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VOLUME 1

Geotechnical Investigation Report

Majuba

General Waste Landfill Site,

ESKOM Majuba Power Station

PROJECT: LL3034
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DATE: May 2018
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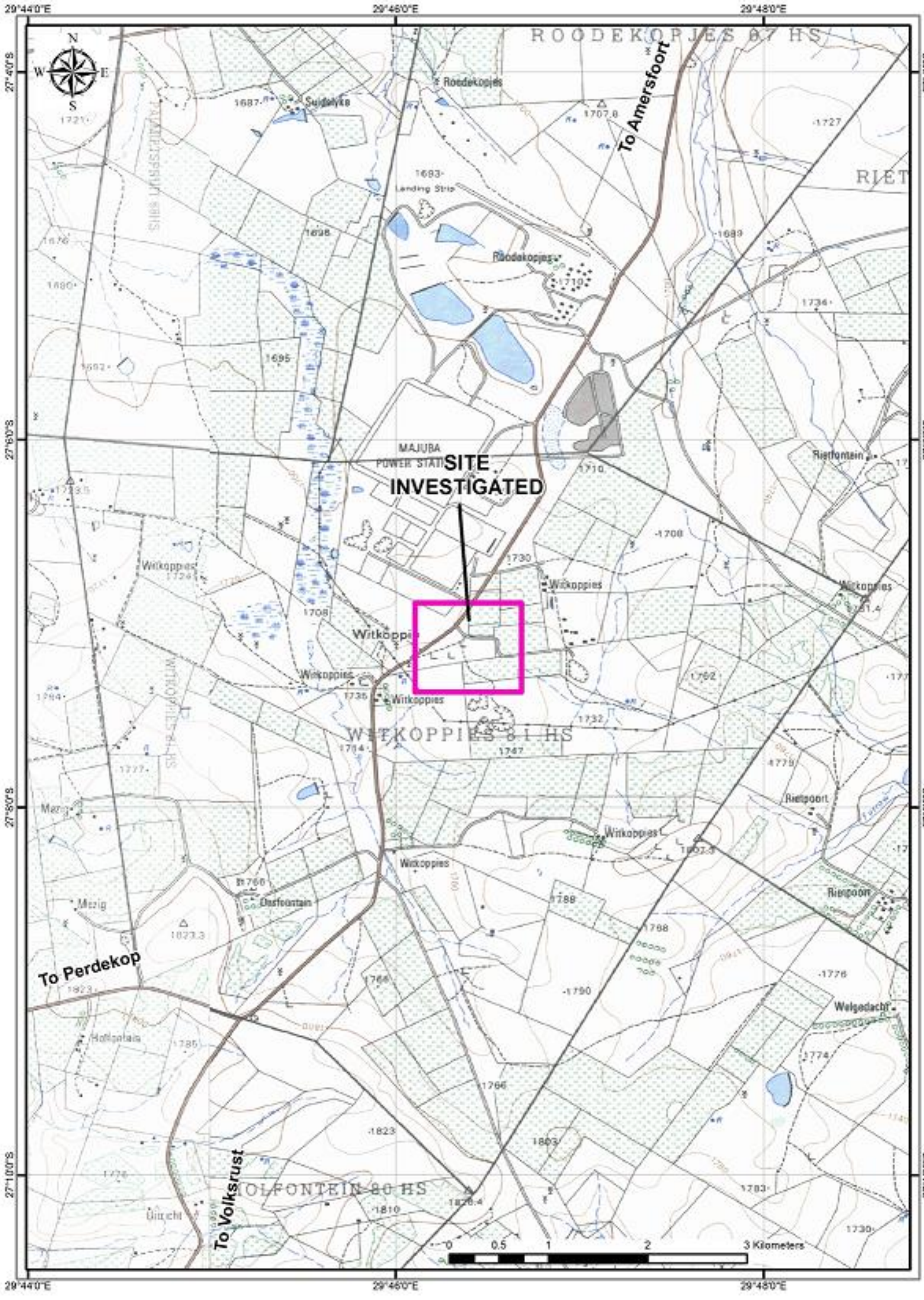

Figure 1. Locality Plan

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VOLUME 1

Geotechnical Investigation

Majuba General Waste Landfill Site, ESKOM Majuba Power Station

1. INTRODUCTION AND TERMS OF REFERENCE

Engeolab CC was appointed by BTW & Associates of Middelburg, Mpumalanga to conduct a geotechnical investigation for the Majuba General Waste Landfill Site at Majuba Power Station. The site is located on Portions 1 and 6 of the farm Witkoppies 81 HS on the southern side of Majuba Power Station – refer to the Locality Plan, Figure 1 in the beginning of the report.

The investigation's aim is to establish the geotechnical and geohydrological constraints of the proposed landfill site which will form part of the Basic Impact Assessment Report for the closure of the existing landfill site and the Scoping and Environmental Impact Report for the proposed new general waste disposal by landfill of G:C:B class.

The scope of work was outlined by quotation Q17-053, dated 3 March 2018. The appointment was confirmed by Mr. J.L. Bouwer Pr Eng. of BTW & Associates (PTY)Ltd on the 5th of March 2018 by means of an e-mail followed by additional correspondence indicating the area of investigation for the development.

The field work was conducted from Monday 9 April to Wednesday 11 April 2018 and on completion thereof, the soil samples were submitted to Letaba Lab, a soils laboratory in Witbank for testing. The water samples were submitted on the same day to Yanka Laboratories, a water laboratory located in Witbank. The results of the water sample tests were received on 16 April 2018 and the soil test results became available three weeks later on the 4th of May 2018.

The report is based on field observations, profiling, sampling, dynamic penetration tests and laboratory test results of representative disturbed soil samples and water samples that were taken from a small dam, a single borehole and four springs.

The report and its appendices are presented as Volume 1 and the drawings are contained in Volume 2.

2. AVAILABLE INFORMATION

The following available information includes:

- Site plan showing layout of the proposed development and boundaries of the site as produced by BTW & Associates (PTY)Ltd,
- A 1:250 000 scale geological series, Sheet 2728 Frankfort, as compiled by South African Geological Survey, 1988,
- Garmap Africa 2008 series,
- Google Earth imagery of the site,
- Map showing Majuba Power Station monitor boreholes,

- Majuba Power Station Ash Disposal: - Groundwater Scoping Study by Lidwala Consulting Engineers, October 2012,
- Minimum Requirements for Waste Disposal by Landfill. DWAF, Second Edition, 1998,
- Background Information Document 001 by BTW & Associates, dated 4 May 2018.

3. SITE DESCRIPTION AND ASSUMPTIONS

The proposed new waste landfill site is a Category B listed activity which entails the disposal of general waste to land covering an area of some 50,100m² with the total capacity of 25,000 tons which equates to 970 tons per year and an expected lifespan of 45 years. The landfill site will be constructed with associated infrastructure with sorting and storage facilities, plant and machinery, security parking and servicing area and an access road. The facility will also be secured with an all-round palisade, access control gate and a guard house.

The site can be accessed by the D979 gravel district road from Amsterdam to Volksrust and is located at co-ordinates 27° 07' 09.4" S and 29° 46' 18.93"E. The site is bounded in the north by the gravel district road which passes close to the security fence along the southern portion of Majuba Power Station. The combination of the district road, an overhead Eskom powerline and steep topography in the south, confines the site to a sidehill fill along the sloping northerly face of a local hillock.

