12 Effects on Geology and Soils

INTRODUCTION

12.1 This chapter of the Environmental Statement (ES) examines the effects that the construction of a new motorway junction may have on the geology and soils of the proposed development area and considers the control and mitigation measures or Segregation Works which will be implemented in relation to the section of the proposed M8 Junction 29A off slip road which is located within the boundary of the restored Southbar Landfill located to the south east of Bishopton in Renfrewshire, Scotland. The proposed Segregation Works will 'enable' the construction of the motorway junction.

12.2 The site is not designated as a Site of Special Scientific Interest and is not recognised as being of regional geological importance. Therefore the assessment has been made to determine impacts to general soil quality and current use.

Relevant Guidance

12.3 The Planning context is set out in Chapter 5 of this statement. The assessment of the potential impact on geology and soils has been undertaken in line with the following regulations, policies and guidance:

- The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 1999
- Scottish Environment Protection Agency, Position Statement on Planning and Soils
- CIRIA C650 (2005) – Environmental Good Practice on Site
- Planning Advice Note (PAN) 51 Planning (2006) - Environmental Protection and Regulation
- PPG6 – Working at Construction and Demolition Sites
- PPG7 – Refuelling Facilities

Background Information

12.4 A range of background information has been reviewed to inform the proposed design of the Segregation Works and this chapter of the ES including:

- Environmental Statement (as amended) for Planning Application 06/1065/PP for the Construction of a Motorway Junction at Land at the Intersection of the M8 Motorway and Greenock Road, Inchinnan, Erskine. September 2006.
ENVIRONMENTAL SITE SETTING

12.5 The site is indicated, by published maps, to be underlain by Late Devensian glaciomarine deposits comprising intertidal and subtidal clay and silt of the Linwood and Paisley Formation. These in turn overly glacial diamictons of the Wildemess Till Formation; boulders and stones in a hard to stiff sandy silt and clay matrix.

12.6 Bedrock across the site is indicated, by published maps, to consist of two formations of Carboniferous age. To the north-east is the Limestone Coal Formation of the Upper Carboniferous period, which generally comprises cyclic sequences of sandstones, siltstones, mudstones, coals, blackband and clayband ironstones and seatrocks. To the south-west is the Lower Limestone Formation of the Lower Carboniferous Period, which generally comprises mudstones with sandstones, siltstones, marine limestones, thin coals and clayband ironstones.

12.7 There are no recorded mine workings in the area and based on the published geological maps, mine workings are considered unlikely.

12.8 Through the site investigations, materials that could be encountered during the construction works or that could be affected by the development have been identified and classified and are described below.

12.9 Approximately one third of the overall site of the proposed junction is within the eastern extent of Southbar Landfill. The remainder of the proposed junction site comprises farmland and the former slip road from the M8 to the A8 carriageway. The landfill slopes up to the west of the junction site at approximately 1:3, while the area covered by the former slip road is generally flat with a slight slope to the northwest.

12.10 Made ground is known to be present in the part of the site associated with the former landfill, as well as at locations within the site close to the A8 and M8 carriageways.

12.11 Southbar Landfill is approximately centred at NGR NS 446 693. The location of the site is shown on Figure 12.1. The Landfill Site is owned and was previously operated by WH Malcolm (WHM) under Waste Management Licence WML/W/0000078. The landfill previously accepted a range of construction and demolition waste types and operated under licence from February 1981 receiving over 500,000 tonnes of waste deposited in several phases of operation until closure in 1999. It is also possible that additional wastes were deposited at the site; these wastes are most likely to have arisen from previous construction activities associated with the M8 Motorway. The landfill site is now closed and was capped, seeded and restored to agricultural use in 2003.

12.12 Prior to WHM ownership, the Site is understood to have been used as a council tip for mixed wastes with anecdotal information suggesting the tipping of mainly ash based materials. Information provided by SEPA suggests that the ash materials were excavated at the time of the extension to the M8 motorway and used in the construction of the road. Anecdotal information also suggests that boreholes constructed along the southern boundary of the landfill encountered ashy materials.

12.13 The proposed off slip road section is located to the west of the M8 motorway to the south of the A8 overpass and adjoins reed beds which are located within the landfill site, running parallel with the M8 boundary and comprising shallow flooded areas about 15 metres in width. The reed beds are used to treat surface water run-off from the restored landfill site.

12.14 The general topography over this section comprises the relatively flat ground associated with the reed beds and the slope of the adjacent landfill site to the west. The land occupied by the reed beds lies at a level of about 8-8.5mOD and extends about 50 metres west of the M8 carriageway. The slope of the
landfill rises to the west from the reed bed area at a relatively uniform gradient of about 1\(\text{vertical} : 6\text{horizontal}\) to 19mOD at the edge of the area surveyed. The existing road embankment supporting the A8 crossing rises from about 10mOD at the toe to 15mOD at the carriageway edge at a slope gradient of about 1:2.5. The height of this embankment gradually decreases in a westerly direction.

12.15 The new roundabout junction straddles the existing A8 carriageway and the agricultural land to the north which lies at a level in the order of 9-10mOD and comprises rough grass pasture.

### ROAD/LANDFILL INTERFACE

12.16 The location of the proposed off ramp is such that the majority of the road will be on the line of the existing tarmacadam road and so there will be negligible impact on surface soils. The soft verge between the existing M8 carriageway and the settlement ponds is likely to be impacted already by air borne pollutants from the M8 traffic.

12.17 The road alignment has been designed with the landfill waste extents in mind such that these are avoided. In the event that such wastes are uncovered during the course of the construction works, then there may be impacts on surrounding soils. However, suitable control and mitigation measures in the form of Segregation Works will be employed as part of road construction to minimise these potential impacts.

12.18 It is considered unlikely that landfill leachate will be intercepted during the road construction due to the alignment and levels of the road and due to the prior implementation of Segregation Works.

12.19 The other parts of the road i.e. the roundabout north (at the on ramp) and the on ramp including the roundabout will be constructed on agricultural land. This land is currently used for both grazing and arable agriculture. There will be a loss in the available land for such activities to allow for the construction and operation of the proposed road. Some of this loss will be permanent to allow for the actual footprint of the road and for other areas that will become inaccessible. However, in view of the actual area affected, (around 4Ha) it is not considered to be significant in the local and regional setting.

12.20 The on ramp will also be constructed on an embankment and so there will be an impact as a result of loading on underlying soils although it is considered that this impact will be beneficial.

12.21 The results of previous site investigations have identified some made ground associated with the existing road access to the landfill, as well as waste materials associated with the historic landfilling activities. Assessments have concluded that these materials are suitable for their proposed new use in terms of human health protection. In addition, the materials generally had low leaching potential other than some ammoniacal nitrogen, which was generally found to be higher in natural soils that in made ground materials.

12.22 During construction of the road junction, there will be a requirement for some excavations relating to matters such as drainage and foundations. Where soils are excavated and stored, there may be deterioration in their overall quality. However, it is considered that suitable mitigation measures can be employed to minimise such impacts.

### SITE INVESTIGATION REVIEW

12.23 Site investigations have been carried out in the road/landfill corridor to identify the nature of made ground, soils and geology in the area of the road/landfill corridor (Appendix 12.1 and 12.2). Prior to conducting the investigation, consultations were carried out with SEPA and Renfrewshire Council to obtain comments on the design of the proposed site works and highway construction project.
12.24 SEPA indicated that they would require determination of whether or not contaminants are entering or are likely to enter controlled waters and at what concentrations, whilst Renfrewshire Council required a site investigation to be carried out, with reporting which included details of:

- nature, extent and types of contamination at the road/landfill interface;
- proposed measures to treat/remove any contamination identified;
- proposed measures to deal with contamination during construction of the road junction; and
- condition of the site on completion of the construction works.

12.25 The SI results of relevance to the proposed segregation works are considered further below.

**Objectives of Site Investigations**

12.26 The objective of the SI was therefore to address those requirements relating to surface water and land contamination and in particular to gain sufficient information to:

- accurately delineate the waste associated with the former landfill in the vicinity of the proposed junction, in order to determine how much landfill waste, if any, would be encountered as part of the development;
- provide an initial characterisation of the waste if any is to be encountered as part of the development;
- provide information on the physical and chemical ground conditions beneath the site in order to provide information for the design of the proposed development;
- accurately determine whether or not contaminants are entering or are likely to enter controlled waters and at what concentrations; and
- provide information on contamination such that the potential impact can be assessed.

