Peter Legg Consulting
Geo-Environmental Engineers
28 8th Avenue, Northmead, Benoni, 1501, South Africa
Tel/Fax: +27(0)11 425 1197 Cell: +27(0)82 881 8090
Email: peterlegg@telkomsa.net

GEOTECHNICAL INVESTIGATION REPORT FOR THE EXTENSION OF THE TUTUKA POWER STATION LANDFILL SITE

Report No : P029-01

Submitted to:

Zitholele Consulting (Pty) Ltd
P.O. Box 6002
Halway House
1685

DISTRIBUTION:

1 Copy	-	**Zitholele Consulting (Pty) Ltd**
1 Copy		Eskom Power Generation
1 Copy		Tutuka Power Station
1 Copy	-	Peter Legg Consulting

February 2010 P029

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

1.1 Background and Terms of Reference

Eskom has a general waste landfill site within the premises of the Tutuka Power Station complex, that receives general waste (including building rubble and garden waste) from the power station itself, as well as from the nearby township of Thutukani and the New Denmark colliery. The landfill site was permitted in terms of Section 20 of the Environment Conservation Act in August 1994 as a Class 2 Domestic Waste Disposal Site, with Permit No B33/2/3/310/45-P129. The landfill has reached its capacity in terms of the permit requirements, and waste is currently being sent to the Kriel landfill. Eskom would therefore like to extend the footprint of the existing landfill, to provide an additional disposal capacity for the next 40 years.

Zitholele Consulting has been appointed by Eskom to carry out the EIA, EMP, Landfill Licence Application, Design and Operating Manual for the landfill extension. Zitholele Consulting has subsequently appointed Peter Legg Consulting as its engineering consultant for the survey of the landfill site, geotechnical investigation, design and operating plan for the proposed landfill extension.

1.2 Objectives

The objectives of the geotechnical investigation were as follows:

- To determine the nature, depth and extent of the different soils and bedrock underlying the site.
- To determine the engineering properties of the soils, particularly in relation to the proposed extension of the landfill. In this regard, the depth and extent of clayey soils that might be suitable for the construction of the landfill liner would need to be determined.
- To comment on the excavation characteristics of materials underlying the site.
- To comment on site water management aspects, particularly pertaining to shallow groundwater or seepage.
- On the basis of the results of the investigations, to make recommendations for the design of the landfill cells and drainage components, and any other site infrastructure required.
- To identify any other geotechnical aspects that may be relevant to the proposed landfill extension.

2 SITE

2.1 Site Description

The landfill site is located approximately 2 km to the west of Tutuka Power Station on the farm Pretorius Vley 374 IS, on property that is owned by Eskom. This property has been zoned for industrial use. The permitted landfill site covers an area of 3.224 ha, although the landfill itself has a footprint area of 2.543 ha. The site is located within a highly disturbed area as a result of extensive gravel excavation operations for the power station site. The landfill itself was sited within a previous

borrow pit, although there is a small area of undisturbed land approximately 100 m wide immediately to the west of the landfill. To the west of this undisturbed area, and to the east of the landfill, there is evidence of gravel excavations, resulting in a highly uneven ground surface and ponded water.

The current landfill is approximately 250 m long by 100 m wide, and is 7 m above natural ground level at its northern end. At the southern end, the landfill surface is at ground level. There is an upslope stormwater diversion drain along the southern side of the landfill that drains in a westerly direction to the borrow pit on the west side. Access to the landfill site is by means of a gravel road from the south side, which then runs along the western toe of the landfill. Cover material for the landfilling operations is obtained from a dolerite borrow pit approximately 400 m to the south west of the landfill.

The site has a gentle slope of approximately 3% in a northerly direction towards an ephemeral stream that flows in a north westerly direction past the northern side of the site towards the Racesbult Spruit. The Racesbult spruit in turn flows in a westerly direction into the Leeuspruit. Notwithstanding the high level of disturbance of the site, the area is well vegetated by typical Highveld grasses. Even in the older borrow pits, natural vegetation has re-established itself.

