14 Geology and Soils

14.1 Introduction

This section outlines the geological and geomorphological interests of the area and assesses the impact that the preferred scheme option may have on these interests. An assessment has also been made on the likely impact of the preferred option on soils, groundwater and areas of contaminated land.

It should be noted that this section does not discuss the value of the soil resources in terms of agriculture or other potential land uses as this has already been covered in Chapter 7 (Land Use).

Potential impacts upon geology and soils during the construction phase are considered separately within Chapter 15 (Disruption Due to Construction).

14.2 Methods

14.2.1 Baseline Methods

The geological information used within this report was obtained from the following British Geological Survey Maps, as well as the recent ground investigation works of March 2006.

- 1:50,000 Series Solid Edition (Sheet 33W). Published 1983.
- 1:50,000 Series Drift Edition (Sheet 33W). Published 1978.

Copies of these maps are presented in Figures 14.1 and 14.2.

The 1:10,560 Sheet NT 46W – Eastlothian to Midlothian 1979 was also referenced.

Historical maps were reviewed to provide general information regarding past and present activities within the study area, thereby assisting in the evaluation of the geological and geomorphological resource of the area. Historical mapping is presented within figures as follows:

- Figure 14.3 Epoch 1 Old County Series, 1843 to 1893.
- Figure 14.4 OS Map Old County Series, published 1908.
- Figure 14.5 OS Map National Grid circa 1950.
- Figure 14.6 OS Map National Grid, published 1971.

Note; although there are significant gaps (up to 46 years) between maps for this area, it is unlikely that any significant feature would appear and then disappear from view in this slowly changing agricultural landscape, and if it had, not leave some anecdotal

evidence. Therefore, it was assessed that the hazard associated with these extended gap periods in the historical map data are very small.

Midlothian Council's Environmental Health Officer was consulted with regard to the region's contaminated land register.

Soils information was obtained from The Macaulay Institute for Soil Research in Aberdeen and the Ordnance Survey Soil Survey of Scotland Map (1966 Scale 1:50,000), as well as the recent ground investigation works of March 2006.

Hydrological information was gathered from the 1:625,000 scale Water Vulnerability Map of Scotland and the 1:625,000 scale Hydrogeological Map of Scotland, as well as the recent ground investigation works of March 2006.

14.2.2 Impact Assessment Methods

This assessment has been carried out following the guidelines set out in Volume 11, Section 3, Part 11 of the DMRB (1993 and amendments).

As outlined in Chapter 4 (Approach and Methods) of this report, impacts were assessed in terms of both the site value and the magnitude of impact. The site value, or status, of each site was determined as detailed in Table 14.1 below.

Table 14.1. Definition of Site Value for Geology and Soils.

Value or Sensitivity	Criteria
High	Any nationally or internationally designated geological site and/or the presence of non-substitutable or highly sensitive geological and soil attributes.
Medium	Any regionally or locally designated sites and/or the presence of geological and soil attributes with limited potential for substitution or moderate sensitivity.
Low	Non-designated sites and/or the presence of geological and soil attributes easily substitutable or with low sensitivity.

The severity, or magnitude, of impact was assessed independently of the site value and assigned to one of the categories listed within Table 14.2 based on professional judgement.

Table 14.2. Impact Magnitude Criteria for Geology and Soils.

Criteria	Definition
Major	Partial (greater than 50%) or total loss of a geological or geomorphological site/resource, or where there would be complete severance of a site/resource such as to affect the value of the site/resource. 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 will impact upon local ecology.
Moderate	Loss of part (between approximately 15% to 50%) of a geological or geomorphological site/resource, major severance, major effects to the setting or disturbance such that the value of the site/resource would be affected, but not to a major degree. Changes to the local groundwater regime are predicted to impact slightly on resource use but not rule out any existing supplies. Minor impacts on local ecology may result.
Slight	Minimal effect on the geological site/resource (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/resource would not be affected. Changes to groundwater quality, levels or yields do not represent a risk to existing resource use or ecology.
Negligible	Very slight change from baseline condition. Change hardly discernible, approximating to a 'no change' condition.

The significance of predicted impacts was then determined through a combination of value and magnitude as illustrated in Table 14.3.

Table 14.3. Assessment of Significance Criteria for Geology and Soils.