**Site Investigation 1**

12.27 The first SI comprised site works took place in two phases, firstly between 8th April and 10th May 2006 and secondly between 30th August and 14th September 2006 (Appendix 12.1). Based on the topography of the whole site and information supplied by WHM with regard to the nature and extent of landfill, site works included the formation of 10 cable percussion boreholes, 20 trial pits and 11 cone penetration tests. The locations of each of the exploratory holes were chosen to investigate the sources detailed in Table 12.1 which summarises the rationale for each of the exploratory locations which are considered relevant to the Segregation Works.

12.28 It was intended that combined gas and groundwater monitoring wells were to be installed in each borehole upon completion. BH4 was initially installed and as a result of the artesian water that was encountered during the drilling operations the installation was removed at the end of the site works and the borehole reinstated to prevent any continued leakage of groundwater to surface. BH1, BH2 and BH3 were also reinstated immediately after completion to prevent any possible leakage of groundwater to surface, and to ensure that a pathway for contaminants to affect groundwater was not created.
### Table 12.1: Selection of SI Locations

<table>
<thead>
<tr>
<th>SI Location</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH1 and BH2</td>
<td>To investigate the nature and extents of the made ground and landfill material and provide information on the underlying natural deposits. To investigate groundwater occurrence and quality.</td>
</tr>
<tr>
<td>BH3 and BH4</td>
<td>To investigate the nature and extents of the made ground and provide information on the underlying natural deposits. To investigate groundwater occurrence and quality.</td>
</tr>
<tr>
<td>TP1 - TP6</td>
<td>To investigate the nature and extents of the made ground and landfill material.</td>
</tr>
<tr>
<td>TP12 - TP14</td>
<td>To investigate the nature of the ground conditions within the area of the site between the M8 and the landfill.</td>
</tr>
<tr>
<td>TP20</td>
<td>To investigate the ground conditions beneath or adjacent to the former slip-road between the M8 and A8.</td>
</tr>
<tr>
<td>SW1 and SW2</td>
<td>To obtain water quality data up stream of the settlement ponds</td>
</tr>
<tr>
<td>SW3</td>
<td>To obtain water quality directly downstream of the settlement ponds</td>
</tr>
<tr>
<td>SW4</td>
<td>To obtain water data from the water course to the south of the landfill</td>
</tr>
<tr>
<td>SW5</td>
<td>To obtain water quality data from the water course directly prior to it feeding into the Lin Burn.</td>
</tr>
</tbody>
</table>

### Summary of Ground Conditions

12.29 Material encountered in the SI Locations in the first SI was classified into four categories; capping material above the landfill, landfill waste, other made ground and natural deposits.

**Capping Material**

12.30 The capping material which covers areas of the landfill varied in thickness and in places was not clearly distinguishable from the landfill waste itself. However, where identifiable, it was described as firm to stiff, brown gravelly silt/clay with the gravel being angular, medium and of mixed lithologies and occasional blaes. Where clearly identified, the capping material varied in thickness from 0.25m to 0.70m.

12.31 This material was encountered over the waste in TP1, TP2, and TP4, and over natural deposits in TP3, TP6 and TP14.

**Landfill Waste**

12.32 Landfill waste was encountered in BH1, BH2, TP1, TP2, TP4, and TP5 and varied in thickness from 1.75m to 3.20m. In general, the waste encountered was described as brown gravelly silt with whole bricks, concrete blocks, road cobbles, fragments of metal, plastic and wood.
12.33 Leachate from within the landfill was encountered in TP4, TP5 and BH1 and BH2. This was described as having a sheen of Light Non-Aqueous Phase Liquid (LNAPL) with a strong hydrocarbon odour and a ‘scum’ on the surface.

12.34 As a result of the site investigation a preliminary interpretation of the extent of the landfill waste was made. It is understood that waste does not extend as far down the landfill slope as the surface water drainage channels or reed beds along the eastern flank of the site and an approximate line of waste extent is marked by the 9m AOD contour line and this is identified on Figure 12.2.

Other Made Ground

12.35 Other made ground deposits were encountered in BH3, BH4 and TP20. These deposits generally consisted of tarmac, blaes, ash, coal and pottery within a matrix of brown sandy, gravelly silt/clay. These deposits were found from the surface to be between 0.85 and 1.80 m thick and are likely to be associated with the road construction.

Superficial Deposits

12.36 Superficial deposits were encountered in all exploratory holes, excavated to a maximum depth of 21.60m in BH2. Superficial deposits generally consisted of soft to firm brown-grey slightly laminated sandy gravelly clay (Linwood Formation) to a depth of between 4.25m and 6.75m. Below this, soft brown brown-grey slightly gravelly silt (Paisley Formation) was encountered to a depth of between 15.80m and 21.40m. In general the stiff material (Wilderness Till Formation) was encountered at -11m AOD to – 4m AOD in the eastern and southern areas of the site, however in the northern areas of the site it was encountered at much shallower depths, generally between 1m AOD and 5m AOD.

Bedrock

12.37 Bedrock was not proven in any of the exploratory holes, however in the part of the site occupied by the landfill, BH1 was terminated at an unidentified obstruction at 17.70m depth and BH2 was terminated at 22.40m after chiselling through 0.80m of broken hard sandstone. In the area of the site between the A8 and Craigmuir farm BH5 encountered an obstruction at 8.6m and TP17 encountered angular boulders from 2.5 m.

12.38 The general sequence of strata established by the first SI is summarised in Table 12.2.
Table 12.2: General Sequence of Strata at Southbar Landfill

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsoil</td>
<td>Topsoil with occasional fragments of glass, pottery and blaes.</td>
<td>0.05m – 0.60m</td>
</tr>
<tr>
<td>Raised Marine Deposits</td>
<td>Typically consisted of soft or very soft grey brown and dark grey sandy gravelly CLAY and SILT. The near surface deposits were firm or occasionally stiff in consistency and mottled grey brown and light brown in colouration.</td>
<td>3.40m – 27.90m</td>
</tr>
<tr>
<td>Glacial Deposits</td>
<td>Generally consisted of stiff or very stiff grey, dark grey and grey brown sandy gravelly CLAY with occasional cobbles and dense to very dense brown and grey brown SAND, gravelly SAND and SAND AND GRAVEL.</td>
<td>Thickness not proven. Encountered at depths ranging between 3.40m and 27.90m below ground level.</td>
</tr>
</tbody>
</table>

Risk from Landfill and Soil Gas

12.39 As part of the first SI, an assessment of the occurrence of landfill gas was carried out based upon monitoring results supplied by WHM for the period June – August 2005. Elevated levels of methane were recorded within monitoring points (gas vents) along a line of monitoring positions parallel to, but further uphill of the proposed road alignment within the landfill. In particular, levels of methane in GV04 and GV08 – GV11 were above the Lower Explosive Limit (LEL) for methane of 5% by volume. The two combined gas and leachate monitoring points LW2 and LW3, close to the alignment of the proposed road however did not record any methane.

12.40 Elevated levels of carbon dioxide were recorded in GV10 and GV11 in excess of the guidance value of 1.5% by volume. However no such levels were recorded in LW2 or LW3.

12.41 The monitoring data suggests that the landfill gas containing methane is collecting more towards the top of the landfill rather than existing throughout thus reducing the likelihood of significant quantities of gas being encountered in the area of interest with respect to the proposed road alignment. The soil gas across the rest of the site is considered to be providing no risk to the development or land users in general.

Risks to the Water Environment

12.42 To determine if any source of contamination on site poses a risk to the water environment in relation to the construction of the off slip road, soil leachability data, groundwater and surface water quality data were obtained and assessed using appropriate assessment criteria.

Soil Leachability Analysis

12.43 Of the determinants detected in the leachability tests, none of the metals or sulphate exceeded their assessment criteria. Samples were selected from all four distinct material types encountered, especially
from the landfill material itself. Based on the leachability analytical results, any metals or sulphate within these strata are considered unlikely to have an adverse effect on the water environment.