The main access road to the closed landfill site which turns off the gravel district road will most probably also provide access to the new site – refer to Figure 2, the Site Plan. The closed landfill site has been fenced off but at the time of the investigation the 2.5m high security fence was in a state of disrepair and the main gate was broken. The closed waste landfill site is blanketed by a layer of soil which was imported during the routine maintenance by the contractor. Top soil had been scraped off over quite a large area to the south and to the east of the site, leaving some areas barren with exposed bedrock which had been eroded in places – refer to Figure 2, the Site Plan.

Several abandoned borrow pits in close proximity to the site are indicated on the Locality Plan, Figure 1 in the beginning of the report. It is presumed that the borrow materials were imported to the power station at the time of its construction.

The area surrounding the site is characterised by historically cultivated areas which had been turned over to pastures that are still used by local cattle breeders. The water seeps and springs are seemingly utilised for stock watering only.

As indicated on Figure 2, the Site Plan, several hillslope seepage wetlands located along the verges of the closed landfill site and the proposed site adjacent and to the east thereof were recorded.

As a sidehill fill, the proposed 50,100m² site extends from the crest of a hillock to the district road located about 180m downslope at an even gradient and surface run-off will naturally follow the topography towards the northern boundary. A hillslope seepage wetland was recorded along the north-western boundary of the closed landfill site, seemingly extending past the gravel district road in a north-westerly direction – refer to Figure 2, the Site Plan.

At the time of the investigation, the proposed site was undeveloped and covered by tall grass which made observations and moving about the site very difficult. The closed waste landfill site is partially overgrown with short grass, alien shrubs and a single Acacia Karoo sapling.

4. METHODS OF INVESTIGATION

4.1 Walk Over Survey

A walk-over survey was conducted to establish drainage features, access and to obtain a general overview of the site. An aerial photograph was used during the walk-over survey to assist in the site orientation, to determine the boundaries and its general outlay.

4.2 Test Pits – Proposed and Closed Landfill Sites

Nine test pits, denoted as TP1 to TP9 were excavated using a CAT 422E tractor-loader-backhoe to refusal depths ranging between 0.5 and 2.6m below existing ground level. Test pits deeper than 1.5m were profiled from surface for safety reasons. The profiling included typical visual and tactile descriptions of moisture, colour, consistency, structure, soil type and origin. The soil profiles are attached as Appendix A and the positions of the test pits are indicated on Figure 2, the Site Plan.

The test pit distribution included the proposed site where six test pits were excavated (TP1 – TP6) and the closed landfill site where test pits TP,7, 8 & 9 were excavated.

4.3 Soil Sampling and Laboratory Testing

Nine disturbed samples representative of the cover and in-situ soils inclusive of decomposed to highly weathered dolerite and shale were selected for laboratory testing to confirm the in-situ assessments of moisture, grading, plasticity, consistency, structure and to ascertain the engineering properties of each horizon.

The following tests were carried out on the samples: -

- Nine foundation indicator tests comprising particle size distribution analysis and Atterberg limit tests. In addition to this, the moisture content of each sample was also determined. These tests permit a basic classification of the soils and group them according to typical engineering properties.
- Three compaction tests comprising Modified AASHTO moisture/density relationships and California Bearing Ratio Values. These tests evaluate the compaction characteristics of the site soils and permit an evaluation of their suitability for use as construction materials.

Copies of the laboratory results are attached as Appendix B and for convenience, a summary of the laboratory test results is presented by TABLE 4.3.1 on the following page.

Table 4.3.1 Laboratory Test Results - Summary

TP No.	Origin	Sample No.	Sample Depth (m)	PI	GM	% Clay	% MC	Activity	Unified Soil Class	G Class
TP2	Clayey shale residuum	DS2A	0.7-0.9	25	0.41	31.8	33.5	M	MH	spoil*
TP4	shale residuum with flaky shale fragments	DS4A	0.3-0.8	12	1.72	23.4	15.6	L	SC	<G9
TP5A	hillwash	DS5A	0.1-0.3	20	0.59	15.5	26.6	L-M	CL	spoil*
TP5B	Sugary textured dolerite residuum	DS5B	0.3-0.9	9	2.33	2.9	7.5	L	SW/SC	G8*
TP5C	Weathered/fractured dolerite	DS5C	0.9-2.1	13	2.7	5.5	7.9	L	GW	G6*
TP6A	Sugary textured dolerite residuum	DS6A	0.4-0.9	6	2.1	3.4	9.2	L	SW/SM/SC	G8
TP6B	Weathered/fractured dolerite	DS6B	0.9-1.8	6	2.39	2.9	6.1	L	SW/SM/SC	G6
TP9A	alluvium	DS9A	0.1-0.7	24	0.33	15.6	29.5	M	CL	spoil*
TP9B	Clayey dolerite residuum	DS9B	0.7-2.2	25	0.49	34.4	29.0	M	MH	spoil*
	*=inferred									

Abbreviations: GM – Grading Modulus, PI – Plasticity Index; - L, M, H = Low, Medium & High Activity

Unified Soil Classification = **CL** - Inorganic clays of low to medium plasticity/lean clays; **SW/SM/SC** = gravelly sands, sand-clay mixtures, sand-silt mixes; **MH** = silt-clays of low plasticity; **SC** = sand-clay mixes; **GW** = well-graded gravels or gravel-sand mixes with little or no fines.

It is interesting to note that the clayey soils derived from in-situ decomposed dolerite and shale as well as the transported soils – that is alluvium and hillwash - tend to have a fairly high moisture content (26 - 33%), whilst the sugary textured dolerite residuum and flaky shale residuum recorded much lower values (10 - 15%). The liquid limits of the tested soils are almost double the recorded moisture content of the site soils indicating that the soils are only partially saturated.

4.4 Test pit and Topographical surveys

The test pit positions were surveyed using a Garmin Oregon 650 hand-held GPS and plotted on the drawing.

4.5 Geophysical Surveys

Three geophysical traverses were conducted alongside the proposed landfill site – refer to Figure 2, the Site Plan. The geophysical survey comprised electromagnetic and magnetic surveys and the aim thereof was to determine local fault zones and dolerite/country rock contact zones. The field data is attached as Appendix C to the report.

Two prominent electro-magnetic anomalies were recorded on Traverses Majuba PS-1 and PS-3 which were carried out parallel to each other.

4.6 Borehole and Spring Census

Five hillslope seepage wetlands were recorded on the site and another hillslope seepage along the toe of the closed landfill site. A 44.2m deep monitor borehole with a static water level at 9.7m below ngl was recorded near a small leachate (?) dam located on the north-western corner of the closed landfill site – refer to Figure 2, the Site Plan.

4.7 Water Sampling

Three of the hillslope seepage wetlands, a single monitor borehole and a small dam (leachate ?) were sampled and the samples were submitted to Yanka Water Laboratory in Witbank for chemical analyses. The test results are attached as Appendix D to the report.

Water quality data, Durov - and Piper diagrams of the water sample data are also included in Appendix D. Piper diagrams are graphical representations of the chemistry of the water samples whilst Durov diagrams are used to represent the dissolved constituents of natural water and show plausible hydrochemical processes.

4.8 DCP's

Hand-held DCP's were carried out adjacent to each test pit and numbered accordingly. The DCP test data is attached as Appendix E to the report.

