptor.
- 9.2.8 The impacts are assessed for the existing use and the construction and operational stages of the proposed development.

Table 9.3: Potential Impacts of Land Contamination on Sensitive Receptors

End Users (maintenance workers / visitors)	Surrounding Land Uses	Construction Workers	Sensitive water resources	Ecological Sites	Built Environment
Direct or indirect ingestion of contaminated soil (operational)	Inhalation or deposition of wind-borne dust (construction stage)	Direct or indirect ingestion of contaminated soil (construction stage)	Existing and/or new pollutant pathways (construction stage)	Phytotoxic impacts on plant species (operational)	Chemical attack of buried concrete structures (operational)
Concentration of flammable or asphyxiating in-ground gases in enclosed spaces (drainage chambers) (operational)	Migration of contamination in sub-surface strata (including gases) (construction stage)	Concentration of flammable or asphyxiating gases in confined spaces (construction stage)	Generation of liquid and/or mobile contaminants (operational)	Toxic impacts on fauna (operational and/or construction stage)	
		Inhalation of asbestos during building demolition (construction stage)		Indirect impacts via contamination of water resources (operational and/or construction stage)	

- 9.2.9 The magnitude of impact is defined wherever possible by using the terms defined in Table 9.4.

Table 9.4: Magnitudes of Impact

Scale of Impact	Examples
Severe	Loss of exposed designated geological feature. Very high risk of exposure of a sensitive receptor to potentially harmful levels of contamination via a confirmed pathway.
Moderate	Quarrying of rock for imported fill, or substantial changes due to cuttings. Proven source – pathway – receptor pollutant linkage identified with elevated level of contamination recorded.
Slight	Superficial disturbance to geology; changes in geomorphology Identified source – pathway – receptor pollutant linkage identified but contamination likely to be low risk.
Negligible	Changes to made ground deposits. No source – pathway – receptor pollutant linkage identified.

- 9.2.10 The level of impact is calculated by combining the magnitude of impact and the importance of geological feature as shown in Table 9.5.

Table 9.5: Matrix for Determination of Level of Impact

Importance Magnitude	Very High	High	Medium	Low	Negligible
Severe	Substantial	Substantial	Substantial	Moderate	Slight
Moderate	Moderate	Moderate	Moderate	Slight	Negligible
Slight	Slight	Slight	Negligible/Slight	Negligible	Negligible
Negligible	Slight	Slight	Negligible	Negligible	Negligible

9.3 Consultations

- 9.3.1 For a complete summary of the organisations consulted, see Chapter 7 – Scoping.
- 9.3.2 Comments were received from The Environment & Heritage Service (EHS), Waste Management and Contaminated Land Division, suggesting that reference was made to Department of Environment, Food and Rural Affairs and the Environment Agency guidance on Land contamination. This has been used in the preparation of this chapter.
- 9.3.3 The Department of Enterprise Trade and Industry, Geological Survey of Northern Ireland expressed a desire to see information of hydrology. This has been addressed within this chapter.
- 9.3.4 The Department of Agriculture and Rural Development, Fisheries Division provided valuable information that there was no evidence of Potato Cyst Nematode or Potato Wart Disease in the study area.

9.4 Baseline Conditions

- 9.4.1 The baseline conditions have been established from desk studies, earlier consultations and published soil survey and geological maps. A preliminary ground investigation containing two boreholes and three trial pits was undertaken in January 2006. Further targeted ground investigation will be required to be undertaken in order to obtain further information on the ground conditions and groundwater regime.
- 9.4.2 Consultation with EHS confirms that there are no geological or geomorphological Areas of Special Scientific Interest (ASSI) or Regionally Important Geological Sites (RIGS) affected by the Scheme. The EHS also have no record of land uses within a 30 m zone of the proposed route, which may represent a potential source of contamination.
- 9.4.3 The Preliminary Sources Study (PSS) dated September 2005 compiles and summarises the desk study data that is available for this Scheme. The anticipated ground conditions along the Scheme are also summarised within the PSS and are discussed in the following paragraphs.