12.44 A total of eight samples taken from all material types detected leachable ammonia in excess of the assessment criteria (0.015 mg/l), ranging from 0.04 mg/l to 2.40 mg/l. It should be noted that the assessment criteria for ammonia is less than the minimum reporting limit of 0.04 mg/l therefore there may be more samples presenting elevated levels that are not reported. On this basis, ammonia is a contaminant of concern and may have an effect on the water environment.

**Groundwater**

12.45 Laboratory analysis was carried out on samples of water retrieved from each of the boreholes installed in the landfill site, prior to boreholes being backfilled and the ground being re-instated. A total of two water samples were retrieved from BH4, before and after installation of the temporary well.

12.46 Monitoring wells were not installed in BH1, BH2 and BH3; however bailed water samples were recovered from these boreholes from within the drilling rig casing. Whilst this method was not carried out in accordance with relevant British Standard guidance and the results of these samples may be compromised by contaminants associated with the drilling operations the samples were deemed to provide an indication of ‘deep’ groundwater quality in the area.

12.47 The concentrations of metals recorded in the groundwater are generally less than the reporting limit. Where detected, and on one occasion, BH3 recorded a level (0.013 mg/l) marginally exceeding the assessment criteria where UK DWS is 0.01 mg/l.

12.48 BH3 also revealed a concentration of chloride (255 mg/l), which marginally exceeds the assessment criteria (250 mg/l). While sulphide concentrations were not detected above the reporting limit, this limit is higher than the EQS for sulphide and is particularly stringent. Given the absence of any other guidance value this EQS has been used.

12.49 Of the six samples taken, all provided concentrations of ammoniacal nitrogen in the groundwater which exceeded the assessment criteria with 4.7 mg/l in BH2 being the highest value. Elevated levels of ammonia were recorded in the leachate samples, although the concentrations recorded were less than those recorded for the groundwater.

12.50 PAHs were detected in BH1, BH3 and BH4 with the highest concentration recorded being for naphthalene (8.18μg/l) in BH1. PAHs were also detected in the overlying soils, within the capping material, landfill waste, other made ground and superficial deposits. The highest concentration of naphthalene detected in the soils was at TP5, 4mg/kg, at a depth of 0.15m within the capping material.

12.51 The source of the PAHs recorded in the groundwater was not ascertained. Anecdotal information suggested ash based materials were tipped in the landfill and ash has been recorded in the ‘other made ground’ material type identified on site. In addition, it is thought that the M8 motorway was constructed on ash sub-base. These combined sources may have affected local groundwater quality.

**Surface Water**

12.52 Surface water samples were taken from five locations around the site. Samples SW1 and SW2 were taken upstream of the settlement lagoons, with SW3 taken down stream of the settlement lagoons but before the confluence. SW4 was taken on the southern drainage ditch of the landfill, while SW5 was close to where the surface drain on the Site flows into the Lin Burn. Figure 12.2 shows surface water sampling locations of which there were two rounds.
12.53 Laboratory analysis of these samples yielded two exceedences of the assessment criteria for mercury and zinc downstream of the lagoons and the southern drainage ditch of the landfill, respectively. Exceedences of the assessment criteria for ammoniacal nitrogen were detected in SW1, SW2 and SW4 in both samples. Similar concentrations were recorded up and downstream of the lagoons with no apparent pattern.

12.54 Other determinants were either less than the reporting limit or where detected significantly less than the assessment criteria.

12.55 From the surface water data presented above it shows that there is no significant difference between the upstream and downstream samples for the majority of determinants detected. For the metals lead, mercury, zinc and chromium, the site may be having a marginal effect on the surface water environment, as slightly increased concentrations of these metals were detected downstream.

12.56 For sulphate, pyrene, ammoniacal nitrogen, BOD and suspended solids, these determinants showed a decrease downstream compared with upstream concentrations. The decrease in suspended solids, BOD, sulphate and ammoniacal nitrogen is likely to be due to the treatment capability of the reed beds adjacent to the landfill.

Landfill Leachate

12.57 Slightly elevated concentrations of ammoniacal nitrogen were found to be present in surface water up to a maximum of 2.99mg/l. The actual landfill leachate concentration sampled and analysed by SEPA was less (0.91 mg/l). This indicates that elevated levels of ammoniacal nitrogen in groundwater samples may be representative of background levels.

Soil Quality

12.58 In order to determine the existing soil quality, in relation to contamination, samples of soil were analysed for a range of determinands.

12.59 In summary, no exceedences of the human health assessment criteria for a commercial/industrial end use were found in any of the soils analysed. In addition, it should be noted that the criteria used is considered to be conservative for the proposed future use of the site as a road.

12.60 A number of soils from the vicinity of the landfill were subjected to leachability tests. The only substance found to be leachable in excess of the assessment criteria was ammonia, which is thought to be naturally occurring in the superficial deposits.

Site Investigation 2

12.61 The second SI was carried out during the period 12th November 2012 to 4th December 2012 (Appendix 12.2) and comprised cone penetration tests, cable tool percussion boreholes, dynamic percussion boreholes and machine excavated trial pits together with in-situ and laboratory testing. The second SI was supplemented by a further three trial pits carried out on 8th July 2013. The aims of the second SI were to:

- establish the geological and groundwater conditions along the route of the slip roads;
- provide geotechnical parameters for the design of the proposed slip road earthworks; and
- provide advice on the design and construction of the road junction.
12.62 The study included ground exploratory works, laboratory analysis of soil samples and monitoring of borehole installations.

12.63 The key objective of the second SI was to gain a better understanding of the nature of the ground conditions below the site in relation to the proposed development and to provide the basis to understand the geotechnical risks associated with the development and allow the preliminary design of the off slip road and on slip road to be carried out. Whilst the second SI was more focused on the eastern aspects of the proposed junction site, further exploratory boreholes and trial pits were carried out in the area of Southbar Landfill and adjacent land.

**Trial Pits**

12.64 In order to investigate the shallow soil conditions at the site a series of eighteen trial pits (denoted TP103 to TP120) were excavated using a mechanical excavator to depths ranging between 2.50 metres below ground level (TP110) and 4.00 metres below ground level (TP103, TP104, TP105, TP106, TP107, TP108, TP111, TP112, TP113, TP114, TP115, TP116, TP117, TP118, TP119 and TP120). Representative disturbed samples were recovered at regular intervals for subsequent laboratory testing. The trail pits carried out on the adjacent land were TP109 and TP110.

**Cable Tool Percussion Boring**

12.65 In order to obtain information on the soil profile at greater depth nine 150mm/200mm boreholes (denoted BH101 to BH109) were sunk using cable tool percussion boring methods to depths of between 5.20 metres below ground level (BH109) and 22.80 metres below ground level (BH101). Undisturbed and disturbed soil samples were recovered at regular intervals for subsequent laboratory testing. In order to monitor groundwater levels, piezometers were placed within boreholes BH103, BH104 and BH106. The boreholes installed in the adjacent land were BH105 and BH106.

**Sequence of Strata**

**Topsoil**

12.66 Topsoil was recorded at all of the exploratory positions within the agricultural land to the north of the A8 carriageway but was absent to the south where boreholes and cone tests penetrated an existing surfaced access road running parallel with and to the south of the A8. The thickness of the topsoil was recorded as 0.40 metres (BH107, BH108, BH109, TP111, TP112 and TP113).

**Made Ground**

12.67 Made ground was recorded at several exploratory positions and ranged in thickness, where proven, between 1.80 metres (BH107) and 3.70 metres (BH106). TP109 and TP110 were both terminated in made ground deposits at of 3.50 metres and 2.50 metres respectively. The trial pits are positioned to the west of the proposed roundabout junction and are likely to have intersected fill materials at the edge of the adjacent landfill.

12.68 BH105 and BH106 were both carried out from an existing surfaced access road to the south of the A8. The boreholes encountered a surface cover of tarmac up to 0.40 metres in thickness underlain by a hardcore layer up to 0.20 metres in thickness. The underlying deposits comprised reddish brown gravelly sand with fragments of blaes, brick and ash and dark grey brown sandy clay/silt with pockets of ash and organic matter.