5. GEOLOGY AND SITE SOILS

The site is underlain by sediments – that is shale and sandstone of the Vryheid Formation, intruded by Post-Karoo dolerite as sheets or sills, often capping the low hills in the area – see Figure 3A, Regional Geology and Figure 3B, the Site Geology as well as Table 5.1 below.

Shallow weathered and intensely fractured dolerite was exposed along the southern fringes of the closed landfill site as well as within the deeply eroded access road – refer to test pits TP1 and TP7. Elsewhere, the bedrock was blanketed by transported soils – that is hillwash and alluvium. The latter covers the area along the toe of the closed landfill site, extending across the district road in a north-westerly direction. Scattered sandstone outcrop was noticed further to the east as well as along the steeper southerly slope of the hillock. The soil and bedrock variations are also indicated on Figure 4, Soil Profiles.

Table 5.1: - Stratigraphic Sequence Of The Site

Lithology	Sub-Group	Group	Sequence
Dolerite	Intrusive	- - -	Post-Karoo
Shale and sandstone	Vryheid	Ecca	Karoo Super Group

The site falls within a region with a Weinert N-Value of 1.3 indicating that chemical decomposition is the dominant mode of weathering.

A north-west trending structural lineament concealed by cover-rocks – thought to be either a fault line or a dolerite dyke - was inferred from the geophysical data and is indicated on Figure 3B, the Site Geology.

6. GEO-ENVIRONMENTAL FACTORS

The southern boundary of the site more or less run along the ridge line, sloping towards the northern boundary along the gravel district road some 200m away. Several hillslope seepage wetlands were identified – refer to Figure 5, Surface Hydrology. These wetlands ostensibly emanate at the dolerite/sedimentary bedrock contact zones to form spring lines at various elevations on and below the landfill terrain, draining away to form wetlands covered by thick stands of hydrophilic grasses and -shrubs.

The water quality data of the hillslope seepage wetlands, the single monitor borehole and the small dam that were sampled on site has been used to determine the hydrochemical characteristics of the closed and proposed waste landfill site's groundwater.

The groundwater quality in terms of electrical conductivity and pH of the site's water sample points give an indication of the present status – refer to Table 6.1 below. In terms of the Class 1 (DWA) water quality, the pH may vary from 4.5 – 10.0 and the electrical conductivity (EC) should be less than 1000mS/m.

TABLE 6.1 Water Quality Data

SOURCE	pH	EC (mS/m)
Spring 1	6,4	23,4
Spring 2	8,17	65,2
Spring 3	7,19	108
Spring 4	8,06	132
Dam	6,96	36,7
Monitor borehole	7,94	66,6

The existing hydrochemical data presented on the Piper Diagram suggests Ca-HCO_3 water type which is typical of recently recharged and shallow aquifers.

6.1 Proposed Landfill Site – Seepage, Surface Run-off and Drainage Conditions

The shallow spring line at 1742m AMSL could almost be in the leachate leakage at excavation refusal depth indicating potential development of phreatic surface within the fill – a design parameter that will have to be taken into consideration – refer to Figure 6 Excavatability. However, this will require minimal infiltration into the fill and good management of surface run-off, as well as continuous inter-layering and good fill - as well as site drainage management.

6.2 Closed Waste Landfill Site – Seepage, Surface Run-off and Drainage Conditions

A well-developed hillslope seepage wetland extends from the north-western toe of the fill, draining in a predominantly north-western direction. Although some seepage was recorded in the base of the 2.6m deep test pit (TP9) excavated near the toe of the closed waste landfill site, the static water level of the monitor borehole was recorded at 9,67m below ngl.

The current site drainage seems functional as erosion of the closed waste landfill site was observed appearing to be adequately vegetated. The main access road's erosion protection has been washed away, exposing shallow weathered bedrock. Where top soil material had been scavenged, weathered bedrock was exposed along the closed waste landfill site's southerly boundaries and beyond – refer to Figure 2, the Site Plan.

7. GEOTECHNICAL APPRAISAL

7.1 Excavatability and Foundation Type

The predicted excavatability of the site soils and bedrock is classified according to SANS 1200D and is presented by Table 7.1.1 below. The excavation refusal depths of the TLB recorded on site are indicated on Figure 6, the Excavation Plan. The average excavation depth on the proposed landfill site is 1.3m but ranging between 0.5 (TP1) and 2,2m (TP3). An estimated total of 65,130m^3 of soft excavatable material and some 15,000m^3 of intermediate excavatable material should be available for construction/backfilling/capping purposes. No boulder excavation is envisaged on site and hard rock excavation can be expected at TLB refusal depth.

Table 7.1.1: Excavation Classes (Modified SABS 1200D)

Sample Position	Simplified Description of Typical Material Properties
Soft excavation	Material that can be efficiently removed or loaded, without prior ripping, by means of a bulldozer, tractor-scraper, track type front-end loader or back-acting excavator without the use of pneumatic tools such as paving breakers.
Intermediate excavation	Material that can be efficiently ripped by a bulldozer fitted with a single-tine ripper or with a back-acting excavator of flywheel power exceeding **0,10 kW per mm** of tined-bucket width or the use of pneumatic tools before removal by equipment equivalent to that specified above.
Hard rock excavation	Excavation in material that cannot, before removal, be efficiently ripped by a bulldozer. This is material that cannot be efficiently removed without blasting or without wedging and splitting.
Boulder excavation (Class A)	Excavation in material containing more than 40 % by volume boulders of size in the range of 0,03-20m3, in a matrix of soft material or smaller boulders.
Boulder excavation (Class B)	Excavation in material containing 40 % or less by volume boulders of size in the range of 0,03-20m3, in a matrix of soft material or smaller boulders and which require individual drilling and blasting in order to be loaded by a track type front-end loader or back-acting excavator.

It is assumed that the proposed landfill site will be excavated to bedrock level which is present at an average depth of 1.3m. The foundation materials – both shale and dolerite bedrock are regarded as competent or stronger than fill materials and are therefore not subject to adverse pore pressure or adverse geological structures.

7.2 On-Site Materials Suitability

7.2.1 Cover Material & Other Material Sources

Waste must be covered daily to reduce odours, nuisance conditions, vermin, fires and scavengers. It should be ideal to obtain this material from or close to the site or even have this material stockpiled on site. Where this material is too clayey – such as the hillwash, alluvium and clayey dolerite and shale residuum, it may form horizontal impermeable layers or preferential flow paths that could surface on the side slopes the landfill. The ideal soils are the sandy soils - that is mainly the sugary textured dolerite residuum that was exposed in TP3, 5 and 6, generally about 0.6m thick with an estimated volume of 280m^3.

Other sources of sandy material may be available in the borrow pits to the south of the site – refer to Figure 7, Other Material Sources.