The site falls within the summer rainfall region of the Highveld, with intense thunder storms common. Average annual rainfall is about 680 mm, whilst average annual evaporation is about 1780 mm. The site therefore has a definite negative climatic water balance.

The location of the site is indicated on Figure A1 and a topographical survey of the site showing positions of the testpits is included as Figure A2 in Appendix A.

2.2 Proposed Development

It is intended to extend the current landfill site to accommodate the waste disposal needs of Tutuka Power Station, Thuthukani village and New Denmark Colliery for the next 40 years. To this end, it will be necessary to extend the current footprint of the landfill, and raise the current height of the landfill. Based on preliminary estimates, a total footprint of approximately 8.48 ha will be required. This will be achieved by using the area between the current landfill and the borrow pit to the west, and by extending the landfill in a southerly direction. The geotechnical investigation therefore covered these areas.

3 INVESTIGATION

3.1 Soil Profiling

Ten test pits were excavated on the site using a Case 580 TLB excavator. All test pits were excavated to refusal. The positions of the test pits were determined using a GPS and are shown on Figure A2.

Each test pit was entered by a geotechnical engineer and profiled in-situ in terms of the standard descriptors of moisture condition, colour, consistency, structure, soil type and origin (MCCSSO)[3]. The soil profiles are included in Appendix B.

3.2 Geotechnical Testing

Although provision was made for sampling of the soils in the testpits for subsequent geotechnical laboratory testing, based on the soils profiled, it was determined that there would be no technical benefit to be gained from laboratory tests.

4 GEOLOGY AND SOILS

4.1 General Geology

According to 1 in 1 000 000 "Geological Map of the Republic of South Africa and the Kingdoms of Lesotho and Swaziland 1997" as prepared by the Council for Geoscience, the site is located within the Vryheid Formation of the Ecca Series of the Karoo Supergroup. This formation consists principally of dark-grey shale, which is carbon rich in places (coal), together with interbedded sandstone units. The shale is laminated and, on weathering, breaks up into plates and flakes. In the greater Tutuka area, the Karoo shales are overlain by a large dolerite sill of significant thickness.

A geological map showing the site location is included as Figure 1 below.