12.69 TP109 and TP110 encountered fill material consisting predominantly of dark grey sandy gravel with fragments of brick, wood, ash, slag, glass and metal together with occasional clay pockets.
Raised Marine Deposits

12.70 Soils considered representative of raised marine deposits were recorded at all of the exploratory positions with the exception of TP109 and TP110 which were terminated in made ground. The thickness of the raised marine deposits was confirmed only in the boreholes and cone tests and varied between 2.25 metres (BH109) and 11.20 metres (CPT103). The raised marine deposits typically consisted of firm, locally soft grey brown, occasionally laminated, slightly sandy clay and silt with bands of sand and silty sand. The near surface deposits were frequently laminated, firm in consistency and mottled grey brown and orange brown in colouration. The thickness of the raised marine deposits generally decreased in a north westerly direction to the proposed roundabout junction.

Glacial Deposits

12.71 Soils considered to represent glacial deposits were reported underlying the raised marine soils at each of the borehole and cone test locations at depths ranging between 2.65 metres below ground level (BH109) and 11.20 metres below ground level (CPT103). The base of the glacial deposits was not proven. These soils generally consisted of dense to very dense brown sand and gravel with occasional cobbles and stiff to very stiff sandy gravelly clay with occasional cobbles and boulders.

Groundwater

12.72 Groundwater strikes and seepages were recorded at the majority of the boreholes and trial pits. Groundwater was reported in the made ground and raised marine deposits at depths varying between 1.40 metres below ground level (TP112) and 2.00 metres below ground level (TP109). Groundwater was also encountered in the glacial deposits at depths varying between 5.50 metres below ground level (BH106) and 10.10 metres below ground level (BH107). The groundwater in the glacial deposits at BH105 and BH106 was found to be under artesian pressure with significant groundwater level rises noted during the standard 20 minute break period, subsequently rising to ground level at BH105.

Additional Trial Pits

12.73 Review of the SI results identified that a gap in information existed along the eastern flank of the Southbar Landfill adjacent to the main site access road and drainage channel. A total of 3 additional trial pits were excavated on 8th July 2013 to further investigate the extent of landfilled waste materials in this area of the site. These trial pits are identified as TP1 (N and S), TP2 (N and S) and TP3 (N and S) on Figure 12.2. Each trial pit was subdivided into a north (N) and south (S) section for the purpose of logging materials as a distinct difference between in situ (N) and made ground/landfill (S) materials was observed. The results of the additional trial indicated that landfilling may have almost extended up to the fence line and drainage channel in this area of the site.

Site Investigation - Summary and Conclusions

Ground Conditions

12.74 Made ground is known to be present in the part of the Site associated with the former landfill, as well as at locations within the Site close to the A8 and M8 carriageways. The Site is indicated to be underlain by Late Devensian Glaciomarine Deposits comprising intertidal and subtidal clay and silt.

12.75 It is considered unlikely that the landfill waste will be encountered during Segregation Works given the inferred waste extents. Also earthworks will predominantly involve the creation of embankments reducing excavation in the area. However, any landfill waste excavated during construction will be removed, characterised and transported to a suitable treatment or disposal facility.
12.76 The SI works have confirmed the following in respect of ground conditions in the vicinity of the proposed off slip road:

- The capping layer/depth is not uniformly consistent across the closed landfill site.
- The types of landfill wastes encountered within the former landfill site were generally as expected e.g. bricks, concrete, blocks with fragments of metal, plastic and wood. Leachate with hydrocarbon odour was also encountered at a number of the boreholes constructed at the site.
- Other made ground consisted of tarmac, blaes, ash, coal etc. and the wastes detected are generally consistent with the types of materials derived from the previous road construction activities.

Surface Water Conditions

12.77 The water quality up and down stream of the settlement ponds is comparable and the water leaving the ponds is not having a detrimental effect on receiving waters. Ammoniacal nitrogen has been recorded in soil leachability samples, the groundwater and the surface water, both upstream and downstream. This may be as a result of the landfill site, but given the concentrations recorded and the fact that higher leachable concentrations were observed in the natural soil it is possible that this is naturally occurring.

12.78 The SI identified that the landfill wastes are not considered to have been deposited in the area of ground sloping down to the existing settlement ponds nor are they deemed to be located in the riparian zone of the streams. The results of the analytical data of the water samples taken from the site appear to indicate that the leachate arising from the closed landfill site is having a negligible impact on the adjacent watercourses, with the concentrations of metals in the small streams adjacent to the former landfill site being deemed not to be significant, furthermore the vegetated settlement ponds do appear to assist in causing further reduction of the pollutant loading associated with the leachate arising from the former landfill site.

Groundwater Conditions

12.79 Concentrations of some metals in groundwater and surface waters sampled are generally less than the reporting limit with rare and marginal exceedences of the assessment criteria for lead, mercury and zinc.

12.80 PAHs and some SVOCs have been detected in the groundwater. The concentrations recorded marginally exceed the stringent assessment criteria and the landfill and local ash deposits are considered the likely sources. PAHs in surface waters were detected marginally above the reporting limit from one location SW5. From the data obtained, the landfill site appears to be having a negligible effect on the water environment.

Landfill and Soil Gas Conditions

12.81 Elevated levels of landfill gas were not detected during the site investigation works and the landfilled waste types encountered would not be expected to result in landfill gas generation.

SEGREGATION WORKS CONTROL AND MITIGATION MEASURES

Introduction

12.82 In facilitating the preferred design and location of the off slip road of the new motorway junction, it is recognised that the footprint of the new road layout may potentially encroach onto land which may have previously been used for deposit of wastes and therefore control and mitigation measures in the form of segregation will be required.
12.83 The primary purpose of any control and mitigation measures will be the physical separation of previously landfilled waste materials from the proposed off slip road. This is required to prevent potential contaminant migration into the area of the proposed off slip road which will ultimately be transferred into the ownership of Transport Scotland.

12.84 The options for achieving segregation of previously landfilled waste materials have been discussed with SEPA who, whilst having no objections to the principle of the proposed new junction, have raised particular concerns regarding the identification of contaminated soils and the management of any waste material arising during the proposed Segregation Works.

12.85 The planning stage ES identified that the following issues would require further consideration in design of the Segregation Works:

- leachate arising from the landfill may be impacting on the surface waters in the vicinity of the site (inclusive of groundwater);
- deposited landfill wastes could potentially be encountered during the construction of the new motorway junction; and
- the treatment lagoons, drainage ditches and watercourses in the vicinity of the site could also be affected by the works associated with the construction of the new motorway junction.

12.86 The Segregation Works are deemed to comprise the following areas of control and mitigation:

- physical separation of the landfilled wastes and associated by-products from the proposed off slip road;
- design and installation of a new access off the A8 and related area of hard standing to allow the landfill owner a new access and turning point;
- works to relocate (i) currently existing gas monitoring points, groundwater monitoring wells and inclinometers on the north slope of the landfill, and (ii) the existing drainage ditch, which drains the northern section of the landfill into the reed beds and to ensure that the relocated equipment and drainage continues to function properly;
- the reduction in number and size of the existing reed bed ponds at the foot of the eastern slope of the landfill so far as necessary to accommodate the off slip road and other works;
- any works required to stabilise the landfill in the context of motorway junction development (including specifically any pollution prevention works) through potential encroachment on the landfill; and
- any specific works required by SEPA to allow the release of the land occupied by the motorway junction from the Waste Management Licence boundary.

12.87 The detailed design of the Segregation Works will be developed whilst giving consideration to the following key areas in respect of the area of the road/landfill corridor:

- planning and licensing requirements;
- site investigation information;
- proposed location for engineered segregation works;
- relocation of environmental monitoring infrastructure; and
• surface water management.

Key Implications for Segregation Works

12.88 The site investigations previously established the extent of previously landfilled wastes and identified key implications arising from the SI which require to be considered in the Detailed Design of Segregation Works with regards to the construction of the proposed M8 Junction 29A:

• SI information has confirmed the likely extent of landfilled wastes which has been used to inform the design and location of the segregation works and this is shown on Figure 12.2;

• SI indicates that made ground and raised marine deposits would be encountered in any excavation work associated with the off slip road construction, however there are potential gaps in SI information which would not specifically exclude encountering landfilled wastes; and

• the capping of the landfill area is not uniformly consistent and therefore leachate generation in the landfilled wastes, whilst minimised, cannot be specifically excluded and therefore segregation works should consider management of leachate which may be encountered in any excavations.

