# 11.0 GEOLOGY AND SOILS

## INTRODUCTION

11.1 This section of the environmental impact statement examines the geological setting of the proposed landfill site development at Meenboll, Co Donegal. It describes the nature and distribution of the subsoil and bedrock stratigraphy that underlies the site and assesses the impact that the proposed landfill site will have on geological features and soils in the locality, during the construction, operation and restoration of the waste disposal facility.

## METHODOLOGY

11.2 The environmental impact of any landfill development is implicitly linked to the geological and hydrogeological setting of a site. The design of a landfill is therefore determined on a site specific basis, related to the characteristics of the prevailing ground conditions and groundwater flow regime. In this regard a principal consideration that controlled the siting of the proposed landfill, within the boundaries of the Meenaboll site, was that it should lie outside the Lough Gartan catchment area, which is used as a public water supply.



11.3 In accordance with the above and the requirements of the Environmental Protection Agency (EPA) Landfill Site Design Manual, the design of the proposed landfill at Meenaboll has been based on a detailed site investigation, the scope of which is outlined below.

11.4 The geological setting of the landfill was determined using a 3 stage site investigation as outlined below:

- Desk Study
- Walkover Survey
- Site Investigation

11.5 A desk study review of the 1:100,000 scale bedrock series map (Sheet 3) and accompanying memoir for South Donegal published by the Geological Survey of Ireland was carried out to provide an indication of the structure, characteristics and stratigraphy of the bedrock formations and the location of geological features such as faults. A drift geological map for the area is not presently available, however a description of drift deposits is included in the geological memoir. A review of unpublished geological field maps for the area was also undertaken at the Geological Survey of Ireland.

11.6 A walkover survey of the site and the surrounding areas was subsequently undertaken to assess the physical form of the terrain and the nature, thickness and distribution of the overburden deposits as indicated by the landscape geomorphology. This included an inspection of any evident exposures of overburden and bedrock materials. The walkover survey was used to verify the preliminary desk study findings and plan follow-up geophysical and exploratory ground investigations.

11.7 The ground conditions that underlie the site were established by a geophysical and exploratory ground investigation which employed various intrusive techniques. The scope of the investigation is outlined below and indicated by Figure 11.1.

- Minerex Environmental Ltd:
  - ~ Stage 1 Geophysical Survey based on a 50m grid over the study area
  - ~ Stage 2 Geophysical Survey based on 8Nr continuous profiles aligned through the landfill area and downgradient of the site to the northwest
- Foundation and Exploration Services:
  - ~ 50Nr Mackintosh (Peat Thickness) Probes put down at 50m grid centres
  - ~ 22Nr Trial Pits opened at 100m grid centres
  - ~ 8Nr Rotary Percussive Drilled Boreholes
  - ~ 5Nr Rotary Percussive and Core Drilled Boreholes



11.8 In the initial phase of the investigation the Stage 1 geophysical survey was used to profile the overburden thickness across the site, identify variations in the bedrock stratigraphy and structural features such as faults. The interpreted survey information was presented as a series of contoured plans that indicate the thickness of the peat and underlying boulder clay deposits, and the depth to rockhead across the site. A plan of the bedrock stratigraphy identifying possible faults was also presented. This information was used in the detailed planning of the exploratory investigation where boreholes were used targeted specific features. Subsequently the Stage 2 geophysical survey was undertaken to further investigate the competence and structure of the rock underlying the proposed landfill area and to trace the continuation of a dyke, identified during Stage 1, beyond the watershed that separates the River Finn and Owenbeg River catchments, downgradient of the site. The Stage 1 and 2 geophysical survey reports are appended to the site investigation report included in Appendix F.

11.9 The ground conditions recorded by the intrusive ground investigation were characterised in accordance with BS5930 the Code of Practice for Site Investigations. The exploratory boreholes were also used to recover samples for laboratory analysis and to facilitate in situ testing of the geotechnical and hydraulic properties of the subsoil and bedrock materials. Rotary core drilling was also undertaken in selected boreholes to facilitate a detailed examination of the bedrock stratigraphy, structure and state of weathering.

11.10 Borehole standpipes were installed on completion of each borehole. These were used to recover samples for geochemical analysis of the baseline groundwater quality and will be maintained for the purpose of compliance monitoring following consented landfilling operations. The standpipes were also fitted with digital water level loggers for continuous monitoring of groundwater levels to determine groundwater flow directions. The site investigation report inclusive of descriptive borehole and trial pit logs and associated test results are included in Appendix F.

11.11 The geophysical and exploratory ground investigation data was developed into a conceptual ground model for the study area. This considered the nature, distribution, thickness and geotechnical properties of the subsoil deposits across the site and the depth, character, hydraulic properties and structure of the underlying bedrock. This model was used to identify the most favourable location for the proposed landfill in relation to the prevailing ground conditions and groundwater regime.

**SITE DESCRIPTION**



11.12 The study area encloses an area of approximately 43 hectares of recently felled commercial foresty that had been planted with conifers. It lies on the western flank of a northeast to southwest trending ridge that extends between the summits of Binswilly Hill and Meenaboll Hill. The summit of Meenaboll Hill represents the principal relief in the area, rising to an elevation of 317mOD, 2km to the southwest of the site.

11.13 The proposed landfill will be engineered as a fully lined containment landfill facility, divided into 5 phases covering an overall area of 4.5hectares. The landfill will be located in the northwest quadrant of the study area between the 240mOD and 220mOD contour intervals, centred over Ordnance grid co-ordinates B 9955E 0915N, where ground conditions are indicated to be most favourable. In this area the ground surface falls under a uniform slight gradient to the northwest. This directs surface run-off toward the Sruhanpollandoo stream, a tributary of the River Finn catchment. A minor stream, that connects with the Sruhanpollandoo stream some 250m downgradient of the site, runs parallel to the northestern boundary of the proposed landfill.

11.14 The watershed divide that separates the River Finn catchment from the Owenbeg River catchment, which drains through Lough Gartan, lies to the northwest of the site. The location of the watershed is reflected by a subtle change in the orientation of the topographic contours, as described in Section 12 of this Environmental Statement.