Drift Geology

- 9.4.4 The drift geology underlying the Scheme is illustrated in Figure 9.1 – Extract from Geological Map (Drift). The Scheme is generally underlain by glacial tills, with the Carrickfergus coastline being edged by Raised Marine Beach Deposits as shown on the extract of the 1:21120 Special Engineering Geological Map for Belfast.
- 9.4.5 The Glacial Till is mostly in the form of relatively featureless spread with the characteristics depending primarily on the underlying rock. Carry over from one outcrop to another in the area of the Belfast Lough is very limited, although it is possible some far travelled erratic pebbles can be found. The Till on the Triassic outcrop on which the Scheme is situated, is a tough plastic clay with a variable proportion of cobbles and boulders.
- 9.4.6 Along the coastline of Carrickfergus, the lowest raised beach is present and extends inland from the present day storm-beach to a cliff of Glacial Till. A previously exposed temporary section in beach deposits (during the construction of the sewage works located to the north of Jointure Bay) revealed a bed of large rounded basalt cobbles, with occasional chalk boulders on which rested about 1.5m of unbedded calcareous sand. Within the sand, particularly towards the sea, were several bands of cobbles generally consisting of a single layer of cobbles. The beach deposits, for the most part, rest directly on a wave cut platform of Triassic rocks but towards the back of the beach they may occasionally be seen to overlie Glacial Till.
- 9.4.7 Although not identified on the geological mapping, alluvium may be evident along the watercourses that run in a south easterly direction.

Solid Geology

- 9.4.8 The solid geology underlying the Scheme is illustrated on Figure 9.2 – Extract from Geological Map (Solid). The Scheme is located on the coastal plain carved from soft Triassic mudstones on the south east edge of the Antrim Plateau. The Triassic rocks of the Carrickfergus area are dividable into three lithostratigraphical units; the Sherwood Sandstone Group, formally known as the Bunter Sandstone; the Mercia Mudstone Group, formally known as the Keuper Marl; and the Penarth Group, the former Rhaetic. Although the Scheme passes over only the Sherwood Sandstone Group and the Mercia Mudstone Group.
- 9.4.9 The Sherwood Sandstone Group is the older of the two groups of Triassic rocks which underlie the Scheme. An isolated exposure of this rock can be found on the foreshore near Greenisland, on the north side of the Lough.
- 9.4.10 The Mercia Mudstone Group subcrops beneath the Scheme and is shown in Figure 9.2 – Extract from Geological Map (Solid). The Group consists largely of fine grained sediments, usually mudstones but with some siltstones and silty mudstones. Sandy bands are known to occur. The thickness of the Mercia Mudstone Group is unknown as existing boreholes have not completely penetrated this Group.
- 9.4.11 Along the Carrickfergus shoreline the Triassic bedrock, in particular the Mercia Mudstone, is subject to igneous intrusions, Basalt and Dolerite of Tertiary age. The outcrops are hard and durable, making them resistant to erosion.

Made Ground

- 9.4.12 The Carrickfergus shoreline has been subject to significant man-made modification over the last one hundred years. The principal man made features include the towns, several farms, highway infrastructure, and the network of public and private services.

- 9.4.13 Most of the coastal road system and the northern area of Belfast is on 'made ground.' Some minor sea level falls have accompanied this landfilling.

Geomorphology

- 9.4.14 The existing A2 Shore Road Greenisland is located on the Carrickfergus shoreline, a fringe of generally flat lying land bordered to the north by an elevated ridge of flat land that forms that Carrickfergus farmed escarpment. The land is low-lying rising from the shoreline to an elevation of around 50 to 60m above ordnance datum at the Belfast – Larne Railway line.

Hydrogeology

- 9.4.15 The 1:250,000 Hydrogeological Map of Northern Ireland indicates that the Scheme overlies two different types of aquifers with contrasting hydrogeological conditions.
- 9.4.16 The southern extent of the Scheme overlies the Sherwood Sandstone aquifer. This is a highly permeable aquifer where interangular flow is significant. It forms part of a highly productive area, in terms of water abstraction, that underlies much of Belfast.
- 9.4.17 The northern extent of the Scheme overlies the Mercia Mudstone aquifer. The rocks of the Mercia Mudstone group are impermeable and generally contain no significant groundwater resources except at shallow depth in the fissured and weathered interface with the overlying Glacial Till.
- 9.4.18 BGS state that the weathered margins of basalt or dolerite intrusions and associated intrusion breccias may be permeable and may act as conduits for storage and transmission of groundwater.
- 9.4.19 The previous ground investigation close to the route has not included the installation of groundwater monitoring instrumentation to determine the groundwater levels.