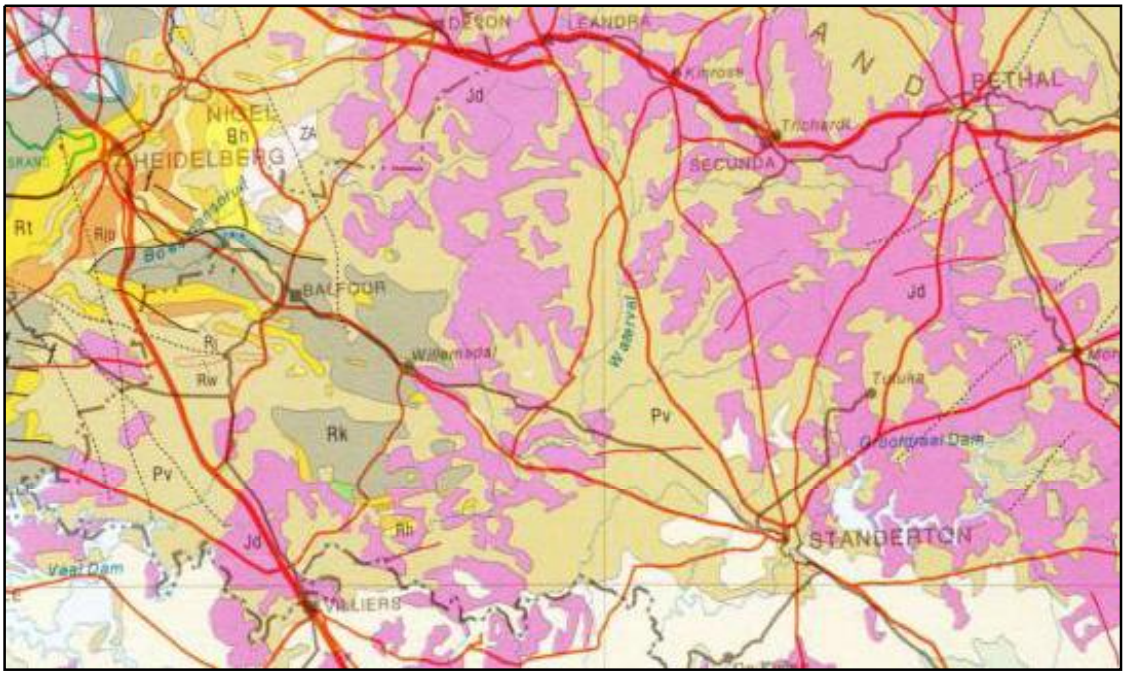


Figure 1: Geological Map showing the Tutuka Power Station site

Legend: Jd = Dolerite
Pv = Karoo Vryheid Formation

4.2 Engineering Geology

According to Brink[(1)], in areas where the Weinert climatic N-value[1] is between 2 and 5, the weathering of the dolerite results in the primary minerals decomposing into secondary minerals of the smectite group, mainly montmorillonite, occurring in the form of grey to black, highly active clays. These clays are best developed in poorly drained areas or flat terrain. The depth of clay is therefore related to the topography, being thicker in flat areas and thinner in steeper areas. The Tutuka Power Station complex and surrounds falls within the zone of 2 < N-value < 5. Therefore highly active black clays, commonly referred to as "black turf" would be expected in the area of the landfill site.

4.3 Site Soils

The test pit profiles in Appendix B give the following generalised soil profile across the site, as summarised in Table 1.

Table 1. Test pit summary showing depths of the different soil horizons

Test Pit No	Black Clay (Turf)	Light brown sand/gravel/clay Pebble marker	Weathered dolorite	Testpit depth (m) (refusal)
TP1	0.45 – 0.8	0.8 – 1.4	1.4 – 2.0	2.0
TP2	0 – 0.4	0.4 – 0.7	0.7 – 1.5	1.5
TP3	0 – 0.25	0.25 – 0.55	0.55 – 1.0	1.0
TP4	0 – 0.45	0.45 – 0.6	0.6 – 1.9	1.9
TP5	0 – 0.45	0.45 – 0.75	0.75 – 2.1	2.1
TP6	0 – 0.5	0.5 – 0.8	0.8 – 1.7	1.7
TP7	0 – 0.4	0.4 – 0.55	0.55 – 1.35	1.35
TP8	0 – 0.4	0.4 – 0.55	0.55 – 1.65	1.65
TP9	0 – 0.3	0.3 – 0.5	0.5 – 1.0	1.0
TP10	0 – 0.45	0.45 – 0.55	0.55 – 1.0	1.0

From the soil profile summary, it is seen that refusal on weathered dolerite occurred in all 10 testpits, with the deepest (2.1 m) being at the lower end of the site, and the shallowest (1.0 m) being at the higher end of the site. This is consistent with the literature, with increased erosion of weathered materials on the higher slopes and increased in-situ weathering of rocks lower down the slope.

Fill (waste)

In testpit TP1, there was a thin layer of waste materials (0.45 m), however waste was not found in any of the other testpits, so that it would appear to be an isolated "pocket" of waste. However during

[1] The N-value is calculated as $N = 12xE_j/P_a$, where E_j = Evaporation during January
P_a = Annual precipitation

construction of the landfill liner, care will have to be taken to remove any waste that has been deposited and backfill the areas with compacted selected fill material.