## GEOLOGY

11.15 The geology of a site is characterised in terms of the nature and startigraphy of the soild (bedrock) geology and the drift (overburden) geology. In accordance with this, the geological setting of the proposed landfill is described below in a regional context and with respect to the site specific ground conditions.

### *The Regional Setting*

11.16 The physical form of the varied landscape of the South Donegal reflects the distribution of the principal rock types and structural geology of the region. In general the more resistant rocks form the main areas of relief.

11.17 The proposed landfill site is located in an upland area on the western margins of the regional outcrop of the Dalradian Supergroup, Figure 11.2, which comprises a sequence of metamorphic rocks. The strata were originally deposited as marine sediments between 810 and 525 million years ago. They were converted to metamorphic rocks during repeated phases of crustal folding that occurred 475 and 385 million years ago, when extreme pressure and temperature changes deformed and altered the mineralogy and texture of the rock.



11.18 The Glendoran and Derryveagh mountain range that rise to the west of the site reflects a change in rock type to the Main Donegal Granite. These highly resistant rocks form part of an extensive igneous body known as the 'Donegal Batholith' that was intruded 475 to 385million years ago.

11.19 Numerous displacement faults and slides occur across the region which are orientated in a predominantly northeast to southwest direction, parallel to the main axis of crustal folding. A number of subordinate northwest trending faults that are associated with the main structural faults are also recorded in the region.

11.20 No regional faults or slides are shown to pass through the study area. The Knockateen and Swilly slides as northeast to southwest trending thrust faults, represent the nearest structural features to the site. They merge to the southwest of the site and extend along the flank of the Meenaboll Hill 600m upgradient of the site. The fault plane, as shown by the geological section in Figure 11.2, is inclined to the southwest beneath the summit of Meenaboll Hill and does not extend beneath the site.

11.21 The drift geology of the region principally reflects the erosional and depositional effects of the last ice age which ended some 10,000 years ago following the Pleistocene period. At this time an ice sheet advanced southwestwards across the region from the Barnesmore and Derryveagh mountains, flowing around the highest mountains and down the glaciated valleys.

11.22 The ice advance sculpted the prevailing landscape and resulted in the widespread deposition of varied glacial sediments. These deposits are typically thin or absent over the upland areas, with the greatest thickness recorded in the low lying regions where depths of 30m are common in drumlin terrains.

***Solid Geology***

11.23 The geological map for the area, Figure 11.2, indicates that the proposed landfill extension is entirely underlain by metamorphic rocks assigned to the Upper Falcarragh Pelite Formation, a sub-division of the Dalradian Supergroup. The Upper Falcarragh Pelite Formation, with an overall thickness of 600m, is described as a stratified sequence of dark grey pelitic schist (metamorphosed mudstone), with beds of paler semi-pelitic schist (metamorphosed sandstone).

11.24 No natural bedrock exposures were recorded at surface within the study area that is entirely mantled by overburden deposits. An isolated exposure was however recorded in a small quarry excavation opened in the northwest extents of the site. The geophysical and exploratory ground investigations recorded that the depth to bedrock varies across the study area from 1.5m to 9.8m, with a mean depth of 3.5m recorded in the vicinity of the proposed landfill. The bedrock contours, illustrated by Figure 11.3, indicate that the rockhead surface is inclined toward the northwest under a slight gradient that reflects the surface topography.



11.25 The bedrock stratigraphy was verified by the geophysical survey and exploratory ground investigation of the site. The geophysical survey indicated that the study area was underlain by a strong competent bedrock, interpreted as psammitic schist (metamorphosed sandstone), without significant fracturing. This was confirmed by the borehole investigation where the bedrock recorded underlying the site principally comprised a sequence of psammitic schists with sub-ordinate pelite horizons. The strata are generally described as a grey to dark grey, schist with a weakly developed foliation. Cores recovered in the exploratory boreholes, indicated that the shallow rockhead was highly fractured and in a slight to moderately weathered state to depths ranging from 0.5m to 2m below the rock surface. Below this the competency of the rock increases with depth, generally being recorded as a fresh to slightly weathered intact material with fractures logged at close to medium spaced intervals. In situ testing of the hydraulic properties of the strata across the site, recorded the permeability of the rock was typically low being of the order of $10^{-5}$ metres/second. This corresponds with the Geological Survey of Ireland classification of the rock as a poor and generally unproductive aquifer (groundwater resource).

11.26 The Stage 1 geophysical survey of the study area also recorded a possible minor fault or fracture zone, Figure 11.3, running from northwest to southeast across the site, along the course of the minor stream that parallels the northeast boundary of the site. During the Stage 2 geophysical survey this feature was traced toward and across the head of the Srunhanpollandoo stream that forms part of the River Finn catchment in the downgradient area of the site. To explore the physical characteristics of this feature the geophysical anomaly it was targeted by three boreholes (BH1, 2 and 6), where intact cores were recovered for detailed inspection. The cores recovered in Borehole 1 penetrated a 5m thick band of igneous rock, which comprised a spotted dark grey, fine to medium crystalline metadolerite (altered dolerite). This intrusion into the metamorphic rocks reflects a wall of igneous rock, known as a dyke. Irregular compound fractures, partially healed by quartz veins, were recorded in the metamorphic rocks on either side of this intrusion, indicating the intrusion was probably emplaced along the line of an older minor fault. Similar compound fracturing and quartz veining was also recorded in Boreholes 2 and 6, however the dyke was not recorded at these locations. In situ testing of the hydraulic properties of the strata at the three borehole locations recorded that the permeability of the rock had a similar low permeability to the psammitic schists underlying the greater site area, being of the order of $10^{-5}$ metres/second.



***Drift Geology***

11.27 On the basis of the ground investigation records the stratigraphy of the drift geology is summarised sequentially below:

- Peat
- Glacial Till
- Bedrock

11.28 The distribution of the drift deposits across the site is illustrated by isopachyte (thickness contours) plans of the peat and glacial till thickness, as Figures 11.4 and 11.5, and by a series of long sections and cross sections through the landfill area, as Figure 11.6.