Source, Pathway, Receptor Risk Assessment

12.89 Based on review of site investigation information and historical information it is noted that a potential source-pathway-receptor linkage would exist between the landfilled wastes and the off slip road and control and mitigation measures may be required to protect this receptor. A horizontal engineered barrier is proposed to be used as a barrier to prevent impact on the off slip road from contaminated groundwater and landfill gas.

12.90 A source, pathway, receptor risk assessment has been developed to consider potential impacts on human health, soils and geology, hydrology/hydrogeology and the proposed structures associated with the off slip road development which will be located within the road/landfill corridor. The source, pathway, receptor assessment also considers potential impact on the water environment specifically in respect of achieving control and mitigation measures in the road/landfill corridor.

12.91 Typical indicators of a potential risk to key receptors are detailed below:

Humans

• Close proximity of proposed development to humans/residences;
• Potential for exposure to landfilled wastes; and
• Potential for exposure to landfill gas and leachate.

Soils and Geology

• Close proximity to soils;
• Potential for run-off from land surface; and
• Potential for leachate generation and movement of leachate into soils.

Hydrology and Hydrogeology

• Close proximity to surface water and groundwater;
• Potential for run-off from land surface;
• Potential for leachate generation and movement of leachate into groundwater; and
• Leachate concentrations exceeding environmental quality standards.

Structures
• Proximity to proposed development of structures associated with road junction;
• Potential for landfill gas migration; and
• Potential for instability of wastes/made ground.

Road/Landfill Corridor Conceptual Site Model
12.92 The conceptual site model of the road/landfill corridor requires consideration of three key elements;
• Defining the Source of potential pollution i.e. Southbar Landfill;
• Describing the Pathway(s) for potential pollution; and
• Evaluation of the key Receptor(s)

12.93 Based on these aspects of the conceptual site model, an assessment of pollutant linkage(s) can be undertaken in the form of a quantitative risk assessment carried out on each of the complete pathways.

Source Term Characterisation

Waste Types and Input
12.94 Whilst the landfill was operational under Waste Management Licence WML/W/0000078, it accepted a range of construction and demolition waste types for disposal from February 1981 receiving over 500,000 tonnes of waste deposited in several phases of operation until closure in 1999. It is also possible that additional wastes were deposited at the site; these wastes are most likely to have arisen from previous construction activities associated with the M8 Motorway.

Phasing and Location of Landfill Cells
12.95 It is understood Southbar Landfill was operated in a series of seven phases with Phases 1, 3, 4 and 7 being located in the road/landfill corridor area along the eastern aspect of the landfill site.

Leachate Generation
12.96 The landfilled wastes are considered to have generated leachate through infiltration of rainwater. Leachate monitoring data indicates that leachate is present within the Southbar Landfill and it is has typical characteristics of leachate generated in a landfill which has primarily accepted non-hazardous waste materials. There is no active management of leachate at the Southbar Landfill, however generation of leachate has been minimised through application of a low permeability cap in some areas and restoration soils with well-established vegetation over the whole of the site.

Landfill Engineering

Basal and Side Slope Sub-grade
12.97 It is expected that the basal and side slope sub-grade for the landfill area will consist primarily of the Raised Marine Deposits which typically consist of soft or very soft grey brown and dark grey sandy gravelly clay and silt.
Basal and Side Slope Lining System

12.98 No engineered basal or side slope lining system was installed at the Southbar Landfill.

Waste Mass

12.99 The landfilled waste was placed in line with the pre-settlement restoration levels to a maximum elevation of 15m AOD.

Capping System

12.100 It is understood that engineered clay was placed on phases in parts of phases 5, 6 and 7 to minimise infiltration of rainwater. Restoration soil was placed to a depth of up to 1m over each phase of the landfill prior to being grass seeded.

Final Landform and Aftercare

12.101 The final landform for the landfill is shown on Figure 12.2. The profile of the restored landfill will continue to allow for predicted settlement of waste, whilst still maintaining drainage gradients towards the periphery. Localised areas of higher settlement may occur within the final restored surface and are identified during the annual survey and/or regular monitoring visits and will be remediated using inert fill materials where necessary. It is intended that minor areas of settlement will remain but they will continue to be monitored during the aftercare period.

12.102 The principles followed in the design of the restoration scheme will ensure that the finished surface of the completed landfill will be suitable for the chosen agricultural after-use. Restoration at Southbar Landfill has been undertaken in accordance with the requirements of SEPA and the Local Planning Authority.

Leachate Monitoring Infrastructure

12.103 The locations of all monitoring wells that are used for leachate quality and level determinations in the landfill are shown on Figure 12.3. Review of the leachate head data indicates leachate heads are typically less than 1m.

Landfill Gas Monitoring Infrastructure

12.104 The potential for landfill gas migration from the landfill will continue to be monitored and assessed against Control and Trigger levels. In order to monitor the effectiveness of the proposed segregation works in the road/landfill corridor, gas monitoring boreholes are/will be installed around the perimeter of the landfill, the proposed location of which are shown on Figure 12.3.

Surface Water Management

12.105 Surface water management at the Southbar Landfill is designed to:

- manage uncontaminated surface water runoff;
- control surface water runoff from the site at all stages of the site development and aftercare;
- provide sufficient capacity to safely control and discharge runoff without impairing the stability of the restoration slopes, constructed lining/capping systems or monitoring installations;
- reduce potential for an increase in flooding risk; and
- facilitate that the surface water discharged from the site is of an acceptable quality.
12.106 Surface water management is currently achieved via a cut off ditch which runs along the eastern boundary of the landfill area which connects in turn to a system of established reed beds which effect silt removal and polishing of the surface water prior to discharge to the Lin Burn, which enters the River Gryfe downstream of its confluence with the Dargavel Burn. It is noted that this discharge is not currently controlled by consent issued by SEPA.

12.107 The existing and proposed surface water management features are discussed in Chapter 11 of this ES an identified on Figure 12.3.

*Surface Water Monitoring Points*

12.108 Surface water monitoring is carried out in accordance with the requirements of the Waste Management Licence.

*Post Closure Controls*

12.109 The post closure controls for landfill are in accordance with those required by the Waste Management Licence.

*Pathway Evaluation*

12.110 The key pathways for potential release of contaminants from the landfill are detailed below.

*Human Exposure*

12.111 Humans may be exposed to the material in the road/landfill corridor via the following pathways;

*Direct ingestion of excavated soils and dust / Air blown particles*

12.112 The proposed enabling works and construction of the off slip road may involve excavation of made ground or landfilled wastes. The site is also located within a rural area with few residential receptors in close proximity to the site reducing the likelihood of exposure.

12.113 The proposed end use for the Southbar Landfill is one of grassland meadow with areas of woodland, shrubs and hedges. Based on this end use it is unlikely that exposure will be to members of public using the site for recreation. Based upon this end use it is considered that a pathway will be present but will be limited by the presence of topsoil and vegetation once this is established.

*Exposure to landfill gas and leachate (outdoors)*

12.114 Landfill gas and leachate are likely contained within the waste mass of the Southbar Landfill and exposure to these outdoors will only be possible during the enabling works for the proposed road junction. Prior to enabling works and the implementation of mitigation measures, a pathway exists for off-site migration of landfill gas and leachate towards the off slip road.

*Exposure to landfill gas (indoors)*

12.115 There are no proposed buildings within the area of the road/landfill corridor and it is considered that no pathway exists for migration of landfill gas into offsite buildings.

*Subsurface Migration to Groundwater and Rock*

12.116 Restoration soils are placed on top of an engineered cap, overlying the landfilled wastes. The engineered cap is designed to minimise infiltration into the underlying waste and prevents any significant leaching and
vertical migration of contaminants into the subsurface and reduces the likelihood of leachate impacting groundwater beneath the landfill.

**Surface Run Off into Surface Waters and Soils**

12.117 Restoration soils have been placed on top of a partially engineered cap on the landfill and surface water management in the form of drainage channels are present which feed into the site surface water management system.

12.118 The surface water management system involves collection and attenuation of all surface water within the reed bed system prior to discharge to a local watercourse.

12.119 It is anticipated that the above management systems and discharge point will remain in place during and after the segregation works and construction of the new road junction.

**Receptor Evaluation**

12.120 “Receptor” is the term used in risk assessments for people or environmental media who may be exposed to contamination at or near an evaluated site. The following receptors were identified for potential exposure to contaminants:

- site users and construction workers;
- geology and soils;
- groundwater and surface water; and
- structures associated with the off slip road.