Site Value	Magnitude of Impact			
	Major	**Moderate**	**Slight**	**Negligible**
High	Major	Major	Moderate	Slight
Medium	Major	Moderate	Slight	Negligible
Low	Moderate	Slight	Negligible	Negligible

14.3 Baseline Conditions

14.3.1 Geology - Solid Strata

Figure 14.1 shows the underlying bedrock of the area between Hope and Fala Tunnel at a scale of 1:5000 based on the British Geological Survey geological map for the Haddington area, Scotland Sheet 33W – Solid Edition.

The main feature of the solid geology of the area is the Lammermuir and the Dunbar-Gifford fault lines, south of Fala Dam. The Lammermuir Fault crosses the route at Fala and the Dunbar-Gifford Fault crosses at Crichton Dean. North of the Dunbar-Gifford Fault the rocks are folded into a shallow syncline with numerous minor gentle folds. To the north of the Lammermuir Fault the sedimentary strata gets progressively younger in the northerly direction. From Fala to Hope there is a series of sandstone, shale and limestone with a number of coal seams. From Hope to Pathhead there is a cyclic sequence of sandstones, siltstones, mudstones and limestones with several thin bands of coal.

A discrepancy to the above is the presence of a large glacial erratic on the north side of the Fala Tunnel. This contains a formally worked 1.2m coal seam, but is not anticipated to extend under the proposed route corridor.

Ground investigation works comprising 18 boreholes and 57 trial pits were carried out in 2006, with the boreholes reaching depths of between 8.0m and 12.5m, but rock head was not encountered. However a BGS borehole at NT45SW7, in a possible buried glacial channel, recorded rock head at 64 metres.

14.3.2 Geology - Drift Strata

Figure 14.2 shows superficial deposits for the area between Hope and Fala Tunnel at a scale of 1:5000. This figure is based on the British Geological Survey geological map for the Haddington area, Scotland Sheet 33W – Drift Edition.

The area was covered by the Southern Uplands ice sheet during the last glaciation of Southern Scotland. Boulder clay was deposited from the ice sheet and in many places it can be divided into two layers. The lower of these deposits is known as lodgement till and is typically a firm tenacious stony clay, which has been deposited during the advance of the ice sheet. The numerous rounded pebbles and boulders are mainly local in origin and the composition of the boulder clay varies markedly according to the nature of the underlying rocks. From Fala to Pathhead it is grey, purple and orange mottled silty clay with fragments of mainly sandstone, limestone and igneous rock.

When the ice sheet melted, the meltwaters deposited sand and gravel kame terraces and esker ridges all along the Lammermuir foothills. The material tends to be poorly sorted with abrupt lateral and vertical changes in grain size. There are significant meltwater deposits overlying the boulder clay in the valleys of the Tyne and Humbie Waters.

As mentioned earlier, ground investigation works comprising 18 boreholes and 57 trial pits were carried out in 2006, with the boreholes reaching depths of between 8.0m and 12.5m, however rock head was not encountered. The results of this ground investigation differed from the above in places, a summary of the findings is given below.

The general sequence of strata was found to consist of the following:

- Topsoil
- Alluvial Deposits (northern section only)
- Glacial Deposits (mix of meltwater deposits and boulder clays)
- Calciferous Sandstone Measures

Boulder clays were expected to be intermittently present over the first half of the scheme (Ch 0 to 1475), however only a mix of glacial meltwater deposits and alluvial deposits were found over this length of the route. This however is quite reasonable as

these granular materials are shown (BGS map) to be either on or very near to the scheme over this area.

An anticipated thin band (on plan) of boulder clay turned out to be much wider than expected, extending from Ch1525 to Ch1925 where it eventually starts to peter-out to be replaced by initially expected glacial meltwater deposits. This wide band of boulder clay also covers the whole area of the new proposed side road at Ch1622, where significant amounts of glacial meltwater deposits were anticipated for the northern half of this side road.

The above glacial meltwater deposits were expected (BGS map) to cover the remaining area (Ch1925 to tie in) uninterrupted, however the ground investigation found this last section of the route to be a mix of glacial meltwater deposits and boulder clay.

14.3.3 Made Ground

There is made ground in the verges associated with the construction of the existing A68 from Magazine Wood along the proposed scheme up to Ch1550 (around 160m west of the B6458 junction), which incorporates the 2.7m high 450m long Crichton Dean retaining wall, which reduces the impact of the existing A68 on the adjacent high yielding farmland. Another length of verge made ground exists between Ch1925 and Ch2225. The ground investigation found the made ground to be generally of poor quality and compaction, although some (up to Ch1475) could be re-used as acceptable fill.