11.29 Peat deposits mantle the entire surface of the study area, where they comprise a very soft and highly compressible material, described as a dark brown, spongy peat with a fiborous texture. The thickness of the deposits, as illustrated by Figure 11.4 and 11.6, ranges from 0.5m to a maximum of 4.4m in the northeastern extents of the study area, with a mean thickness of 1.5m recorded in the vicinity of the proposed landfill site.

11.30 Glacial Till deposits that underlie the peat were laid down as ground moraine by the advancing ice sheet over the glacially eroded bedrock surface. They typically represent an ill-sorted material with a wide range in grain size, generally comprising a fine matrix charged with cobbles and occasional boulders. In accordance with this the exploratory investigations recorded that the deposits comprise an inter-stratified sequence of firm to stiff, bluish grey sandy gravelly clay or medium dense, very clayey, silty sand and gravel, grading locally toward a very gravelly, very silty sand. In situ testing recorded the hydraulic conductivity of the material varied from $10^{-7}$ to $10^{-4}$ metres/second with low permeability values recorded in the clays and moderate permeability values in the sand and gravel horizons. The thickness of the deposits within the study area, as illustrated by Figure 11.5 and 11.6, ranges from 0.5m to a maximum of 5.2m in the northeastern extents of the site, with a mean thickness of 2.5m to 3.0m recorded in the vicinity of the proposed landfill.

## SOILS

11.31 The proposed extension area is mantled by peaty topsoils that are classified as surface water gleys of wetness class 3 (SWG3). Peat is formed from the anerobic decay of plant materials leached of minerals and nutrients in saturated ground conditions. The deposits are associated with very poor drainage conditions and are typically waterlogged for most of the year, being fully saturated to ground surface. In agricultural terms the soils are of very poor amenity, generally only suitable for rough grazing purposes, or in the case of the study area coniferous plantation. The textural limitations of the peaty soils also inhibit attempts to improve the drainage of the material.



## PROPOSED DEVELOPMENT

11.32 The ground conditions recorded beneath the site are geotechnically suitable for its proposed development as a landfill. Any subsoil materials requiring excavation will either be deployed directly in engineered earthworks or stored on-site in material stockpiles for reuse in landscaping and restoration operations, are detailed below.

### *Site Construction*

11.33 During the development of each of the phases of the landfill, construction will begin by stripping the peaty topsoil and excavating the compressible peat deposits. The excavated topsoil will be stored onsite in stockpiles and allowed to drain. If the material is suitable for reuse in landscaping operations it will be re-used as a soil improver in restored areas. Any unsuitable materials will be spread over non-structural areas within the site boundaries.

11.34 Following the topsoil stripping operations glacial subsoils above formation levels will be excavated to expose the rockhead surface. Laboratory tests indicate the material produced by these excavations should compact to a density suitable for reuse in earthworks. The materials will either be stored on site in temporary stockpiles or used directly as fill material in the construction of containment and landscaping bunds around the landfill margins, following removal of the peat. The granular materials may also be used as a source of general and emergency cover.

11.35 The underlying bedrock will then be excavated to reduce the level of the ground surface to the proposed formation surface of the landfill base. This will necessitate ripping to loosen the rock for excavation and possibly hydraulic breaking. If the rock material produced by the excavations is of a suitable size, it will be processed by crushing and grading operations for reuse as aggregate in the construction of drainage and engineering works. Crushing plant shall be fitted with an overhead dust control system to avoid any nuisances arising from operation of such machinery.

***Site Operation***

11.36 Any suitable material generated during the development of site will be used as general fill in earthworks, cover material or in the case of the peaty topsoil, as a soil improver for use in the phased restoration of the site. Some imported materials such as quarry dust or sand imported from the locality may also be stockpiled within the landfill area, to ensure continuity of supply for covering on site.



11.37 Any stockpiles of soil material that are not for immediate use will be planted with grass seed to reduce the possibility of dust production.

**IMPACTS AND MITIGATING MEASURES**

***Impacts***

11.38 The construction of a landfill by the excavation of cells and formation of bunds has the potential to destroy any features of geological interest that may exist within the site. The impact of the landfill may therefore be related to the importance and quality of bedrock and drift exposures and landforms of geomorphic interest, which may be obliterated or covered during construction. These issues are examined below.

11.39 No natural bedrock exposures are present within the site and the drift cover is complete. The rock formation that underlies the site outcrop extensively throughout the region, and good quality exposures occur widely elsewhere. In addition, no mineral assemblages of economic importance are known to be associated with the metamorphic rock formations that outcrop in the study area. Consequently the site would not be considered one of special interest with respect to its bedrock geology.

11.40 The drift deposits that underlie the site occur extensively throughout the region. No drift exposures or geomorphic landforms of significant interest exist within the site, where the terrain reflects an extensive area of featureless terrain covered by peat. Consequently the site would not be considered as one of special interest with respect to Quaternary geology.

11.41 The development of the landfill site will inevitably lead to the disturbance and/or loss of soil over an area of 4.5 hectares. However, the waterlogged peaty gley soils found over the site are of limited agricultural use, being generally only suitable for rough grazing or coniferous plantation. Therefore the loss of the peaty soils over the area will not be significant in terms of the quality of the land or proportional loss of these types of soils in the area.

11.42 On the basis of the above the construction of the landfill and resultant loss of geological exposures, geomorphic features or soils would not represent a significant environmental impact.



***Mitigating Measures***

11.43 All suitable excavated materials will be reused in the construction of engineered earthworks, landfill restoration and landscaping operations.

11.44 Improper storage can cause damage to the topsoil integrity and processes. To mitigate this the peaty topsoil stripped from the landfill area will be stored in a heap no higher than 3 metres, to prevent excessive compaction. The stored topsoil will be kept free from the passage of vehicles and intermixing with other materials and will be re-used as soon as practicable.