**Geology and Soils**

12.121 The road/landfill corridor is known to be underlain by made ground comprising man-made materials on original ground surface.

12.122 Geological mapping indicates the site is underlain by Late Devensian glaciomarine deposits comprising intertidal and subtidal clay and silt of the Linwood and Paisley Formation. These in turn overlie glacial diamictons of the Wilderness Till Formation; boulders and stones in a hard to stiff sandy silt and clay matrix. An area of Peat is indicated to the east of Craigmuir Farm.

12.123 Bedrock across the Site is indicated to consist of two formations of Carboniferous age. To the northeast is the Limestone Coal Formation of the Upper Carboniferous period, which generally comprises cyclic sequences of sandstones, siltstones, mudstones, coals, blackband and clayband ironstones and seatrocks. To the southwest, Lower Limestone Formation of the Lower Carboniferous Period is generally shown to comprise mudstones with sandstones, siltstones, marine limestones, thin coals and clayband ironstones.

12.124 There are no economically important mineral resources in the immediate vicinity of the site.

**Hydrogeology and Hydrology**

12.125 Chapter 11 considers hydrogeological and hydrological characteristics of the proposed development in more detail and a summary is presented below.

12.126 The Bedrock Aquifer Productivity Map (BGS, 2004) indicates that the Carboniferous sedimentary rocks are indicated to be moderately productive (1 – 10 l/s) comprising both fracture and intergranular flow. The
Superficial Deposit Aquifer Productivity Map (BGS, 2004) indicates that the superficial deposits are moderately productive and flow is intergranular.

12.127 The Groundwater Vulnerability Map of Scotland (SNIFER, 2004) classifies the Site as ‘vulnerability category 2’, which is defined as ‘vulnerable to some pollutants, but only when continuously discharged/leached’. Extracts of the hydrogeological maps and groundwater vulnerability map were included in the Planning Application for the new road junction.

12.128 The coastal and river alluvial deposits beneath the site are classified as a concealed aquifer of limited or local potential. The underlying bedrock may be considered moderately permeable.

12.129 The nearest classified watercourse is Dargavel Burn which is a tributary of the River Gryfe and is located approximately 1 kilometre south west of the off slip road section. The Dargavel Burn is classified as A2 (good). Lin Burn is located immediately to the south of both the off slip road and on slip road sections and is also a tributary of the River Gryfe which joins the Black Cart Water which flows to the River Clyde.

12.130 Surrounding the landfill on the north, east and southern sides are drainage ditches. The northern and eastern ditches drain into the reed beds, which are situated, between the toe of the landfill area and M8 carriageway. The ponds discharge to a sampling chamber at the confluence with surface water from the southern ditch. These in turn discharge under the motorway to the Lin Burn.

Risk Assessment

Risk Assessment Methodology

12.131 The methodology for assessing the potential risks to receptors associated with construction of the off slip road within the boundary of the Southbar Landfill is based upon the source - pathway - receptor principle.

12.132 This approach establishes the potential pollutant linkages and exposure pathways that may be present on the site, through the development of a conceptual site model which is based on:

- the nature and composition of in situ material to be used and potential hazards this may pose;
- a review of the environmental setting of the site;
- likely mechanisms for contaminant fate and transport through the environment; and
- the proposed end use of the site.

12.133 As the pollutant linkages have been established a qualitative assessment of the risk can be made by assessing the probability of exposure so that an overall qualitative risk evaluation is made.

12.134 The criteria for assessing the probability of exposure are summarised in Table 12.3.

12.135 The criteria for assessing the consequence of exposure are summarised in Table 12.4.
Table 12.3: Definition of Probability of Occurrence

<table>
<thead>
<tr>
<th>Probability</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>No pollutant linkage present.</td>
</tr>
<tr>
<td>Low</td>
<td>Pollutant linkage is theoretically present but unlikely to occur.</td>
</tr>
<tr>
<td>Medium</td>
<td>Pollutant linkage plausible.</td>
</tr>
<tr>
<td>High</td>
<td>Pollutant linkage likely.</td>
</tr>
</tbody>
</table>

Table 12.4: Potential Consequence of Hazard

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Humans</th>
<th>Geology and Soils</th>
<th>Water Environment</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>Serious damage to health</td>
<td>Significant pollution of soils</td>
<td>Significant pollution of sensitive water resource</td>
<td>Substantial impact on structures associated with off slip road</td>
</tr>
<tr>
<td>Moderate</td>
<td>Non-permanent health effects</td>
<td>Moderate pollution to soils</td>
<td>Moderate pollution to non sensitive water resource / minor pollution to sensitive resource</td>
<td>Change to structures associated with off slip road</td>
</tr>
<tr>
<td>Mild</td>
<td>Slight short term health effects</td>
<td>Slight pollution to soils</td>
<td>Slight pollution to non sensitive water resource</td>
<td>Some measurable effects but no impact on function</td>
</tr>
<tr>
<td>Negligible</td>
<td>No measurable health effect</td>
<td>Insignificant pollution to soils</td>
<td>Insignificant pollution to non-sensitive resource</td>
<td>No measurable effects</td>
</tr>
</tbody>
</table>

12.136 The overall risk evaluation is based on the following classification summarised in Table 12.5.

Table 12.5: Risk Classification

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Negligible</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>Low</td>
<td>Low to Medium</td>
<td>Medium to High</td>
<td>Very High</td>
</tr>
<tr>
<td>Moderate</td>
<td>Negligible to Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium to High</td>
</tr>
</tbody>
</table>
12.137 The definition of each classification is summarised within Table 12.6.

**Table 12.6: Risk Classification and Definition**

<table>
<thead>
<tr>
<th>Risk Classification</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>No identifiable risk of harm.</td>
</tr>
<tr>
<td>Low</td>
<td>Possibility of harm or impact could arise, but the effects are likely to be mild.</td>
</tr>
<tr>
<td>Medium</td>
<td>Possibility of harm or impact could arise, but the effects are likely to be localised or non-permanent, possible action measures may be required.</td>
</tr>
<tr>
<td>High</td>
<td>Significant harm or impact likely, unless action taken.</td>
</tr>
<tr>
<td>Very High</td>
<td>Significant possibility of severe harm or major impact, remedial action required.</td>
</tr>
</tbody>
</table>

**Summary of Pollutant Linkages**

12.138 A risk based assessment of the pollutant linkages within the road/landfill corridor prior to Segregation Works has been undertaken and the results are provided within Table 12.7. Of the six pathways assessed, four have been classified as low risk with two classified as medium. The risk assessment identifies that the possibility of harm or impact could arise from the construction work in the road/landfill corridor in respect of leachate and contaminants in waste/made ground and whilst the effects are likely to be localised or non-permanent, mitigation and control measures require further consideration.
### Table 12.7: Summary of Qualitative Risk Assessment – Pre-Enabling Works