Colluvial Soil (black clay)

There is a layer of expansive colluvial black clay that is the product of decomposed transported dolerite. This black clay layer varies in thickness across the site from 0.25 m to 0.5 m. Because of its highly expansive nature, this clay is totally unsuitable as a founding stratum or for use in a compacted clay liner. As the site investigation was carried out during the summer rainfall period and because there had been significant rain in the weeks prior to the investigation, the black clay was moist to very moist, and did not show desiccation cracking. However, the very high linear shrinkage of the black clay results in large shrinkage cracks on desiccation. It should therefore be removed from the site before the landfill liner is constructed and stockpiles for use as landfill cover material.

Residual dolerite

Beneath the black clay there is a layer of light brown (yellow to orange brown) medium dense to dense, residual dolerite that varies from gravely sand, to sandy gravel, to sandy clay in places. This material should form the base of the landfill liner. It could also be used as a founding stratum for lightly loaded buildings with foundation bearing pressures up to 200 kPa.

It is also noted that this soil is the material that has been exploited from the area for use in roads and construction fill.

Weathered Dolorite

Beneath the residual dolerite soil is a layer of weathered dolerite that increases in strength with depth. The weathered dolerite appears as “granular (sugar) dolerite” in the upper zones of the soil profile with typical “onion” shell cobbles and small boulders. There is evidence of decomposition of the dolerite. Lower down in the profile, the weathered dolerite becomes more like “gravel dolerite” with a disintegrated and fractured nature. The consistency of this horizon is dense to very dense, which indicates a safe bearing capacity of about 400 kPa. This material would provide a suitable founding stratum and would also be suitable for use in engineered fill and pavement layers.

Bedrock

Depth to weathered dolerite bedrock increases down the slope from about 1.0m on the upper side of the site to 2.1 m on the lower side of the site. If required as a founding stratum, the weathered dolerite bedrock would provide a safe bearing capacity of about 500 kPa. The weathered rock would be excavatable by means of a large hydraulic excavator or dozer ripper, without the need for blasting.

4.4 Groundwater

Despite the fact that the investigation was carried out during a period of high rainfall, no groundwater was encountered in any of the testpits. In the original landfill Permit Application Report by SRK[4], it was reported that a perched aquifer exists above the dolerite sill. At the time of the report (1990), this perched aquifer was reported as being at a depth of 8 m in the upstream monitoring borehole, and 2.5 m in the downstream boreholes.

As the landfill liner will be constructed at shallow depth (< 1 m), there should be no need to install subsoil drainage systems beneath the liner. It may be prudent to install a subsurface upslope "fin drain" immediately to the south of the landfill to intercept any perched groundwater seepage.

5 GEOTECHNICAL EVALUATION

This geotechnical evaluation is based on the field observations, and previous experience with similar types of soils.

The overlying black clay cannot be used for liner construction or for foundation loading needs to be removed. It should be stockpiled for use in landfill cover operations. As the ash and rubble fill overlies the black clay, it will also need to be removed.

The underlying sandy residual dolorite soil should be shaped to form a subgrade surface for a geosynthetic landfill liner system. This material could also be used as a subgrade material for the site roads.

If any buildings are constructed on the site at a later stage, they can be founded on the residual dolorite soil with a safe bearing capacity of 200 kPa, or on the slightly deeper weathered dolorite with a safe bearing capacity of 400 kPa.

For bulk excavation operations, the weathered dolorite should be excavatable down to a depth of at least 2 m, although some ripping may be required.

6 RECOMMENDATIONS

Based on the investigations and the geotechnical evaluation of the findings, the following recommendations made regarding the proposed Tutuka landfill extension.

6.1 Bulk earthworks and landfill liner

All the black clay (average 0.4 m deep) must be removed and stockpiled for use as landfill cover material.

At least 300 mm of residual dolorite soil must excavated and stockpiled for use as a cover layer over the liner. The excavated surface must be graded and shaped to the falls indicated on the drawings, and compacted to 95% Mod AASHTO density to form a subgrade surface for the landfill liner.