7.2.2 Liner Material & Other Material Sources

Material selection for the proposed landfill's lining system is confined to the area investigated. Ideally the site should be situated in an area with suitable clayey in-situ material which is ideal for landfill construction. As a guideline, the DWA "Minimum Requirements for Waste Disposal by Landfill" stipulates the following for a clay liner soil: -

- Plasticity Index >10%
- Particle Size <25mm
- Permeability $<1x\ 10^{-6}$ cm/s

This permeability rate is also highly dependent on the compaction of the material together with the moisture content and plasticity index and the following soils are anticipated as suitable for a clay liner: -

Table 7.2.2.1 Summary of Suitable Clay Liner Material

Horizon	PI	Permeability* (cm/s)	Thickness (m)	Estimated Volume (m^3)	Excavation Class	Site Constraints
Hillwash	20	1.9E-0	0.3	4,500	soft	Grass roots to 0.1m
Alluvium	24	5.3E-07	0.6	240	soft	Shallow perched water table & grass roots to 0.1m
Shale residuum	12 - 25	5.0E-07	0.3	170	soft	-
Clayey dolerite residuum	25	5.9E-07	1.5	600	soft	Perched water table

*inferred from soil test data – refer to 'ESTIMATED SOIL PROPERTIES' attached as Appendix B to the report.

An estimated volume of some 5,510m^3 of soft excavatable material suitable for a clay liner may be sourced from various horizons on – and in close proximity to the proposed landfill site. Other material sources suitable for the clay liner may be available in the low-lying flood plain of the local streams – refer to Figure 7, Other Material Sources.

As far as can be ascertained there is no clean sand available on site which could be used as the protection layer on top of a geomembrane and even as a leakage detection layer if the sand is of suitable quality and evenly grained.

7.3 Compaction characteristics

Three disturbed representative soil samples were submitted for compaction tests and foundation indicators – refer to Table 4.3.1, Chapter 4.3. The volume of spoil exceeds the better-quality construction material (G6 – G9 class) which appears to limited on site and selected fill, base course and upper sub-base materials for pavement materials will need to be imported from yet unproven sources in the vicinity of the site or from commercial sources.

7.4 Stability of Excavations

The stability of the test pit excavations was assessed by simple field tests such as: -

- the ease of excavation by the backhoe and;
- slumping/ravelling of the test pit side walls occurring within 30 minutes from time of excavation;
- stand-up times of the test pit excavations.

Although no shear strength tests were carried out at this stage of the investigation, the predominantly fine material together with the moderate to high plasticity thereof indicates that an average estimated angle of internal friction of some 25° can be anticipated. Although no slumping occurred within the test pits excavated on the proposed landfill site – that is TP1 to TP6 and the excavations were seemingly safe, it is recommended that the sidewalls of all excavations deeper than 1.5m should be shored or cut back to 60° from the horizontal. Furthermore, spoil from excavations should not be placed closer than the equivalent depth of the excavation to avoid unnecessary loading of the sidewalls, especially under very moist or saturated conditions as is expected on site. As the terrain dips towards the northern boundary, slope instability of soil berms/landfill containment walls can be expected and cognisance should be taken of the engineering characteristics of the site – and imported soils as well as the foundation bedrock.

It is recommended that excavations in excess of 1.5m be inspected by an experienced professional to assess the safety thereof. Notwithstanding this, the responsibility of safe excavations remains with the contractor who is in the best position to assess the stability thereof during construction.

7.5 Site Drainage

A storm water management system should be designed to remove all surface water from the site and direct it to natural drainage lines. It is emphasised that the storm water system accommodates the removal of any accumulated surface water and it should also conform to drainage requirements of landfill sites in general.

7.6 Closed Landfill Site

The closed landfill site has been capped as part of the routine maintenance procedures and the contractor used top soil material ostensibly obtained from site and areas in close proximity. The single test pit (TP8) excavated in the middle of the capped landfill site exposed industrial waste, domestic refuse and building rubble intercalated with imported soil layers. No seepage was recorded and the material was dry. Tension cracks related to sliding movements or settlement associated with highly compressible refuse were not detected and the sandy nature of the top soil layer prevented it from shrinking or expanding and the relatively smooth surface was seemingly undisturbed. No odours could be detected, there were no vermin or scavengers nor any fires. Some grasses, alien shrubs and a single Acacia Karoo sapling had sprouted on the top soil layer indicating a stable environment.

8. DISCUSSIONS AND DEVELOPMENT RECOMMENDATIONS

8.1 General

The closed - and proposed landfill sites are underlain by sedimentary bedrock intruded by a dolerite sill in various stages of decomposition. The bedrock is sequentially blanketed by residuum and transported soils that can be applied as clay liner - and capping material. Excavation refusal depths within the sedimentary and intrusive bedrock vary on the terrain with the deeper excavation achieved within the weathered intrusive dolerite.

Whether the inferred 'fault' or 'dyke' referred to in Chapter 5 has created groundwater compartments or acts as a channel-way connecting the elevated water 'reservoirs' with the lower-lying three wetlands is unknown and can only be determined by drilling boreholes to assess the bedrock geology, to monitor and to model the groundwater regime and - flow direction(s) on the site.

8.2 Closed Waste Landfill Site

The closed waste landfill site appears to be well-constructed and the routine maintenance has seemingly been done thoroughly. Erosion, settlement, tension cracks and downhill creep were not observed thereby indicating negligible to low failure hazard potential.

The seepage emanating along the toe of the fill is attributed to typical groundwater drainage rather than leachate from the landfill site.

8.3 Surface Hydrology, Drainage and Monitoring

Several perennial and non-perennial hillslope seeps ostensibly emanating at the dolerite/sedimentary bedrock contact zones form spring lines at various elevations on and below the landfill terrain, draining away to form wetlands – refer to Figure 5, Surface Hydrology. The shallow spring line indicates a possible aquifer at 1742m AMSL which could almost be in the leachate leakage at excavation refusal depth indicating limiting potential of phreatic surface within the fill. However, this will require minimal infiltration into the fill and good management of surface run-off.

The following aspects will also have to be addressed, namely: -

i) a sub-soil drainage system underneath the layer works;
ii) monitor boreholes for groundwater modelling and water quality monitoring;
iii) erosion protection and prevention;
iv) storm water system.

8.4 Excavatability

The excavation refusal depths presented by Figure 6, Excavatability, indicate a deeper excavation trend along the ridge and to the south-east which should be taken into account with the future investigation/planning of the site.

8.5 Clay Liner and Capping Material

Site soils suitable for clay liner application and capping material required at the proposed landfill are present on site but not in sufficient quantities and additional material will have to be obtained elsewhere. Several alternative sites have been identified in close proximity to the site – refer to Figure 7; other options include the use of soil/ash mixes, geosynthetic clay liners or soil enhancement by mixing the on-site materials with bentonite or resins. The latter is very expensive and requires extensive laboratory testing to determine the required mixture to achieve the necessary permeability requirements to ensure consistent mixing, moisturising and placing.

8.6 Sandy Protection Layers and Sandy Detection Layers

No clean, evenly graded sands of suitable quality that may be required for protection layers on top of a HDPE geomembrane and even as leakage detection layers were recorded on site but may be available in the floodplains of streams that drain the surrounding area.

8.7 Topographical Surveys

It is recommended that a topographical survey be carried out for accurate on-site measurements for the design and operational control and planning of the proposed landfill site.

9. ISSUES TO BE ADDRESSED

The followings aspects should be addressed during the detailed EIA phase to be carried out for both the closed and the proposed waste landfill sites, namely: -

9.1 Additional Water Sampling

Water samples are to be taken on a quarterly interval of springs, wetlands and drainage courses within a 1km radius of the site to assess the surrounding country side's ambient water quality more thoroughly.

9.2 Insufficient clay liner material is present on site and it is recommended that a GCL be used as the containment barrier of the landfill site.