<table>
<thead>
<tr>
<th>Pollutant Linkage</th>
<th>Source</th>
<th>Pathway</th>
<th>Receptor</th>
<th>Probability</th>
<th>Consequence</th>
<th>Risk Classification</th>
<th>Current Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contaminants within landfill waste and made ground</td>
<td>Ingestion of airborne dust</td>
<td>Site Users / Construction Workers</td>
<td>Low</td>
<td>Mild</td>
<td>Low</td>
<td>Topsoil and vegetative cover reduces dust emission and exposure to wastes. PPE worn by site users/construction workers.</td>
</tr>
<tr>
<td>2</td>
<td>Contaminants within landfill waste and made ground</td>
<td>Direct ingestion / dermal contact with waste</td>
<td>Site Users / Construction Workers</td>
<td>Low</td>
<td>Mild</td>
<td>Low</td>
<td>Topsoil and vegetative cover reduces direct contact pathways. PPE worn by site users/construction workers.</td>
</tr>
<tr>
<td>3</td>
<td>Landfill gas with landfill waste</td>
<td>Inhalation of gases/Risk of explosion</td>
<td>Site Users / Construction Workers</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Waste types indicate low levels of landfill gas present. Topsoil and vegetative cover reduces direct contact pathways. Significant dilution within ambient air. PPE worn by site users/construction workers.</td>
</tr>
<tr>
<td>4</td>
<td>Contaminants within landfill leachate</td>
<td>Subsurface migration to groundwater</td>
<td>Soils and groundwater below and downstream of site</td>
<td>Medium</td>
<td>Moderate</td>
<td>Medium</td>
<td>Landfill constructed on low permeability geology classified as a concealed aquifer of limited or local potential.</td>
</tr>
<tr>
<td>5</td>
<td>Contaminants within soils/made ground</td>
<td>Surface run off (leaching of contaminants)</td>
<td>Receiving surface waters</td>
<td>Medium</td>
<td>Moderate</td>
<td>Medium</td>
<td>Surface runoff is contained within the surface water management system and discharged to a local watercourse.</td>
</tr>
<tr>
<td>6</td>
<td>Landfilled wastes/made</td>
<td>Stability</td>
<td>Structures associated with</td>
<td>Low</td>
<td>Mild</td>
<td>Low</td>
<td>Landfilled waste materials are monitored for settlement and annual surveys are</td>
</tr>
<tr>
<td>Pollutant Linkage</td>
<td>Source</td>
<td>Pathway</td>
<td>Receptor</td>
<td>Probability</td>
<td>Consequence</td>
<td>Risk Classification</td>
<td>Current Mitigation</td>
</tr>
<tr>
<td>------------------</td>
<td>--------</td>
<td>---------</td>
<td>----------</td>
<td>-------------</td>
<td>-------------</td>
<td>---------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td></td>
<td>ground</td>
<td>new road junction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>undertaken. Waste placement ceased in 1999 and majority of waste settlement has now occurred.</td>
</tr>
</tbody>
</table>
PROPOSED MITIGATION MEASURES

Introduction

12.139 The key element of mitigation and control measures which will take place in the road/landfill corridor in relation to the presence of waste materials is the proposed physical separation of the off slip road from the Southbar Landfill. This is required to prevent potential leachate and landfill gas migration from the landfilled wastes into the area of the off slip road which will ultimately be transferred into the ownership of Transport Scotland.

12.140 Consideration has been given to the installation of a horizontal engineered barrier to prevent migration of leachate and landfill gas from the landfill site to the area of the off slip road.

Design Objectives for Segregation Works

12.141 A Detailed Design of the engineered barrier system will be developed and will outline the functional criteria and objectives of the system. The Design Documents will provide the constructor of the system with detailed drawings, specifications, CQA requirements during implementation of the design, a monitoring plan and a schedule for the installation of the barrier.

12.142 The primary objective of any subsurface barrier will be to provide hydraulic isolation between the off slip road and the landfill site. The barrier must neither degrade nor allow diffusion of target contaminants through the barrier during its design life. The site investigation information gathered in respect of the groundwater at the proposed location of the new junction is considered appropriate to inform development of the Detailed Design.

12.143 The design will consider a hydrogeological assessment which defines the subsurface stratigraphy and the hydraulic conductivity of the aquifer and underlying impermeable zones. The hydrogeological considers the following:

- soil and rock borings to define stratigraphy, particularly the extent and properties of an aquitard bottom (that is, a confining unit);
- groundwater sampling from monitoring wells and piezometers to define the water quality and aquifer heads; and
- testing of aquifers to define the hydraulic conductivity of the water-bearing zones and the extent of the contaminant plume.

12.144 The hydrogeological assessment will include the direction and rate of groundwater flow and the extent and properties of the low-permeability zone, as those properties will affect the key-in of the vertical barrier. The site investigation information gathered in respect of the groundwater at the proposed location of the new junction is considered appropriate to inform development of the Detailed Design.

Engineered Barrier System

12.145 The proposed horizontal barrier system will be located beneath the proposed off slip road and the will be constructed upon the existing in-situ/made ground materials which currently lie within the boundary of the Southbar Landfill Site.

12.146 The horizontal barrier system will be constructed of the following materials in sequence from the top of the barrier down:

- geocomposite drainage layer;
- geosynthetic clay liner;
• 300mm thick sand/gravel graded filter layer; and
• geotextile/geogrid separating layer.

12.147 The sand/gravel graded filter layer will be laid to a cross fall towards the landfill site and a sealed drainage channel incorporating a 150mm diameter drainage pipe. This will facilitate drainage of contaminated groundwater or leachate from beneath the off slip road towards the drainage channel which will transport water to the landfill reed bed system.

12.148 The geocomposite drainage layer will also be laid to a cross fall and will collect any water which drains through the embankment construction materials associated with the off slip road. This water will drain to a separate surface water ditch located on the landfill side of the off slip road.

12.149 It is proposed to construct a berm structure on the landfill site to ensure surface water run-off from the restored landfill site is collected and transferred to the reed beds on site as per the current design.

12.150 The horizontal barrier system will be installed along the section of the off slip road which lies between the M8 motorway and the proposed new roundabout on the existing A8.

Construction Quality Assurance (CQA)

12.151 The CQA programme is important to the successful implementation of the design and to the performance of the barrier wall. Sufficient CQA data will be crucial in assessing the performance of a barrier. The installation contractor’s quality control testing, independent CQA inspection and testing, and documentation by the engineer are components of the CQA programme and a CQA Plan for the proposed capping and drainage works will be submitted to SEPA for approval prior to work being carried out.

Engineered Barrier Performance Monitoring

12.152 Accurate and adequate monitoring data will be essential to be able to evaluate the performance of the subsurface engineered barrier. The extent to which monitoring will be carried out will be determined as part of the Detailed Design.

Engineered Barrier System Summary

12.153 Whilst a range of engineered barrier systems exits it is anticipated that the most appropriate and economical option for use in the Segregation Works at or within the road/landfill corridor will be a horizontal geosynthetic membrane installed beneath the off slip road. Any detailed design of such a system would consider the key design objectives identified above and provision for CQA and performance monitoring of the barrier system would also be made.

12.154 The risk based conceptual model of the pollutant linkages within the road/landfill corridor can be reconsidered in respect of the proposed segregation works and the results of the qualitative risk assessment considered with a horizontal barrier in place beneath the off slip road are provided within Table 12.8. Of the six pathways assessed, all are now classified as low risk. Based upon this assessment no further quantitative assessment of the Segregation Works is considered necessary.
### Table 12.8: Summary of Qualitative Risk Assessment – Post-Enabling Works

<table>
<thead>
<tr>
<th>Pollutant Linkage</th>
<th>Source</th>
<th>Pathway</th>
<th>Receptor</th>
<th>Probability</th>
<th>Consequence</th>
<th>Risk Classification</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contaminants within landfill waste and made ground</td>
<td>Ingestion of airborne dust</td>
<td>Site Users / Construction Workers</td>
<td>Low</td>
<td>Mild</td>
<td>Low</td>
<td>Topsoil and vegetative cover reduces dust emission and exposure to wastes. PPE worn by site users/construction workers.</td>
</tr>
<tr>
<td>2</td>
<td>Contaminants within landfill waste and made ground</td>
<td>Direct ingestion / dermal contact with waste</td>
<td>Site Users / Construction Workers</td>
<td>Low</td>
<td>Mild</td>
<td>Low</td>
<td>Topsoil and vegetative cover reduces direct contact pathways. PPE worn by site users/construction workers.</td>
</tr>
<tr>
<td>3</td>
<td>Landfill gas with landfill waste</td>
<td>Inhalation of gases/Risk of explosion</td>
<td>Site Users / Construction Workers</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Waste types indicate low levels of landfill gas present. Topsoil and vegetative cover reduces direct contact pathways. Significant dilution within ambient air. PPE worn by site users/construction workers. Segregation works would further minimise gas migration potential.</td>
</tr>
<tr>
<td>4</td>
<td>Contaminants within landfill leachate</td>
<td>Subsurface migration to groundwater</td>
<td>Soils and groundwater below and downstream of site</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Landfill constructed on low permeability geology classified as a concealed aquifer of limited or local potential.</td>
</tr>
<tr>
<td>5</td>
<td>Contaminants within soils/made ground</td>
<td>Surface run off (leaching of contaminants)</td>
<td>Receiving surface waters</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Surface runoff is contained within the surface water management system and discharged to a local watercourse.</td>
</tr>
<tr>
<td>Pollutant Linkage</td>
<td>Source</td>
<td>Pathway</td>
<td>Receptor</td>
<td>Probability</td>
<td>Consequence</td>
<td>Risk Classification</td>
<td>Comments</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------</td>
<td>---------</td>
<td>-----------------------------------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>---------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Landfilled wastes/made ground</td>
<td>Stability</td>
<td>Structures associated with new road junction</td>
<td>Low</td>
<td>Mild</td>
<td>Low</td>
<td>Landfilled waste materials are monitored for settlement and annual surveys are undertaken. Waste placement ceased in 1999 and majority of waste settlement has now occurred.</td>
</tr>
</tbody>
</table>
Additional Mitigation of Impacts

12.155 It is considered that a further risk to geology and soils during construction of the road junction will be the potential reduction in physical quality of soils. In order to preserve the physical quality of soils, measures will be employed such as:

- selection of suitable plant and equipment;
- Selective working in wet weather conditions;
- handling of soils in an appropriate manner fit for future use; and
- storage conditions appropriate to material type and end use.