11.45 To mitigate the effects of wetting and weathering on the workability and mechanical properties on excavated subsoils, the materials will either be reused directly in engineered earthworks or deposited in stockpiles formed with graded banks to promote surface run-off. These shall be sited away from streams to avoid their potential siltation. As a further mitigating measures settlement ponds and a reed bed (wetland) will be constructed downgradient of the landfill. This system shall collect surface run-off from the site, and allow suspended solids to settle or be filtered out. This would mitigate potential impacts on surface water quality downstream of the site during the construction and operational phases of the site.

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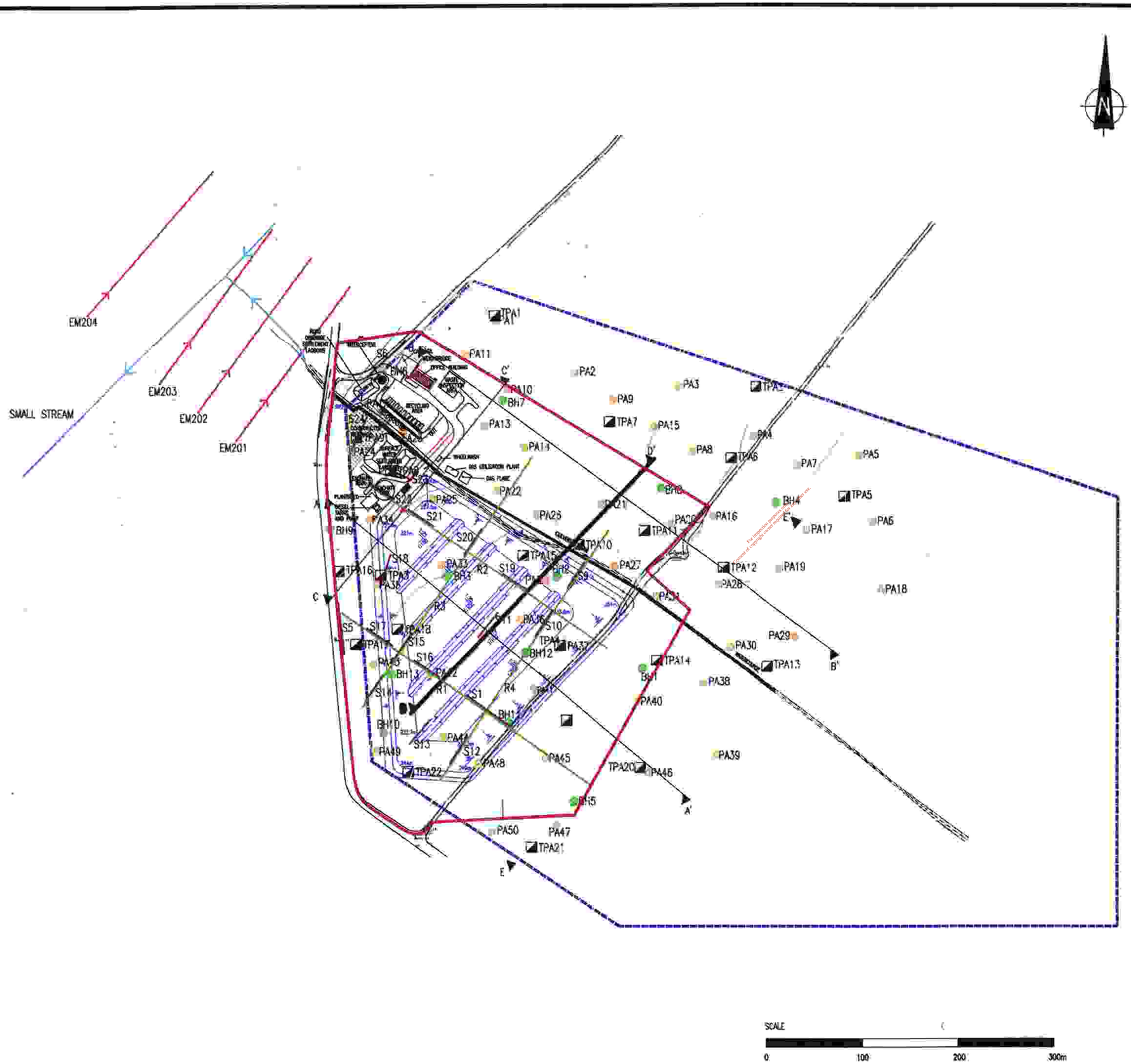
**FIGURES**




1. KEY

STUDY AREA EXTENTS

PROPOSED LANDFILL LAYOUT

TP1 TRIAL PIT

BH1 BOREHOLE

PA1 PROBE LOCATION

A A' GEOLOGICAL SECTION (SEE FIG 11.6 FOR SECTION DETAILS)

NOTE:

PHASE 1 GEOPHYSICAL SURVEY POINTS WITHIN STUDY AREA ARE BASED ON A 50m GRID (OMMITED FOR CLARITY)