The landfill liner should consist of a geosynthetic clay liner (GCL), placed on the prepared subgrade, and covered with a 300 mm layer of residual dolorite soil compacted to 95% Mod AASHTO density.

6.2 Drainage

To intercept and drain away the perched groundwater upslope of the landfill, it will be necessary to install a 1 m deep "Fin-drain", comprising of a 900 mm high flownet drainage core with a M100 geopipe all wrapped in Bidim grade A2, and backfilled with selected sandy material (residual dolorite soil). This drain will need to daylight to the side of the landfill.

6.3 Building foundations

For future buildings on the site, take all building foundations down to the dense weathered dolorite layer, (average 0.6 m depth). Maximum foundation bearing capacity should be 200 kPa. Either a blinding layer or the foundation concrete should be placed as soon as possible after excavation in order to prevent deterioration of founding surfaces through exposure.

6.4 Site roads

For the site roads, shape, rip and scarify after stripping of the black clay. Recompact the subgrade. Construct roads with a 300 mm thick gravel wearing course of residual dolorite sandy gravel, compacted to 95% Mod AASHTO density.

These site roads will need to be maintained through regular grading and compaction, particularly during the rainy season.

PETER LEGG CONSULTING

Peter Legg, PrEng

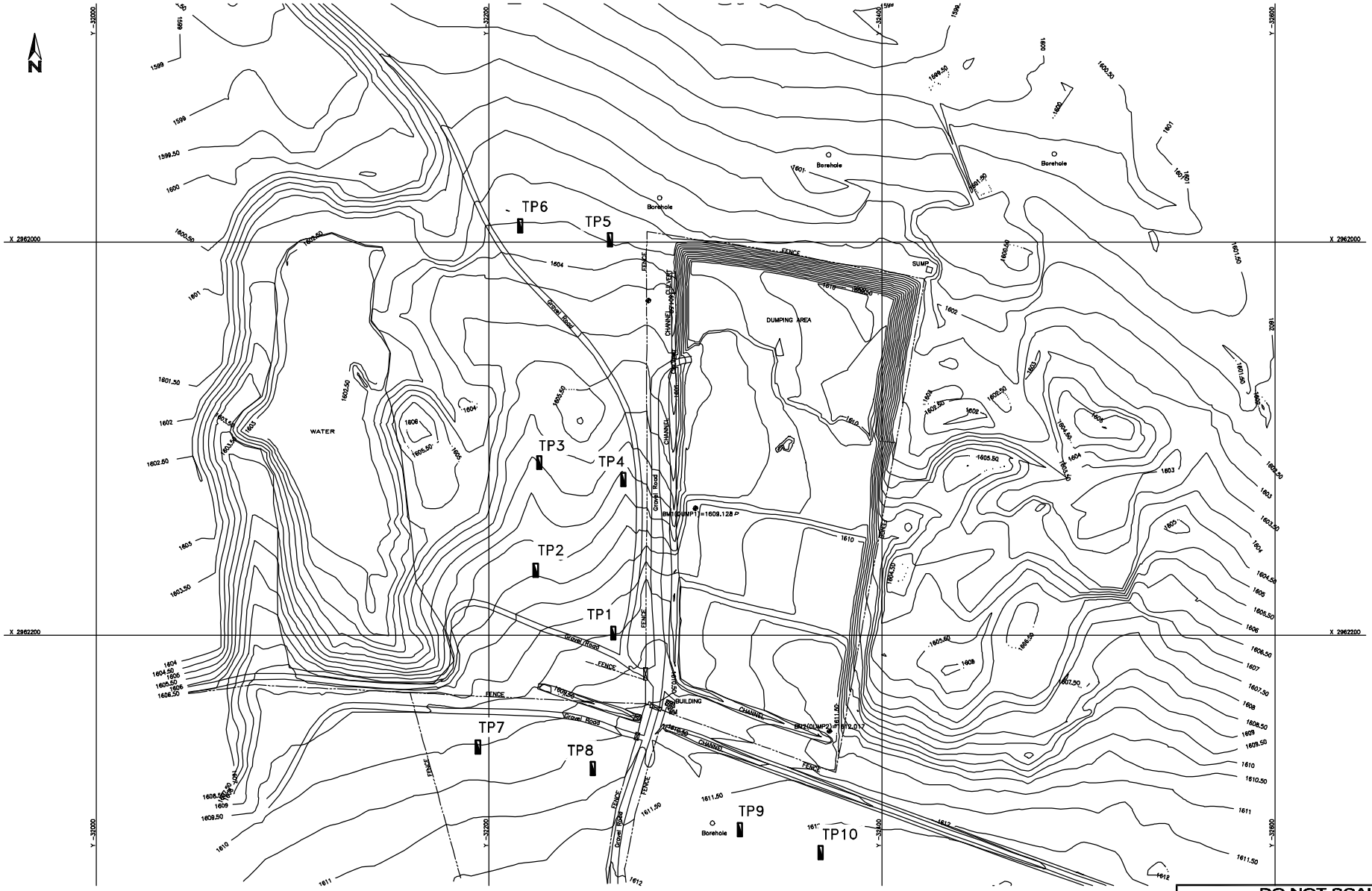
APPENDIX A

Figures

Figure A1: Site Locality Plan

Figure A2: Site Survey showing Testpit positions

Figure A1. Site Locality Plan



DO NOT SCALE

REVISION	DESCRIPTION	INITS	DATE CHECKED	INITS	DATE APPROVED