10. GENERAL

Variances in groundwater, soil and rock quality and quantity from those predicted may be encountered during construction and these should be recorded, however no warranty against these variations is expressed or implied, due to the geological changes that can occur over time due to natural processes, or human activity.

However, it is impossible under the constraints of a feasibility study of this nature to guarantee that zones of poorer geological materials or deeper excavation or better quality water were not identified that could have had a significant bearing on the outcomes thereof. The investigation has therefore attempted, through interpolation and extrapolation at known test locations, to identify problem issues of a geotechnical and groundwater nature on which this report is based.

Every effort was made during the feasibility study to ensure that generally accepted practices of our profession were used in the sub-surface evaluation of the site, and that the sampling and testing was representative of the soil/rock/water conditions observed on-site.

11. BIBLIOGRAPHY

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12. APPENDICES

- Appendix A Test Pit Profiles
- Appendix B Soil Test Data
- Appendix C Geophysical Data
- Appendix D Water Test Data
- Appendix E DCP’s

Appendix A
Test Pit Profiles

BTW Associates
Eskom Majuba

HOLE No: TP01
Sheet 1 of 1

JOB NUMBER: LL3034

Scale 1:10

0.00	Moist, dark brown, loose, intact, clayey SAND with grass roots; Transported Top Soil.
0.30	Moist, light beige, firm, intact, Sandy CLAY with angular and tabular shale fragments; Transporter Soils.
0.40	Moist, dark-khaki-brown, medium dense, intact, coarse surgery textured, clayey SAND derived from in-situ decomposed DOLERITE.
0.50	

NOTES

1) No seepage

2) Refusal on fractured dolerite.

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

INCLINATION : Vertical
DIAM :
DATE :
DATE : April 2018

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

ELEVATION :
X-COORD : S27 07' 11.5"
Y-COORD : E26 46' 23.3"

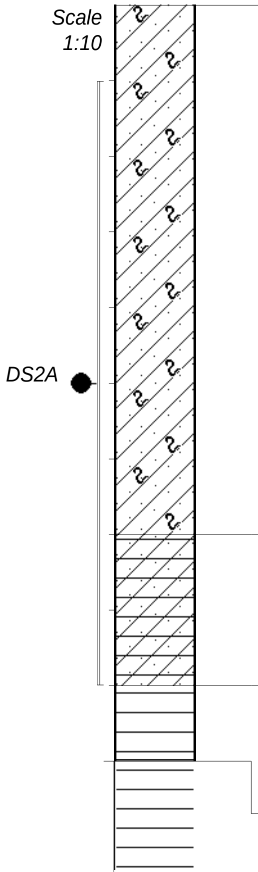
HOLE No: TP01

BTW Associates
Eskom Majuba

HOLE No: TP02
Sheet 1 of 1

JOB NUMBER: LL3034

Scale 1:10



0.00 — Moist, dark brown, firm, intact, sandy CLAY with grass roots to 0.1m; Hillwash.

0.70 — Moist, beige streaked yellowish-orange, firm to stiff, intact, sandy CLAY derived from in-situ decomposed SHALE.

0.90 — Light beige streaked orange with some relict fracture surfaces and bedding planes, laminated to thinly bedded, closely to medium jointed very soft rock SHALE.

1.00 — Refusal of backhoe on beige slightly weathered SHALE.

NOTES

1) No seepage

2) Sampled as follows: DS2A 0.1m--0.9m

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : April 2018

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

ELEVATION :
X-COORD : S27 07' 04.6"
Y-COORD : E29 46' 21.8"

HOLE No: TP02

BTW Associates
Eskom Majuba

HOLE No: TP03
Sheet 1 of 1

JOB NUMBER: LL3034

Scale 1:15

0.00 – 0.30	Moist, dark brown to greyish-black, medium dense, intact, medium grained clayey SAND with grass roots; Hillwash.
0.30 – 1.00	Moist, dark-khaki-brown, medium dense, intact, coarse surgery textured, clayey SAND derived from in-situ decomposed DOLERITE.
1.00 – 2.10	Dark khaki-brown with ivory specks, close to medium fractured with zones of spheroidal gravels in a sugary textured matrix as above, decomposed to highly weathered amygdaloidal DOLERITE.
2.10 – 2.20	Slow excavation of backhoe in close to medium fractured and less weathered DOLERITE than above.

NOTES

1) No seepage

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : April 2018

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

ELEVATION :
X-COORD : S27 07' 07.2"
Y-COORD : E29 46' 29.2"

HOLE No: TP03

BTW Associates
Eskom Majuba

HOLE No: TP04
Sheet 1 of 1

JOB NUMBER: LL3034

Scale 1:10

0.00	Moist, dark greyish-brown, firm, intact, Sandy CLAY with grass roots; Hillwash.
0.30	Abundant orange-brown partially slaked flakey SHALE fragments and tabular SHALE gravels in a matrix of moist, dull grey firm CLAY; - highly weathered SHALE.
0.80	Dull grey, highly weathered, thinly bedded and close to medium jointed soft rock SHALE.
1.20	Refusal on dull grey slightly weathered SHALE.

DS4A

NOTES

1) Point seepage at 1.2m

2) Sampled as follows: DS4A 0.3m--0.8m

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer
TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : April 2018
DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

ELEVATION :
X-COORD : S27 07' 03.9"
Y-COORD : E29 46' 31.7"

HOLE No: TP04

BTW Associates
Eskom Majuba

HOLE No: TP05
Sheet 1 of 1

JOB NUMBER: LL3034

0.00	DS5A	Moist, dark greyish-brown, firm, intact, Sandy CLAY with grass roots; Hillwash.
0.30	DS5B	Moist, khaki-brown speckled ivory, loose to medium dense, sugary textured coarse clayey SAND derived from in-situ decomposed amygdaloidal DOLERITE.
0.90	DS5C	Brown speckled ivory, medium weathered, medium fractured, highly weathered very soft amygdaloidal DOLERITE.
2.10		Refusal on brown stained, medium fractured, slightly weathered DOLERITE.

Scale 1:10

NOTES

1) Ponding in base of test pit.

2) Sampled as follows: DS5A at 0.1m--0.3m; DS5B 0.3m--0.9m; DS5C 0.9m--2.1m .

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : April 2018

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

ELEVATION :
X-COORD : S27 07' 10.2"
Y-COORD : E29 46' 33.1"

HOLE No: TP05

BTW Associates
Eskom Majuba

HOLE No: TP06
Sheet 1 of 1

JOB NUMBER: LL3034

Scale 1:10

0.00	Moist, dark greyish-brown, firm, intact, Sandy CLAY with grass roots; Hillwash.
0.40	Moist, khaki-brown, medium dense, intact, coarse surgery textured, clayey SAND derived from in-situ decomposed DOLERITE.
0.90	Brown speckled ivory, medium weathered, medium fractured, highly weathered very soft amygdaloidal DOLERITE.
1.80	Slow excavation from 1.7m in less weathered DOLERITE.