PHASE 2 GEOPHYSICAL SURVEY

R1 2D-RESISTIVITY PROFILE

S1 SEISMIC PROFILE

EM201 VLF-EM LINE

SCALE: 1:4000

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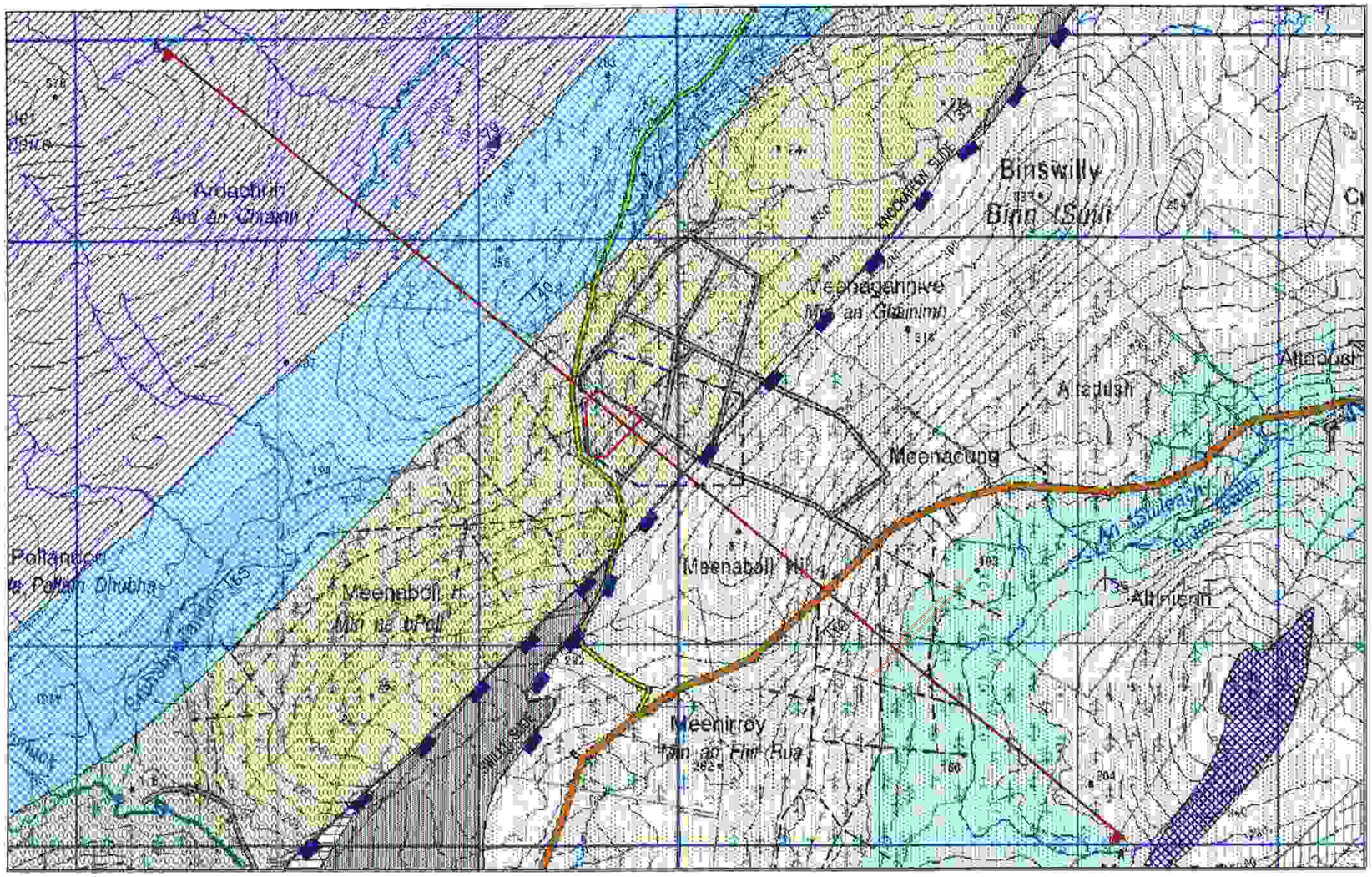
MEENABOLL LANDFILL PROJECT

TITLE

SITE INVESTIGATION PLAN

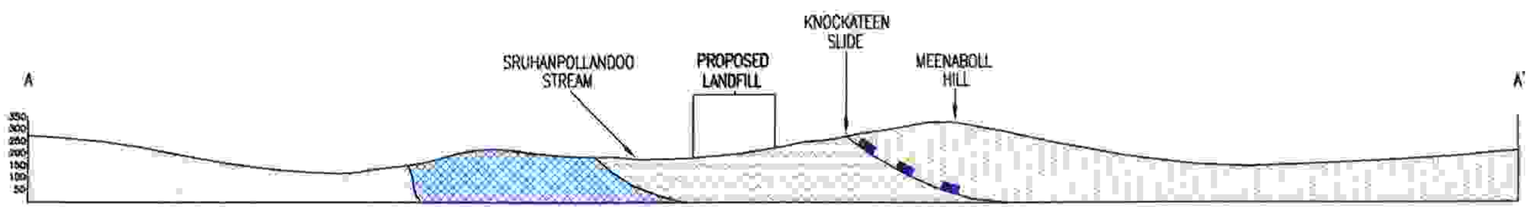
FIGURE

11.1




SCALE

0 500 1000 1500 2000 2500m




GEOLOGICAL SECTION

SCALE: 1:25000

1. KEY

- LOWER CRANA QUARZITE FORMATION (PSAMMITIC SCHIST)
- TERMON FORMATION (BANDED WITH SEMI-PELITIC AND PSAMMITIC SCHIST)
- TERMON, KNOCKLETTERAGH MEMBER (PEBBLY GRITS)
- SLIEVE TOOEY QUARTZITE FORMATION (QUARTZITE WITH PEBBLE BEDS)
- PORT ASKIG FORMATION (DIAMICTIC, SCHIST AND QUARTZITE FORMATION)
- LOUGHROS FORMATION (QUARTZITE AND SEMI-PELITIC SCHISTS)
- UPPER FALCARRAGH PELITE FORMATION (PELITIC, SEMI PELITIC AND PSAMMATIC SCHIST)
- SESSIAGH-CLONMASS FORMATION (QUARTZITE, DOLOMITIC MARBLE AND SCHIST)
- MAIN DONEGAL GRANITE (COARSE BIOTITE GRANITE AND GRONODIORITE)
- METADOLORITE FORMATION (HORNBLENDIC)
- THRUST FAULT (SHEARING)
- PROPOSED LANDFILL SITE
- STUDY AREA EXTENTS
- GEOLOGICAL SECTION A