Soils

- 9.4.20 The area surrounding Greenisland is mainly agricultural land used for the grazing of sheep and cattle. The Agricultural Land Classification (ALC) system classifies land into five grades;
- Grade 1 – excellent;
 - Grade 2 – very good;
 - Grade 3: 3A – good 3B – moderate;
 - Grade 4 – poor;
 - Grade 5 – very poor.
- 9.4.21 The "best and most versatile (BMV) land" is classified as Grades 1, 2 and 3a – this is the land which is most flexible, productive and most likely to deliver future crops. A desktop assessment carried out by The Department of Agriculture and Rural Development (DARD), of the Northern Ireland soils map shows that the soil type for this area is surface water gley. This would fall into Grade 3B, which is of moderate quality, but which falls outside the BMV land.
- 9.4.22 The field boundaries are generally intact hedgerows, with no areas of forestry or shelterbelt woodlands. The field boundaries are judged to be an important component

of the farmed landscape and their disturbance should be minimised wherever possible or mitigation implemented as appropriate.

Mineral Resources

- 9.4.23 The British Geological Survey of Northern Ireland Georeport reported that “Salt mining in the Carrickfergus and Woodburn areas has ceased but has left a legacy of abandoned mine workings some of which are unstable. The principle areas of concern are however located to the north and east of Carrickfergus and do not affect the route corridor.”
- 9.4.24 The Geological Survey of Northern Ireland's Mines Database contains records of three shafts, the nearest of which is in excess of 1000m from the Scheme. BGS have stated that these shafts appear to have been exploratory shafts sunk in search for coal or salt. There is no indication of underground workings associated with these shafts.

Site History

- 9.4.25 A review of the historical ordnance survey maps indicate that there are areas of potentially contaminated land associated with past use of the footprint of the Scheme. These include contamination arisings (including asbestos) associated with the demolition of buildings, surgical waste associated with the former hospital, contamination associated with the operations and arisings from a former factory and agricultural contamination associated with historic and ongoing agricultural use of parts of the Scheme.
- 9.4.26 Detailed contamination investigation will be designed to assess whether there is any significant risk.

Landfill Sites

- 9.4.27 There are no known registered landfill sites close to the Scheme.

Site investigations

- 9.4.28 A small investigation (Soil Mechanics 2006) has been carried out along part of the proposed route. This investigation comprised the drilling of two boreholes and the excavation of three shallow trial pits.
- 9.4.29 Three samples were subjected to chemical analysis for a suite of determinants, including screening for asbestos. The concentrations recorded in all samples were below those that would be considered to represent a significant risk to human health or the wider environment. No asbestos was identified in any of the samples.
- 9.4.30 As this investigation did not assess ground conditions along the entire route, further ground investigation will be undertaken prior to construction of the road.

9.5 Predicted Impacts

- 9.5.1 The main construction works will be discussed in Chapter 5 – The Proposed Scheme. Construction of the Scheme will involve excavating minor cuttings and structures foundations in the superficial deposits and forming embankments of and on the superficial deposits. Excavation of rock is not likely to be required.
- 9.5.2 The impact on water quality is assessed separately in Chapter 10 – Water Quality and Drainage.

- 9.5.3 The determination of the level of impact relating to geology, soils and contamination during the construction phase is based on Table 9.5 and is summarised in Table 9.6.

Table 9.6: Significance of Impact during Construction

Feature	Potential Impact	Magnitude of Impact	Importance of Receptor	Significance of Impact
Designated Geological Sites	None	N/A	N/A	N/A
Underlying geology	Removal of superficial deposits or rock	Slight	Low	Negligible
Geomorphology	Changes to the landscape	Slight	Low	Negligible
Soils	Loss of Soils	Slight	Low	Negligible
Mineral Resources	None	N/A	N/A	N/A
Landfill Sites	None	N/A	N/A	N/A
Contaminated Land	Disturbance of contamination, changes to pollutant pathways.	Slight	Medium	slight [#]

[#] - this will be required to be confirmed by further assessment following contamination investigation