DS6A

NOTES
1) No seepage

2) Sampled as follows: DS6A at 0.4m--0.9

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : April 2018

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

ELEVATION :
X-COORD : S27 07’ 07.6"
Y-COORD : E29 46’ 24.8"

HOLE No: TP06

BTW Associates
Eskom Majuba

HOLE No: TP07
Sheet 1 of 1

JOB NUMBER: LL3034

Scale 1:10

0.00	Shale fragments and tabular gravels loosely packed in a matrix of, moist, light beige-brown sandy CLAY derived from in-situ decomposed SHALE.
0.30	Moist, khaki-brown speckled ivory, loose to medium dense, sugary textured coarse clayey SAND derived from in-situ decomposed amygdaloidal DOLERITE.
0.50	Refusal on light grey DOLERITE with brown stained relict fracture surfaces.

NOTES

1) No seepage

2) DOLERITE outcrop ±5m north-west of test pit.

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : April 2018

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

ELEVATION :
X-COORD : S27 07' 13.4"
Y-COORD : E29 46' 16.3"

HOLE No: TP07

BTW Associates
Eskom Majuba

HOLE No: TP08
Sheet 1 of 1

JOB NUMBER: LL3034

Scale 1:10

0.00 – 0.30	Slightly moist, brown, medium dense, intact, medium grained clayey SAND with grass roots; Imported Topsoil - Capoing Layer.
0.30 – 2.00	Domestic waste intercalated with soil layers as above; Imported Topsoil.

NOTES

1) No seepage

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : April 2018

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

ELEVATION :
X-COORD : S27 07' 08.9"
Y-COORD : E29 46' 19.0"

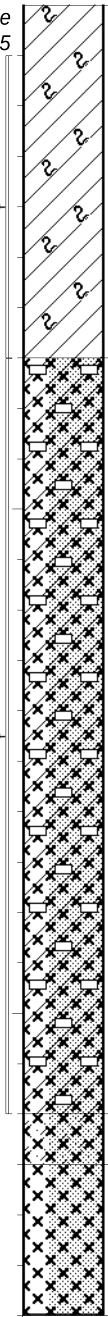
HOLE No: TP08

BTW Associates
Eskom Majuba

HOLE No: TP09
Sheet 1 of 1

JOB NUMBER: LL3034

Scale 1:15



DS9A

DS9B

0.00 Moist black, fine to stiff, slickensided CLAY with grass roots; Hillwash.

0.70 Moist, olive-brown, firm, slickensided CLAY with abundant CALCRETE Nodules derived from in-situ decomposed DOLERITE.

2.20 Moist, khaki-brown speckled ivory, loose to medium dense, sugary textured coarse clayey SAND derived from insitu decomposed amygdaloidal DOLERITE.

2.30 Brown speckled ivory, medium weathered, medium fractured highly weathered very soft amygdaloidal DOLERITE.

2.60

NOTES

1) Ponding in base of test pit

2) Sampled as follows: DS9A 0.1--0.7m; DS9B 0.7m--2.2m

CONTRACTOR : ROTEK
MACHINE : CAT422E
DRILLED BY : Mandla
PROFILED BY : PG Hansmeyer

INCLINATION :
DIAM :
DATE :
DATE : April 2018

ELEVATION :
X-COORD : S27 07' 05.4"
Y-COORD : E29 46' 14.2"

HOLE No: TP09

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

BTW Associates
Eskom Majuba

LEGEND
Sheet 1 of 1

JOB NUMBER: LL3034

	GRAVELS	{SA02}
	SAND	{SA04}
	SANDY	{SA05}
	CLAY	{SA08}
	CLAYEY	{SA09}
	SHALE	{SA12}
	HYPABYSSAL/anorthosite/syenite aplite	{SA18}
	GABBRO FAMILY	{SA42}
	DOLERITE	{SA18}{SA42}
	CALCRETE NODULES	{SA27}
Name	DISTURBED SAMPLE	{SA38}
	ROOTS	{SA40}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : A. Nolan
SETUP FILE : STANDARD.SET

DATE : 14/05/2018 09:47
TEXT : C\dotFILES\LL3034.txt

LEGEND
SUMMARY OF SYMBOLS

Appendix B
Soil Test Data

LETABA LAB (Pty) Ltd
CIVIL ENGINEERING MATERIALS LABORATORY

Reg No. 1995/12513/07
Vat No. 4630157248

♦ Polokwane
♦ Bloemfontein
♦ Mbombela (Nelspruit) **
♦ Tzaneen
♦ eMalahleni (Witbank)
♦ Mashishing (Lydenburg)

Tel. No: 087 285 0816 **e-mail :** letaba@letabalab.co.za www.letabalab.co.za

GRAVEL, SOIL AND SAND ANALYSIS

TMH 1:1986
Method A1-A6,A7, A8 & A9*

Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park

Date Sampled: 13-Apr-18

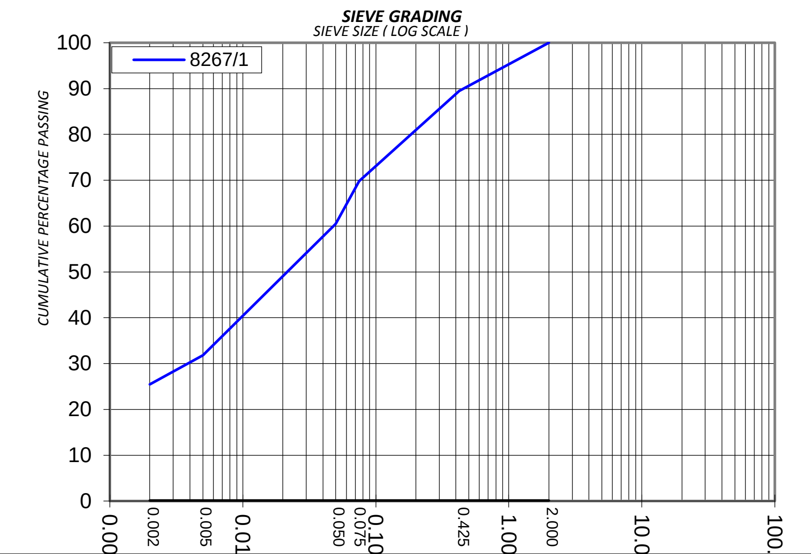
Contract : **LL3034 - Majuba Power Station**

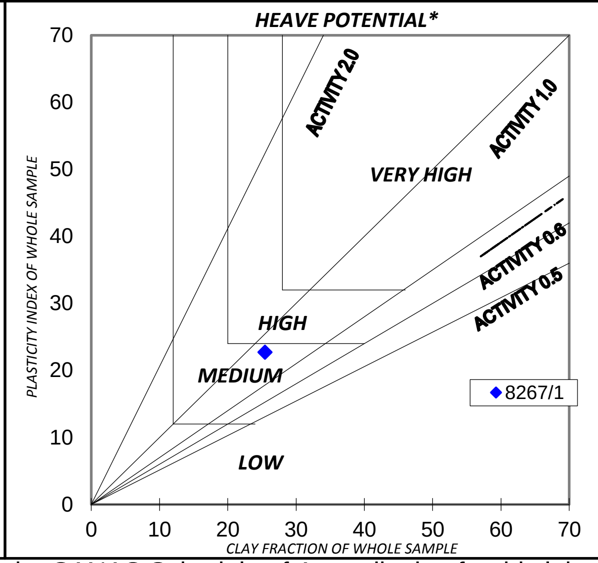
Doc No: 8267/1(i)