N

SCALE: 1:25,000

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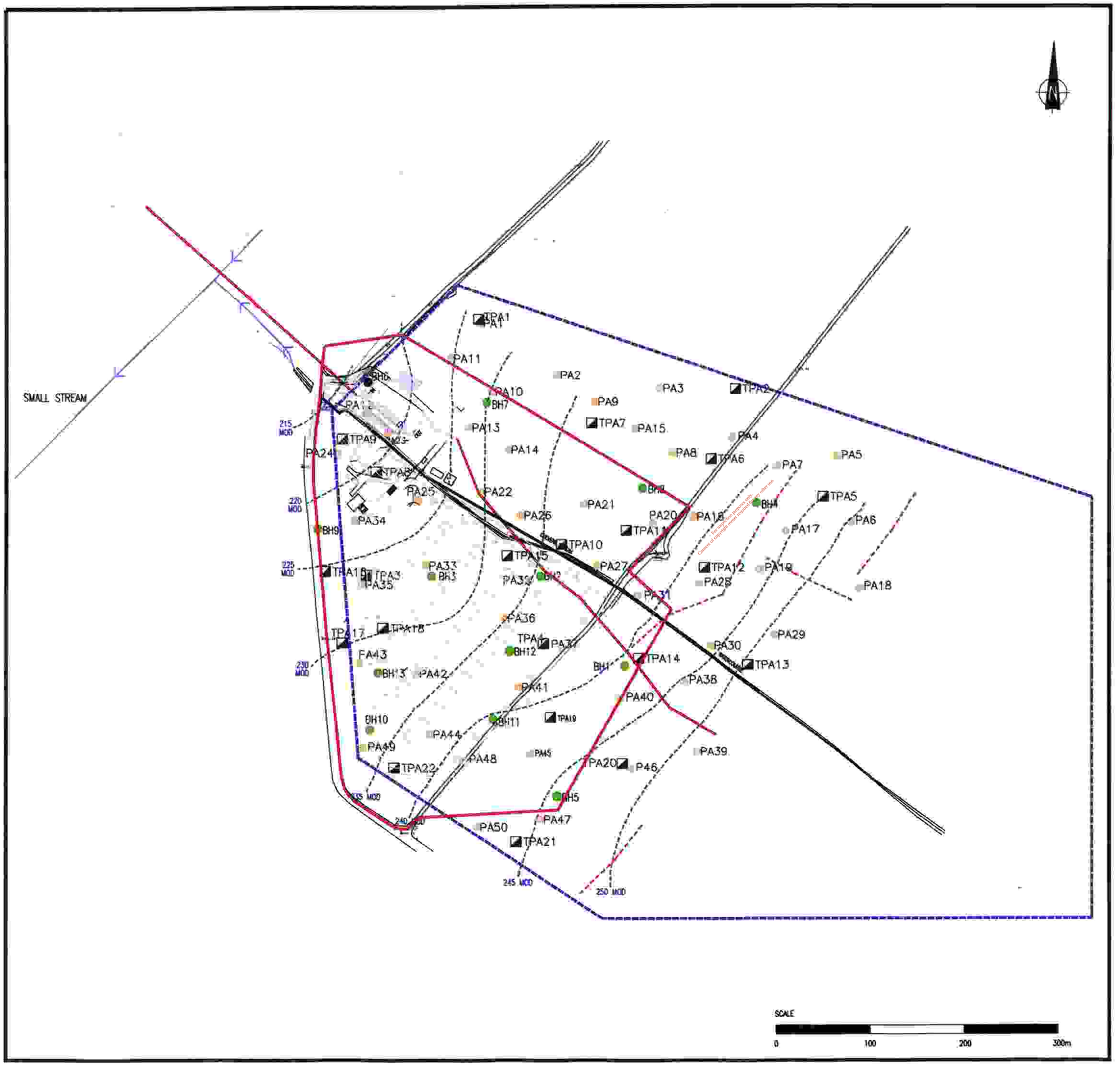
SOLID GEOLOGY MAP

FIGURE

11.2




1. KEY

PROPOSED LANDFILL SITE

STUDY AREA EXTENTS

TP1 TRIAL PIT

BH1 BOREHOLE

PA1 PROBE LOCATION

DOLERITE DYKE/FAULT ZONE

MINOR FAULT

UPPER FALCARRAGH PELITE FORMATION

215 MOD ROCKHEAD SURFACE CONTOUR IN METRES ABOVE ORDANANCE DATUM

SCALE: 1:4000

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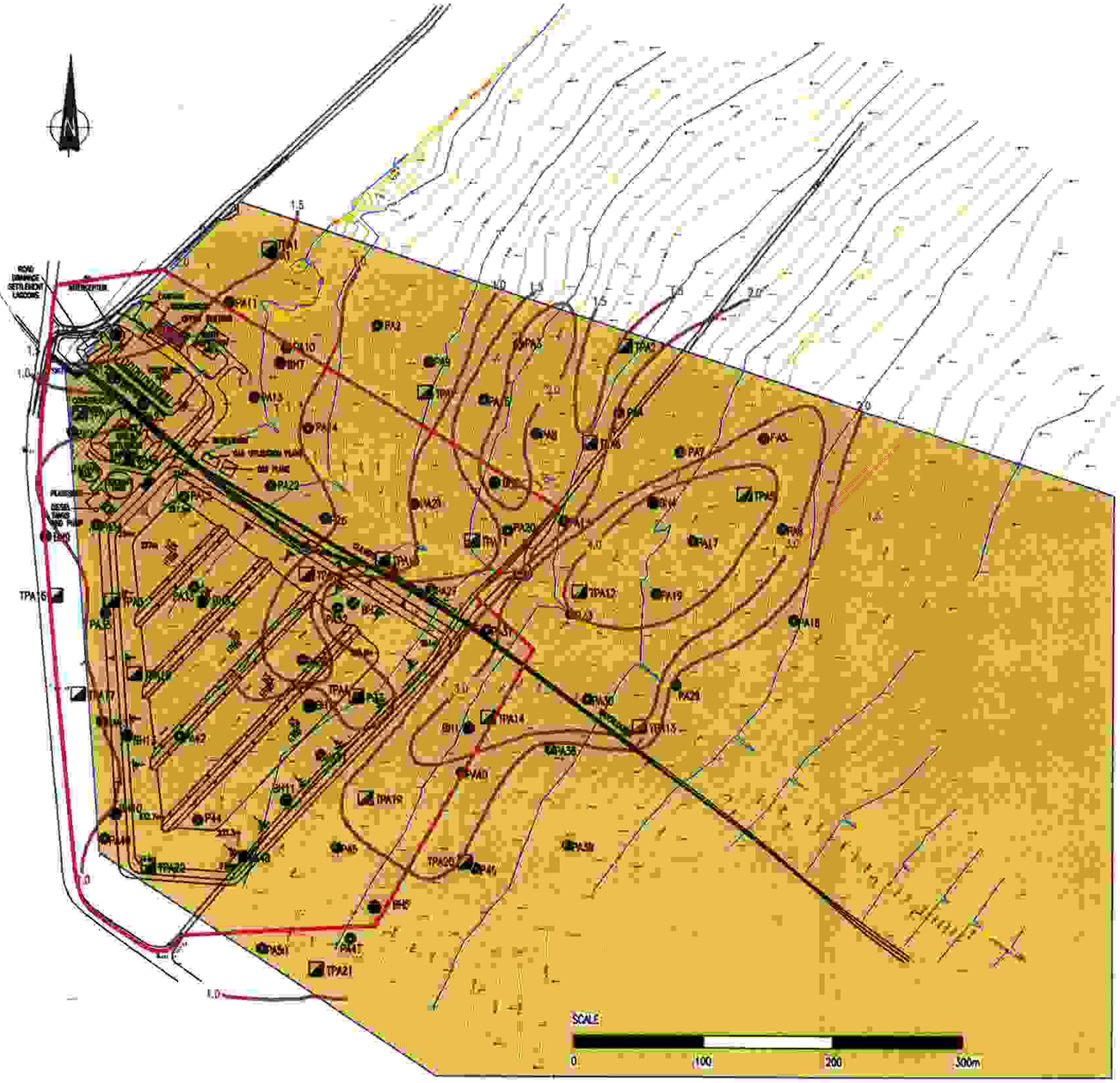
TITLE
CONTOURED PLAN OF BEDROCK SURFACE