- 9.5.4 After the topsoil has been excavated under the offline section, it will be stored, in managed temporary stockpiles, and reused for covering verges, earthworks slopes and landscaping wherever possible.
- 9.5.5 Temporary excavations will be required during the construction stages to permit construction of the retaining walls along the online section of the Scheme. This will involve excavating the ground behind the walls to accommodate their construction. Following construction the excavations will be backfilled and reinstated as required.
- 9.5.6 The offline section of the Scheme will require minor cuttings in superficial deposits and the construction of embankments along this length of the mainline. Excavation of rock is not expected to be required in order to form the cuttings. Approach embankments will be required for the construction of the farm accommodation overbridge, which crosses over the mainline.
- 9.5.7 The PSS identified potential sites of contamination in a wide study area being considered for a number of route options. With the exception of localised areas of made ground associated with the existing infrastructure and potential areas of contamination associated with former land uses, no significant areas of contaminated land are anticipated along this Scheme route.
- 9.5.8 There is the potential for areas of made ground to be exposed and direct and indirect contact to occur with site construction staff. In addition, the exposure of contaminated ground could result in the generation of contaminated fugitive dusts, which could impact on surrounding properties, including residential areas.
- 9.5.9 The unmitigated impact of contaminated land is assessed as slight.
- 9.5.10 No designated geological sites will be affected by the Scheme.
- 9.5.11 No mineral resources will be affected by the Scheme.

9.5.12 No landfill sites will be affected by, or are in a location by which they could significantly affect, the Scheme.

9.5.13 Once the Scheme has been constructed there will be no operational environmental effects associated with the geology and soils along the route.

9.6 Mitigation

9.6.1 A targeted ground investigation and risk assessment will be carried out in those areas where the risks of contaminated made ground are considered highest. This will include areas where previous demolition works or previous or current uses have the potential to have created a contamination source. Should contaminated land be confirmed then appropriate remediation/mitigation measures will be agreed with the EHS and implemented.

9.6.2 The ground investigation will consider the potential presence of ground gases, notably carbon dioxide and methane and their impact on ground works and the entry of excavations.

9.6.3 Should any potentially contaminated ground be encountered during the construction stages of the Scheme, the Contractor will be required to investigate the area and then assess whether there is a need for containment or disposal of the material. The Contractor will also be required to assess whether additional Health and Safety measures require to be implemented. Any such investigations will be required to be undertaken in consultation with the appropriate consultees including EHS.

9.6.4 The Contractor will be required to produce a Construction Management Plan or equivalent which will provide details of environmental control measures, which must as a minimum include those measures outlined below.

9.6.5 During construction of the Scheme the Contractor will be required to minimise adverse effects on the geology and soils by implementing good operational practices. Effects on soil resources will be mitigated by employing high standards of soil handling and management during the construction and by avoiding the creation of bare areas of permanently exposed soil that would be vulnerable to erosion.

9.6.6 Sufficient topsoil and subsoil will require to be removed during construction to ensure that there is material for the verges and side slopes to be recovered.

9.6.7 The Contractor will be required to undertake pollution control measures to deal with any contaminated land encountered during the site operations. These measures will include as a minimum the following:

- Caution will be adopted when undertaking earth works during site clearance and construction in case local and isolated “hotspots” of contamination are identified within the made-ground. If necessary, in order to minimise the risks of contaminants being mobilised and contaminating other soils/water during the development of the site, workers will be briefed as to the possibility of the presence of such materials.
- In the event that contamination is identified during site works appropriate remediation measures will be taken to protect future site users, structures and services.

9.6.8 The Contractor will be required to site spoil and temporary stockpiles away from watercourses and drainage systems, and surface water will be directed away from

stockpiles to prevent erosion. Any runoff from stockpiles will be treated appropriately prior to discharge. Full details will be provided within the Construction Management Plan or equivalent.

9.6.9 It is anticipated that there will be no long-term changes in the groundwater regime due to the construction of the Scheme or any long-term adverse effects.

9.6.10 Following the mitigation measures for during the construction of the Scheme, no mitigation measures are necessary during the operational stage. Contaminated land sites may require ongoing measurement/monitoring.

9.7 Residual Impacts

9.7.1 Residual impacts of the Scheme are considered to be a negligible adverse effect on the geology and geomorphology

9.7.2 Residual impacts of the Scheme are assessed as slight with respect to contaminated land issues. Intrusive investigation will be undertaken to obtain evidence for further risk assessment.

9.8 Summary

9.8.1 This chapter has considered the impact of the Scheme on the geology and soils, along with contaminated land in the area. It has concluded that there are negligible adverse impacts on the geomorphology, agricultural soils, drift geology, solid geology and hydrogeology.

9.8.2 A number of potential contamination sources have been identified along the Scheme route. Mitigation measures are provided which, when implemented, will adequately manage the potential impacts associated with contaminated land and result in a slight impact.

9.9 References

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