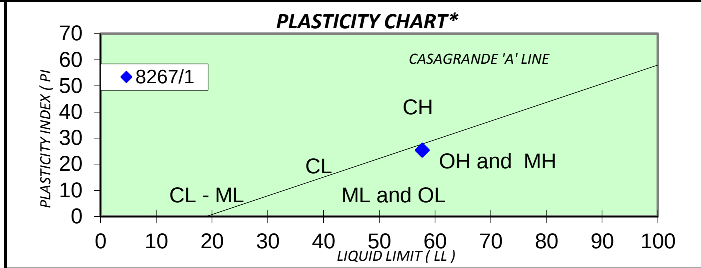
Description : **TP 2 DS2A from 0.1-0.9 m below existing ground level**

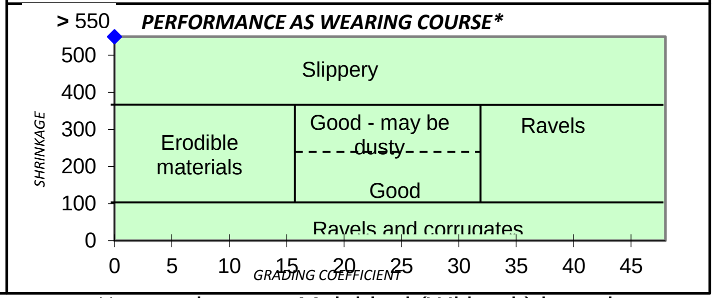
Date Tested: 13-Apr-18

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis – Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Soil Mortar Analysis % of mat. <2,00 mm*: Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications*: Unified Soil	COLTO	US.Highway	Group Index
0.1-0.9	8267/1	drk Olive Inorganic silt							100	89	70	60.5	31.8	25.5	10.5	19.7	28.7	31.8	<0.002	48.0	0.3	0.41	58	25	12.7	MH	N/A	A-7-5	16









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch
THIS MATERIAL IS NOT SUITABLE FOR WEARING COARSE AS THE SHRINKAGE PRODUCT IS GREATER THAN 550

pH =7.31 , Electrical Conductivity =0.9243 mS/cm Moisture Content = 33.5%

Please note that test results are only relevant to the sample delivered to the lab by the client. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any opinions and interpretations expressed fall outside the scope of our accreditation.

Date Issued: 3/May/18 *Technical signatory (Name) :* **H.P. du Preez** *Signature:*

LETABA LAB (Pty) Ltd
CIVIL ENGINEERING MATERIALS LABORATORY
Reg No. 1995/12513/07
Vat No. 4630157248
♦ Polokwane ♦ Bloemfontein ♦ Mbombela (Nelspruit) **
♦ Tzaneen ♦ eMalahleni (Witbank) ♦ Mashishing (Lydenburg)
Tel. No: 087 285 0816 **e-mail :** letaba@letabalab.co.za www.letabalab.co.za

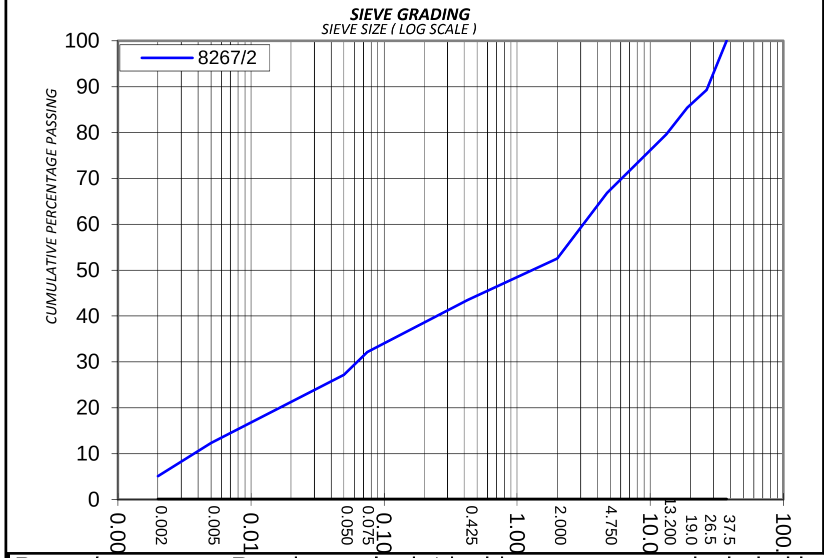
GRAVEL, SOIL AND SAND ANALYSIS

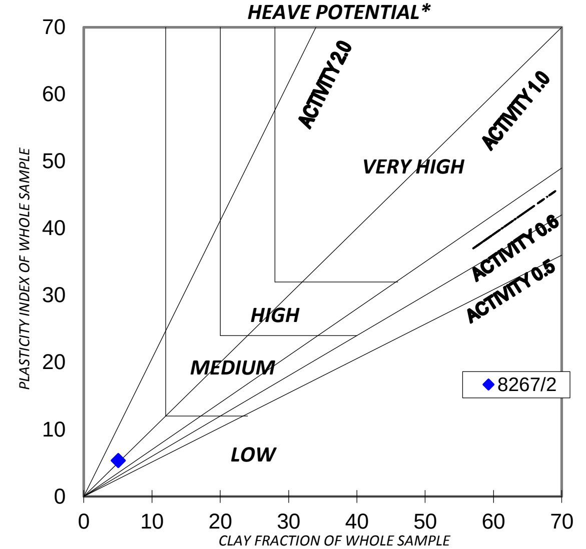
TMH 1:1986
Method A1-A6,A7, A8 & A9*

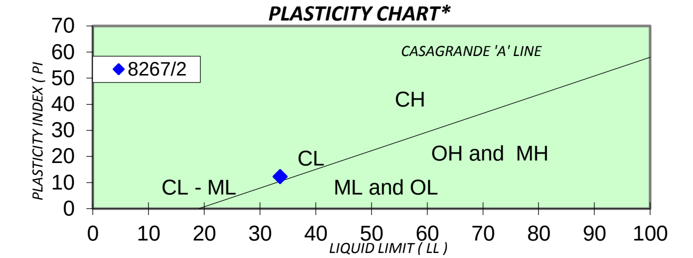
Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park
Contract : **LL3034 - Majuba Power Station**
Description : **TP 4 DS4A from 0.3-0.8 m below existing ground level**

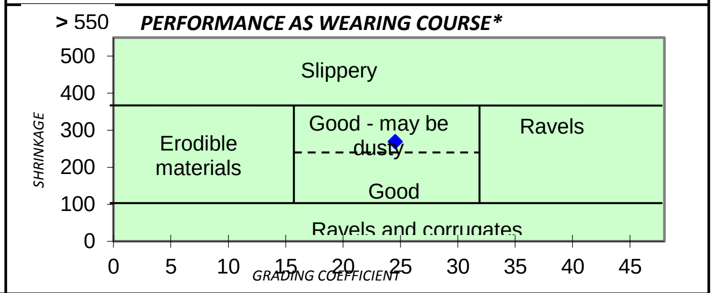
Date Sampled: 13-Apr-18
Doc No: 8267/2(i)
Date Tested: 13-Apr-18

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis – Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Soil Mortar Analysis % of mat. <2,00 mm*: Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications*: Unified Soil	COLTO	US.Highway	Group Index
0.3-0.8	8267/2	drk Olive Clayey sand		100	89	85	80	67	53	43	32	27.1	12.3	5.1	17.3	21.5	28.2	23.4	0.004	840.5	0.3	1.72	34	12	6.2	SC	<G9	A-2-6	0









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch

pH =7.69 , Electrical Conductivity =0.4917 mS/cm **Moisture Content = 15.6%**

Please note that test results are only relevant to the sample delivered to the lab by the client. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any opinions and interpretations expressed fall outside the scope of our accreditation.