FIGURE
11.3




1. KEY

PROPOSED LANDFILL SITE

STUDY AREA EXTENTS

TP TRIAL PIT

BH BOREHOLE

PA PROBE LOCATION

PEAT THICKNESS CONTOUR IN METRES

PEAT EXTENTS

SCALE: 1:4000

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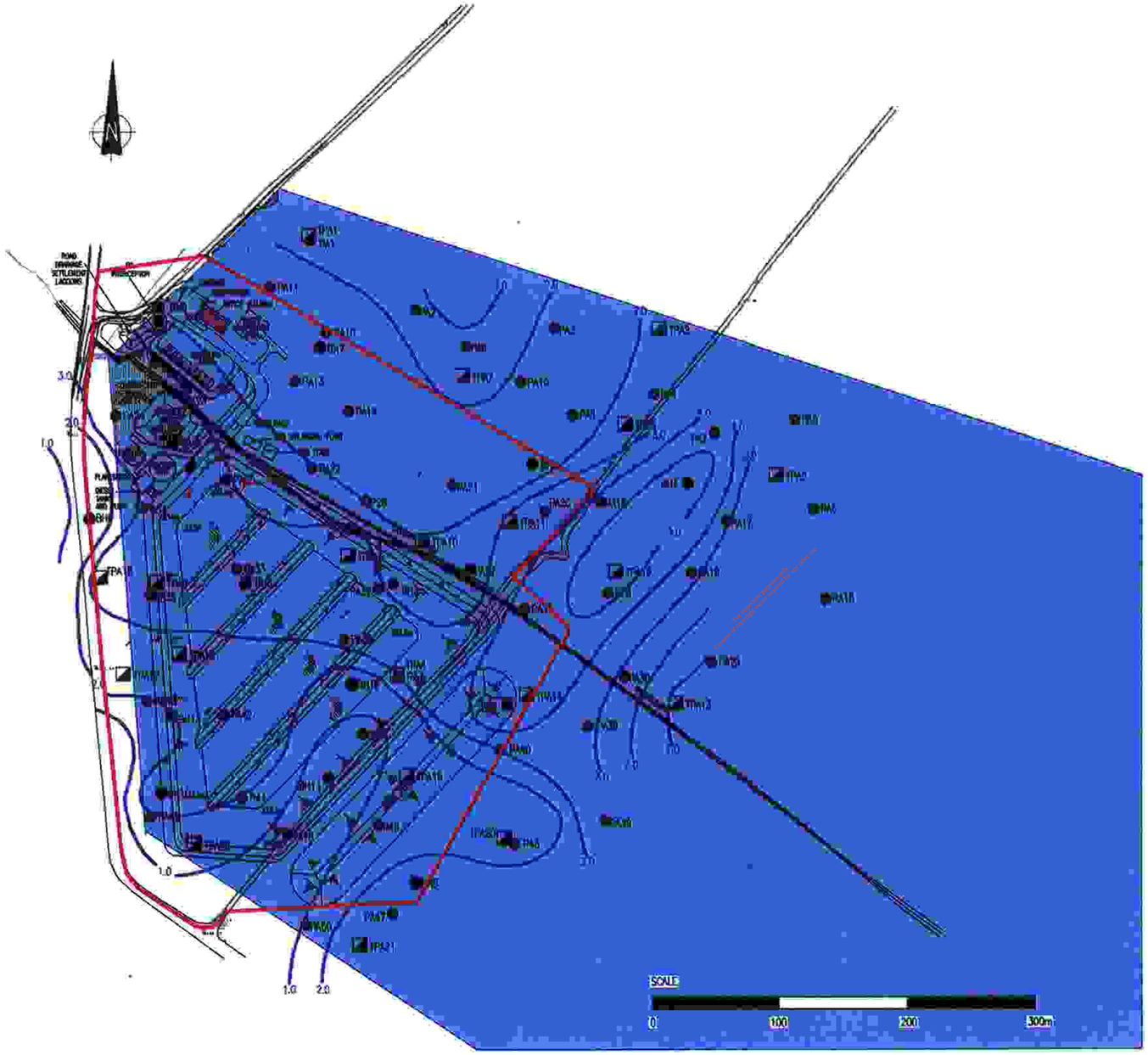
CONTOURED PLAN OF PEAT THICKNESS