14.3.4 Soil

Brown calcareous soils, brown forest soils and alluvial soils are understood to underlie the A68 through the study area. From the commencement of the scheme to the U60 Longfaugh junction the soils are of Winton Association and the parent material can be identified as Till, which is derived from Carboniferous sediments. Through the Salters Burn valley there are mainly Alluvium deposits. Outwith this valley between Longfaugh and the Tynehead junction the soils are of Darvel Association and the parent material can be identified as Fluvioglacial sands and gravels, which is mainly derived from Lower Carb igneous and sedimentary rocks. Finally, from Tynehead to the Fala Tunnel the soils are of Tynehead Association and the parent material can be identified as Drifts, which is derived from Lower Calciferous Sandstone sediments and Ordovician sediments. These soils range from freely drained to imperfectly drained. The value of these soils in terms of land capability for agriculture is discussed in Chapter 7 (Land Use).

14.3.5 Hydrogeology

The following hydrogeological information has been obtained from SEPA which is based on the BGS 1:625,000 Hydrogeological Map of Scotland, and from the recent ground investigation works carried out in 2006 for this scheme.

The 1:625,000 scale Groundwater Vulnerability Map of Scotland shows the geological class (bedrock) are highly permeable formations usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. The superficial drift deposits overlying these are shown to be of low permeability in the southern half of the site. The majority of surface soils on the site are classified as 'soils of high leaching potential' and as such have little ability to attenuate diffuse contaminants and in which non-absorbed diffuse contaminants and liquid discharge will leach rapidly. Hence, much of the groundwater deposits are potentially vulnerable from any surface contamination, particularly in the northern section of the site.

Both Amey Highways, in their role as the previous Management Agent for the Scottish Executive / Transport Scotland (up to April 2007), and Midlothian Council were contacted with regard to previous ground investigations, but both organisations were unable to provide any information. Previously, the British Geological Survey (BGS) have provided a Geological Report containing borehole information for the area (a copy is included within Appendix 13).

As part of the 2006 ground investigation, standpipes were installed at the locations detailed in Table 14.4 below to monitor groundwater levels in order to assess groundwater conditions.

Table 14.4. Standpipe – Groundwater Level Monitoring.

Exp. Hole	Depth to Base of Standpipe (m)	Groundwater Measured Depths from Adjacent Ground Level (m)						
		23/03/06	31/03/06	20/04/06	19/05/06	02/06/06	03/07/06	10/07/06
BH01A	8.5	Dry	Dry	Dry	8.1	8.18	8.15	8.18
BH02	8.0	Dry	Dry	Dry	Dry	Dry	Dry	Dry
BH04	8.5	3.45	3.35	3.41	3.54	3.55	3.51	3.53
BH06	7.0	-	Dry	Dry	Dry	Dry	Dry	Dry
BH07	8.0	2.79	2.76	2.73	2.7	2.74	2.74	2.83
BH08	7.5	4.12	4.08	4.09	4.08	4.12	4.30	4.3
BH10	7.5	5.9	5.47	5.49	5.57	5.51	5.46	4.90
BH11	5.0	1.69	1.35	1.38	1.41	1.65	1.51	1.82
BH13	7.5	1.65	1.58	1.6	1.63	1.85	1.74	1.89
BH14	10.0	Dry	GL	0.1	0.3	-	GL	GL

Notes: Exp. Hole – Exploratory Hole; BH – Borehole; GL – Ground Level.

Table 14.4 shows that the Groundwater within the vicinity of the scheme is averaging 3.16m below ground level. This will have little effect on the slope stability for the proposed cut slopes within the scheme, however standpipes will be monitored throughout the detailed design stage.

It should be noted that the BH14 results are thought to be incorrect, it is more likely to be dry and that a blockage has resulted in the later high readings.

There is a water spring (actually believed to be an old culverted burn) within the scheme boundary, located 230 metres north of the B6458 Tynehead junction. The 'spring' originates on the southern side of the A68, adjacent to the northbound carriageway, and is culverted beneath the A68 to the north side of the carriageway. The spring then runs as a small drainage ditch between the A68 and Old Crichton Dean before joining the Salters Burn, 50 metres north of the U77. The spring will be affected slightly as the culvert beneath the A68 will require to be extended to accommodate the road widening. Similarly affected will be Crichton Dean culvert and an un-named burn at the B6458 Tynehead Junction, the latter in addition will also have to be piped under the proposed new side road linking the A68 to the U77.