12.156 To provide additional protection of geology and soils a number of pollution prevention measures and emergency procedures will be implemented in the road/landfill corridor. These will include special measures in the event of a release of waste or leachate during Segregation Works. In particular these will include:

- Any landfill material that is excavated following the construction of the Segregation Works will be removed off-site and taken to an appropriate facility for storage or treatment, designed such that any underlying soils are not compromised.
- Fuel storage and refuelling will take place at designated areas and in a manner so as not to impact underlying soils with the appropriate license for storage being obtained.

12.157 The following mitigation proposals were identified in the SI with regards to the construction of the proposed M8 Junction 29A:

- During construction, measures should be taken to minimise run off from all areas of the site to prevent silting and pollution of the adjacent watercourses.
- Where the proposed road alignment crosses the watercourses that exist on the site, care should be taken to ensure minimal disturbance to the bed of the watercourse.
- During construction, measures should be taken to ensure that minimal amounts of dust and debris are allowed to leave the site.
- Any landfill waste and leachate arising during Segregation Works will be removed from site and transported to a suitable disposal or treatment facility.

12.158 Although it is considered that the landfill gas does not pose a significant risk to either the construction of the proposed road layout, or the long term safety of the road, it would be advisable to monitor gas levels throughout the construction phase in the vicinity of the landfill as a precaution and install appropriate gas vents if cutting through the landfill waste.

Surface Water Management

12.159 Surface water management at the Southbar Landfill is currently achieved via a cut off ditch which runs along the eastern boundary of the landfill area which connects in turn to a system of established reed beds which effect silt removal and polishing of the surface water prior to discharge to the Lin Burn, which enters the River Gryfe downstream of its confluence with the Dargavel Burn.

12.160 The proposed route of the M8 Junction 29A off slip road is located so that the existing drainage ditch along the eastern flank of the landfill will require to be diverted as part of the embankment construction works and the only practical location for this diverted channel is to the south of the road junction. It is recognised that
this encroaches closer to the former Southbar Landfill site and it is therefore recommended that the new channel is protected from potential leachate contamination.

12.161 The supporting embankments of the proposed off ramp encompass a marginal portion of the existing treatment ponds located between the former landfill site and the M8, however it is anticipated that much of the reed beds could be retained within the proposed works design to facilitate the continued treatment of surface water arising from the landfill. It is considered that the partial loss of some of the existing treatment ponds is unlikely to have a material impact on downstream water quality. The proposed route of the engineered barrier system within the road/landfill corridor lies to the west of the reed beds therefore ensuring sub-surface migration of potential contamination from the landfill is prevented from ingress to the reed beds.

Other Requirements for Segregation Works

Southbar Landfill Access

12.162 Provision of a new site access from the new roundabout on the A8 and a related area of hard standing at the site entrance to allow for a turning point is required as part of the Segregation Works. The Detailed Design of Segregation Works should include the design of the new site access of sufficient dimensions to enable a single articulated HGV to turn and to enable the offload of a tracked or wheeled item of construction plant.

Environmental Monitoring Infrastructure

12.163 The Waste Management Licence for the Southbar Landfill requires environmental monitoring to be carried out in relation to the closed and restored landfill site. This consists of groundwater, surface water, leachate, landfill gas and landfill stability monitoring.

12.164 Based on a review of information for the landfill site, it would appear that existing leachate and surface water monitoring infrastructure will remain unaffected by the proposed Segregation Works, however the facilities for monitoring groundwater, perimeter landfill gas migration and stability may be impacted and provision should be made in the detailed design for reinstatement or replacement of this monitoring infrastructure. Figure 12.3 shows the location of environmental monitoring points in relation to the proposed Segregation Works.

Waste Management Licence Modification

12.165 The new junction land currently forms part of the Southbar Landfill Site as designated by the Waste Management Licence Boundary. As part of the Segregation Works the Waste Management Licence would require modification to amend the Site Boundary to enable the subject land and therefore the off slip road to be removed from the auspices of the Waste Management Licence.

12.166 SEPA have indicated in discussion to date that they do not regard this as an overly complicated process and is one which they would endeavour to facilitate. However, there will be a requirement to submit a formal application to achieve this in accordance with and as part of the defined Segregation Works.

12.167 A formal Waste Management Licence Application will require to be made by WHM to amend the Site Boundary and in effect partially surrender the area of the Landfill Site which forms the new junction land. It should be noted that Site Investigations have been carried out at the site which demonstrate that the area of land subject to exclusion or partial surrender is not an area which has been subject to landfilling under the remit of the Waste Management Licence, the area in question largely having functioned as access to the landfill and surface water management.

12.168 In preparing a Waste Management Licence Modification Application, the following information will be required.
Site Engineering Report

12.169 This would detail all significant engineering works carried out to prevent or minimise pollution of the environment and harm to human health. The report would include:

- dates of when those works were carried out;
- details of liaison with Regulatory bodies, landowners etc.;
- a copy of all relevant plans or specifications;
- details of restoration work carried out after site operation was complete including details of the construction of the capping system; and
- information on the physical stability of the site including locations of fixed settlement monitoring points.

Geological, Hydrological and Hydrogeological Report

12.170 This would contain information about the site and its surrounds, including:

- the flow of groundwater;
- drainage patterns; and
- site specific geology.

Pollution Control Measures Report

12.171 This would describe pollution control measures, including information about:

- leachate and gas management systems; and
- location and construction (where known) of all monitoring points which should be clearly marked on plans.

Monitoring Report

12.172 This would contain monitoring data for the site and an interpretation of that data (including trends) to help ensure that the information is both reliable and comprehensive. SEPA will also require details of any quality assurance system used or independent verification of the data obtained. SEPA will also require information on:

- the quality and quantity of leachate present;
- future leachate generation rates or leaching potential;
- the flow and concentration of landfill gas, or gassing potential; and
- the potential for leachate or landfill gas to impact on the surrounding environment.
Figures
SEGREGATION WORKS LOCATION PLAN

Site: M9 JUNCTION 29A INTERCHANGE

Date: OCTOBER 2013

FIGURE 12.1

Scale: 1:50,000 @ A4

Project: ENVIRONMENTAL STATEMENT - SEGREGATION WORKS

Revision: 0
NOTES

2. ADDITIONAL DRAWING INFORMATION TAKEN FROM LOYS SURVEYS LTD, DRAWING TITLE: LAND SURVEY, DATED: OCTOBER 1996.

LEGEND

- LANDFILL SITE INJURY
- EMBANKMENT
- SETBACK FROM EMBANKMENT
- CURRENT INFERRED EXTENT OF LANDFILLED WASTES
- LINE OF PROPOSED ENGINEERED SEGREGATION SYSTEM
- SEGREGATION WORKS LAYOUT PLAN

FIGURE 12.2
NOTES


2. ADDITIONAL DRAWING INFORMATION TAKEN FROM LOYS SURVEYS LTD, DRAWING TITLE: LAND SURVEY, DATED: OCTOBER 1996.


SURFACE WATER MONITORING LOCATION POINTS

INCLINOMETERS

SEGREGATION WORKS ENVIRONMENTAL MONITORING PLAN

FIGURE 12.3
NOTES

2. ADDITIONAL DRAWING INFORMATION TAKEN FROM LOYS SURVEYS LTD, DRAWING TITLE: LAND SURVEY, DATED: OCTOBER 1996.

SEGREGATION WORKS SITE INVESTIGATION LOCATIONS

FIGURE 12.4