FIGURE

11.4




1. KEY

PROPOSED LANDFILL SITE

STUDY AREA EXTENTS

TP TRIAL PIT

BH BOREHOLE

PA PROBE LOCATION

2.0 GLACIAL TILL THICKNESS CONTOUR IN METRES

GLACIAL TILL EXTENTS

SCALE: 1:4000

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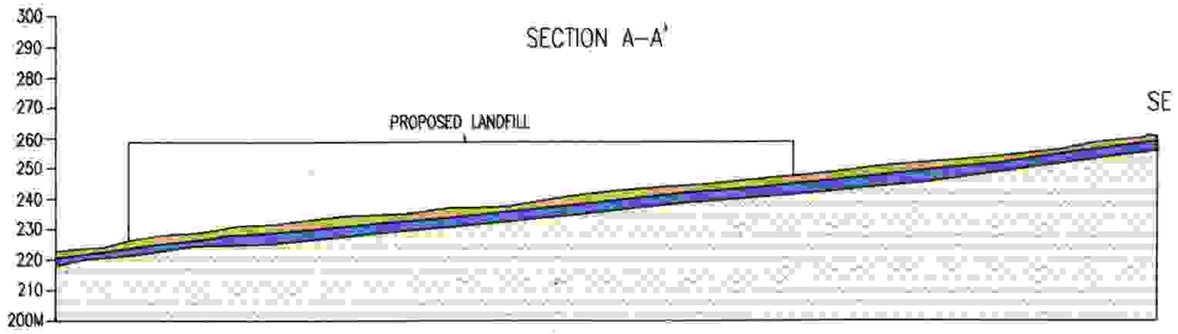
CONTOURED PLAN OF GLACIAL TILL THICKNESS

FIGURE

11.5

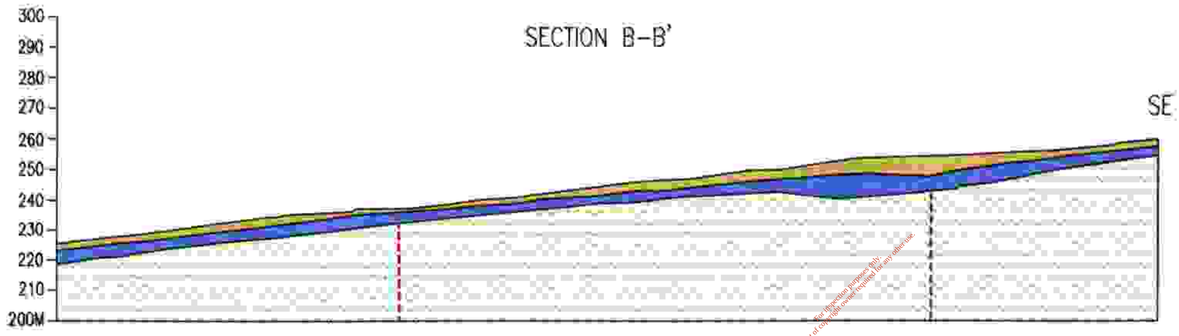
NW

SECTION A–A'



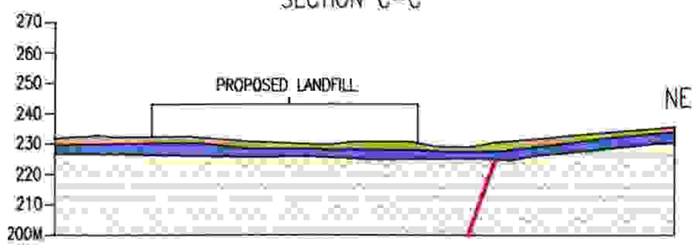

NW

SECTION B–B'



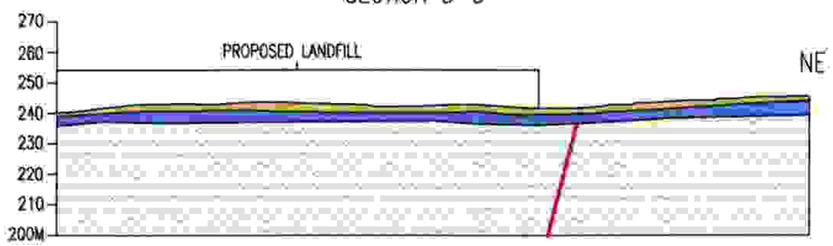

SW

SECTION C–C'



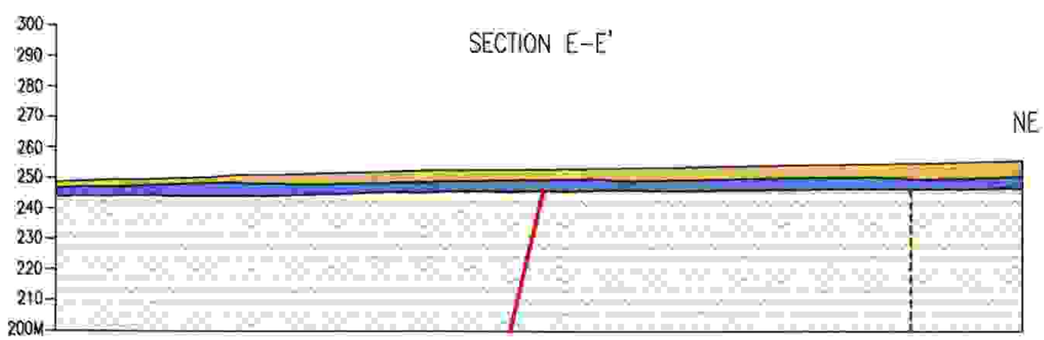

SW

SECTION D–D'




SW

SECTION E–E'




1. KEY

- PEAT
- BOULDER CLAY (GLACIAL TILL)
- BEDROCK (UPPER FALCARRAGH PELITE)
- FAULT/DYKE
- MINOR FAULT

SCALE: 1:2000

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TITLE

GEOLOGICAL SECTIONS

FIGURE

11.6