It should be noted that although the Water Environment (Controlled Activities) (Scotland) Requlations 2005 are now in operation within Scotland, which includes a new abstraction licensing / regulation regime, at the time of consultation for this assessment SEPA may not have been fully aware of all existing abstractions in the vicinity of the site.

There is no specific information on groundwater quality available from SEPA for the area of interest.

14.3.6 Designated Sites

There are no designated Sites of Special Scientific Interest (SSSI) relating to geological or geomorphological features within the scheme area, nor are there any designated Regionally Important Geological Sites (RIGS).

14.3.7 Mineral and Other Resources

The proposed scheme is situated in Midlothian, a previously prominent coal mining area. Thin bands of coal are noted on the solid geological map for the area and as such it was decided that a Coal Mining Report should be commissioned. The report concluded that although reserves of coal exist, there are no records of past, present or proposed future coal workings in the area. However, the BGS report (Appendix 13) noted the existence of old/recent coal workings 200 metres north of Fala Tunnel. These appear to be located in a large glacial erratic which is evident on Figure 14.2.

The 1862 Ordnance survey map in Figure 14.3 shows three limestone works in the area, at Hope, Magazine and Marl Law. These were fed with raw material from several limestone quarries in the vicinity. Several kilns are also shown on the plans and these are still visible on site today. Associated with these old limestone works and quarries are shallow mine workings. The shallow mine workings take the form of stoop and room, i.e. a regimented layout of pillars to support the rooms or stalls, with the height of the workings being up to 3.9 metres and the span between pillars generally greater than 3 metres.

The BGS hold working plans of the Hope and Magazine mines and copies of these, at a reduced scale, can be found in Figure 14.8 & 14.9. It can be seen that both the Hope and the Magazine Mines are close to the route of the existing A68, to the north of the proposed scheme. However, these plans are not abandonment plans and therefore the full extent of the workings is unknown. In addition, the accuracy of the plans is such that their exact position is not known. The approximate location of the mines has been transposed onto a plan containing the survey of the existing road and is illustrated on Figure 14.10.

No areas of current mineral extraction have been identified within the present study area. The nearest area of extraction can be found at the coal workings in the large glacial erratic at the south end of the scheme.

14.3.8 Contaminated Land

Midlothian Council's Environmental Health Officer has confirmed that "at the present time, the Council's Contaminated Land Register does not contain any record relating to this site or to any adjoining or adjacent land". He goes on to state however, that "In relation to Part IIA of the Environmental Protection Act 1990, implementation of the contaminated land regime is currently at an early stage and Midlothian Council has yet to commence its survey of the area".

Midlothian Council's Environmental Health Officer advised that there are two potential sites of contamination within 50 metres of the A68 as shown on Figure 14.7. The two sites are both abandoned open cast limestone quarries, one contained within Magazine Wood, adjacent to the southern Hope lay-by and the second is situated within Marl Law Wood, to the north of Crichton Dean.

It is considered that both potential sites are significantly far enough away in distance from the proposed A68 scheme to not be affected by the online widening.

Additionally, no potential contaminants of concern were encountered during the 2006 ground investigation works.

14.3.9 Overall Value of Geological/Soil Resource

Overall, the value of the geological and soil resources of the site can be considered of low value/sensitivity, based on the definition provided in Table 14.1.

14.4 Predicted Impacts

Road schemes have the potential to impact upon the geology and soils of an area through direct and indirect impacts on sites of importance or scientific interest, loss or sterilisation of mineral deposits or soil resources, disturbance of contaminated land or surcharging of ground which may accelerate erosion and subsidence.

The proposed option will not impact on any sites of geological interest, mineral extraction locations or any known areas of contaminated land. No impact is predicted in relation to surcharging of ground.

The proposed option will require substantial earthwork embankments to be formed to allow a third lane to be created adjacent to the existing carriageway. Earthwork locations are indicated on Figures 9.3 to 9.6, with the approximate earthwork quantities given below:

	Cut (m^3)	Fill (m^3)
Preferred Option	16,694	41,613

It is anticipated that a proportion of the cut material will be suitable as fill. These quantities, based on the results of the ground investigation interpretative report (September 2006), have been estimated as follows:

Granular Material: 9,100m^3 potentially available.

Clays 4,700m^3 potentially available.

Unacceptable: 3,000m^3 potentially unusable.