REFERENCES

ZITHOLELE CONSULTING

Zitholele Consulting (Pty) Ltd
MIDRAND OFFICE
Thandanani Park, Matuka Close, Midrand
P O Box 6002 , Halfway House, 1685
South Africa
Tel: +27(0)11 254-4800
Fax:+27(0)11 315-3284
http://www.zitholele.co.za

CLIENT			
ESKOM			
DRAWN	DATE	DRAWING CHECK	DATE
RS	03.11.09		
DESIGNED	DATE	DESIGN CHECK	DATE
AUTHORISED	DATE	SCALE	
		1:1000	

PROJECT	
TUTUKA POWER STATION LANDFILL EIA	
DRAWING TITLE	
GEOTECHNICAL INVESTIGATION SITE SURVEY SHOWING POSITIONS OF TEST PITS	
PROJECT No	DRAWING No / REVISION
12333	FIGURE A2 / A

A1

APPENDIX B

Test Pit Profiles and Photos

TUTUKA LANDFILL SITE

DETAILED SOIL PROFILES OF TEST PITS

TEST PIT TP1

0 – 0.2m	Moist, yellow brown, soft, intact, slightly silty clay with roots. Fill and topsoil.
0.2 – 0.45m	Slightly moist, loose, waste consisting of insulation, plastic, ash, etc
0.45 – 0.8m	Moist, dark grey with yellow gravel and sand particles, firm to stiff, intact, gravelly sandy clay. Colluvium.
0.8 – 1.4m EOH	Slightly moist, light yellow brown, dense, fractured, gravel. Highly weathered dolorite.
1.4 – 2.0m EOH	Slightly moist, light yellow brown, very dense, jointed/fractured, sandy gravel. Weathered dolorite.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP2

0 – 0.4m	Very moist, dark grey, soft, slickensided, slightly gravelly clay (turf). Colluvium.
0.4 – 0.7m	Slightly moist, light yellow brown, dense, fractured, gravel. Highly weathered dolorite.
0.7 – 1.5m EOH	Slightly moist, light yellow brown, very dense, jointed/fractured, sandy gravel. Weathered dolorite.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP3

0 – 0.25m	Very moist, dark grey, soft, slickensided, slightly gravelly clay (turf). Colluvium.
0.25 – 0.55m	Slightly moist, light beige brown, medium dense, intact, gravelly sand with rounded pebbles. Pebble marker.
0.55 – 1.0m EOH	Slightly moist, light yellow brown, dense to very dense, intact, sandy gravel. Weathered dolorite with onion skin weathered pebbles.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP4

0 – 0.45m	Very moist, dark grey to black, soft, slickensided, slightly gravelly clay (turf) with occasional dolerite cobbles. Colluvium.
0.45 – 0.60m	Slightly moist, light beige brown, medium dense, intact, gravelly sand with rounded pebbles. Pebble marker.
0.60 – 1.9m EOH	Slightly moist, light yellow brown, dense to very dense, intact, sandy gravel. Weathered dolorite with onion skin weathered pebbles.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP5

0 – 0.45m	Very moist, dark grey to black, soft, slickensided, slightly gravelly clay (turf). Colluvium.
0.45 – 0.75m	Moist, light orange brown, medium dense, intact, sandy gravel with rounded pebbles at base. Pebble marker.
0.75 – 2.1m EOH	Moist, light orange brown, dense to very dense, intact, sandy gravel with dolerite pebbles and cobbles. Weathered dolorite.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP6

0 – 0.50m	Very moist, dark grey to black, soft, slickensided, slightly gravelly clay (turf). Colluvium.
0.50 – 0.80m	Moist, light beige brown mottled black, firm/medium dense, intact, gravelly clay with pebbles at base. Pebble marker.
0.80 – 1.10m	Slightly moist, beige with black spots, dense, intact, gravelly sand. Highly weathered dolorite.
1.10 – 1.70m EOH	Moist, light orange brown, very dense, jointed, sandy gravel. Moderately weathered dolorite.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP7

0 – 0.40m	Very moist, dark grey to black, soft, slickensided, slightly gravelly clay (turf). Colluvium.
0.40 – 0.55m	Moist, light beige brown mottled black, firm/medium dense, intact, gravelly clay with pebbles at base. Pebble marker.
0.55 – 0.75m	Slightly moist, light beige brown, medium dense, intact, gravelly sand with rounded pebbles. Pebble marker.
0.75 – 1.35m EOH	Moist, light orange brown, very dense, jointed, sandy gravel. Moderately weathered dolorite.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP8

0 – 0.40m	Very moist, dark grey to black, soft, slickensided, slightly gravelly clay (turf). Colluvium.
0.40 – 0.55m	Moist, light beige brown mottled black, firm/medium dense, intact, gravelly clay with pebbles at base. Pebble marker.
0.55 – 0.70m	Slightly moist, light beige brown, medium dense, intact, gravelly sand with rounded pebbles. Pebble marker.
0.70 – 1.65m EOH	Moist, light orange brown, very dense, jointed, sandy gravel. Moderately weathered dolorite.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP9

0 – 0.30m	Very moist, dark grey to black, soft, slickensided, slightly gravelly clay (turf). Colluvium.
0.30 – 0.50m	Moist, light beige brown mottled black, firm/medium dense, intact, gravelly clay with pebbles at base. Pebble marker.
0.50 – 1.00m EOH	Slightly moist, light brown, very dense, jointed and laminated, sandy gravel. Weathered blocky dolorite.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

TEST PIT TP10

0 – 0.45m	Very moist, dark grey to black, soft, slickensided, slightly gravelly clay (turf). Colluvium.
0.45 – 0.55m	Moist, light beige brown mottled black, firm/medium dense, intact, gravelly clay with pebbles at base. Pebble marker.
0.55 – 1.00m EOH	Slightly moist, light brown, very dense, jointed and laminated, sandy gravel. Weathered blocky dolorite.
Notes:	1. Refusal on weathered dolorite. 2. No water encountered.

APPENDIX C