It should be noted that the proportion of clay is greater than expected in the Stage 2 assessment. All site won cut materials are to a greater or lesser degree, weather susceptible, with increases in moisture content due to heavy rain or poor drainage measures resulting in less material remaining acceptable. This is more so with the clays than the granular soils, and the above quantities are based on good weather conditions. Therefore, the exact amount of excavated material that can be re-used as suitable fill will be maximised if the weather is dry and the material can be kept free of water during earthworking operations.

Topsoil over natural ground was encountered across the site in fields and landscaped areas with thicknesses varying between 300mm and 450mm. It is likely that the majority of this topsoil will be suitable for covering conventional slopes and verges as Class 5A material (acceptable topsoil). Verge topsoil was also reasonable at CH0+00 to CH4+75 and CH15+50 to CH19+25 on the A68 and in the side roads, where it averages 200mm, but it is generally thin and poor quality elsewhere.

Unfortunately, due to the topography, in particular the embankment widening which tends to predominate, it is not possible to achieve a perfect earthwork balance which would negate the requirement for imported material. So even with good site earthworks management and reasonable weather conditions (assuming earthworks are not undertaken during winter) the required import will equate to 27,800m^3 assuming that all the acceptable cut can be used. Similar protective measures should be applied to insitu carriageway formations in areas of clays.

Earthworks slopes of between 1:1.8 and 1:2.25 (vertical : horizontal) are proposed for the cuttings (averaging at 1:2), with embankment side slopes of 1:2.1 for clays (Class2) and 1:1.9 for granular materials (Class1).

It is not anticipated that any new areas of exposed solid strata will be created during the earthworks process due to the depth of rockhead derived from the geotechnical investigation (see section 14.3.1).

Due to the nature of the geological material in the study area, there are no particular landscape, engineering or cost benefits to be gained from the exposure of new strata as it will be weather susceptible. It is anticipated that any newly exposed areas of strata created during the earthworks process would therefore be appropriately landscaped.

The proposed earthworks are anticipated to result in a **moderate adverse magnitude** (Table 14.2) on the geological and soil conditions of the site (low value) through removal of existing soils and drift deposits and deposition of fill material from outwith the site area. In accordance with Table 14.3, the impact significance is assessed as **slight adverse**.

Impacts upon hydrogeology comprise a very slight reduction in ground permeability caused by the construction of embankments on alluvial material, the increasing in length of three culverts and the creation of two piped/drainage culverts for the new side road linking to the U77. Additionally on this side road, there will be the local lowering of the phreatic surface at Ch180 by 1.0m along the toe of the proposed cut. These impacts are anticipated to be **slight adverse** in impact magnitude and therefore of **negligible impact** in terms of the overall hydrogeology of the area.

14.5 Mitigation

No specific mitigation is applied as no significant impacts upon geology and soils have been identified. Nonetheless, handling / protection of material during the earthworks stages will be important, as identified above, in terms of material reuse. Therefore the best practice measures identified below will be applied to minimise impacts whether significant or not.

As outlined above, the impact of excavated material generated through cutting activities may be mitigated through maximising its re-use on site, with stripped topsoil re-used for landscaping purposes. It therefore follows that earthworking operations will not be carried out in wet adverse weather, and that the earthworking operations will be programmed outwith the wet winter period. On-site storage of soil will require to be appropriately protected from the weather to maximise its reuse and will not be stored for prolonged periods. It has also been identified within the ground investigation interpretative report where potential exists for some wet granular soils to be dried out slightly and hence made suitable for reuse. Any additional soil procurement will be from local sources where possible, for continuity of materials and to reduce the impact of transporting material over long distances. Additionally, it has also been identified

within the interpretative report where potential exists for site won granular materials to be used for specialist classes of fill for uses such as capping or structures, thus minimising impacts in geological terms on import sites out with the scheme.

Similar protective measures to the above will be applied to insitu carriageway formations in areas of clays that would be vulnerable to wet weather and over trafficking.

It was never going to be possible to achieve an earthwork balance for the proposed scheme, however in a bid to minimize its impact the design has sought to maximize site won suitable material where practically possible. As a result, the requirement for imported material should only have a **slight adverse impact** on the geology of the area.

14.6 Residual Impacts

The residual impact for the proposed option (moderate) is assessed to be of slight significance in relation to Table 14.3. Mitigation measures will not be able to fully compensate for the imbalances in cut and fill requirements, which will very slightly alter the physical geology of the site.