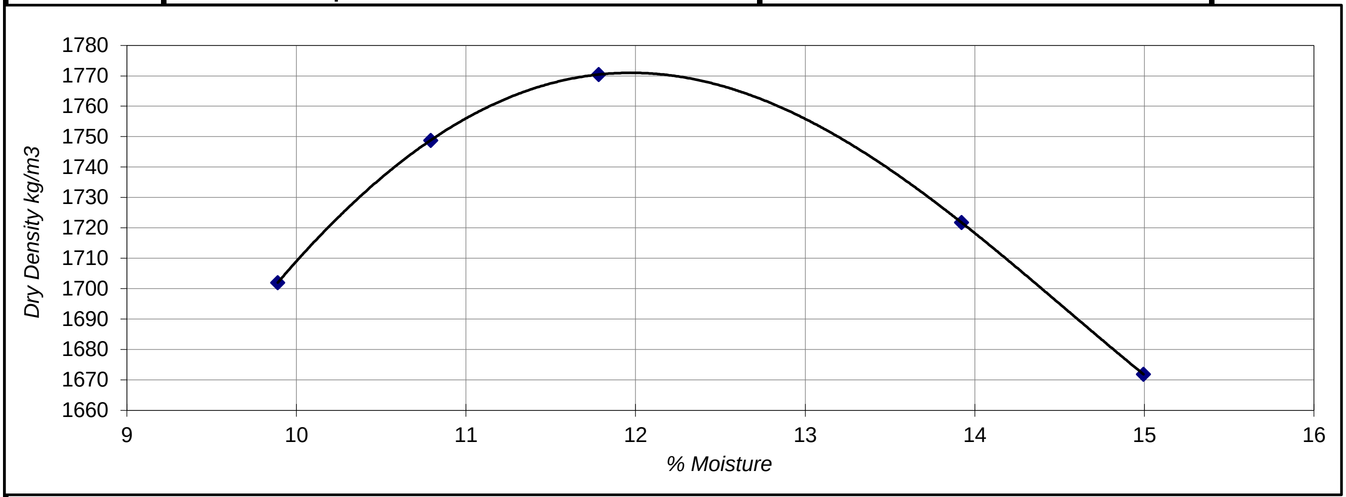
Date Issued: 3/May/18 *Technical signatory (Name) :* **H.P. du Preez** *Signature:*

LETABA LAB

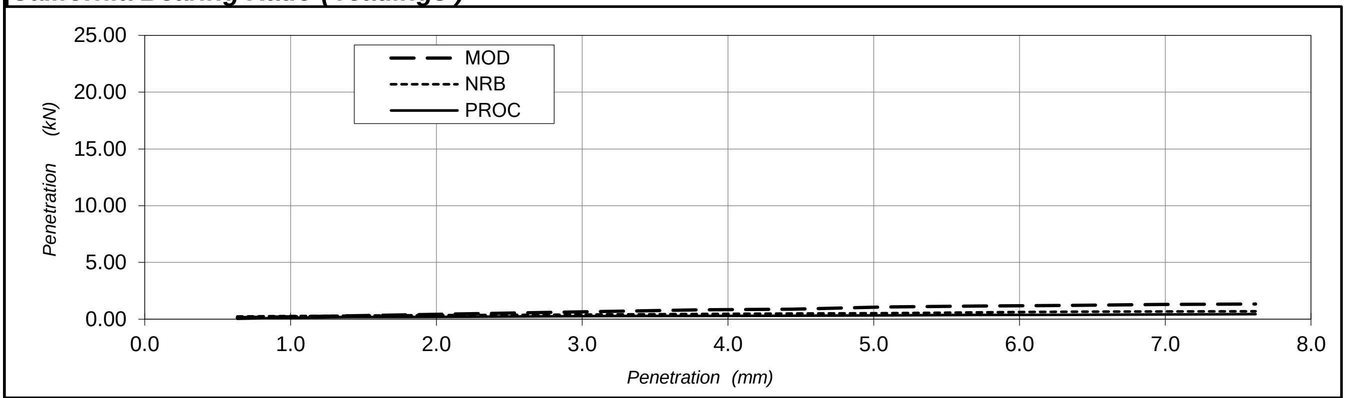
CBR and Modified A.A.S.H.T.O Density data

Client:	***Engeolab CC***	Doc No: 8267/2(ii) *Date:*	**13-Apr-18**
Contract :	***LL3034 - Majuba Power Station***	*Sample no:*	***8267/2***
Description:	***TP 4 DS4A from 0.3-0.8 m below existing ground level***		

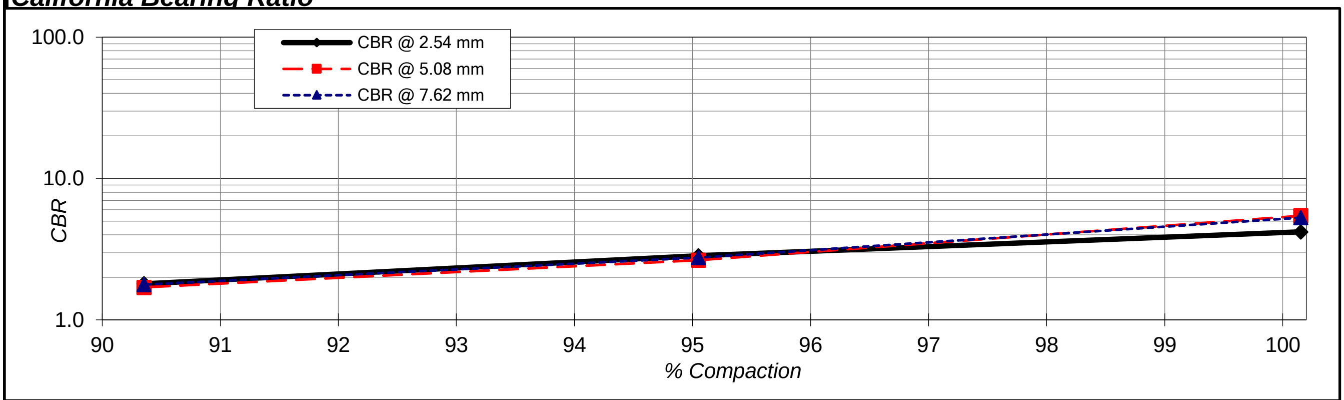
Maximum dry density =	**1771 kg/m³**
Optimum moisture content =	**12.0 %**



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	**100**	**98**	**97**	**95**	**93**	**90**
CBR of 13.344 kN	**4**	**4**	**3**	**3**	**2**	**2**

Briquette Info	***Mod***	***N.R.B.***	***Proc.***
Dry Density (kg/m³)	**1774**	**1683**	**1600**
Compaction Moisture (%)	**11.8**	**11.8**	**11.8**
Compaction (%)	**100.2**	**95.1**	**90.4**
% Swell	**0.94**	**1.51**	**2.19**

Please note that test results are only relevant to the sample delivered to the lab by the client. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any opinions and interpretations expressed fall outside the scope of our accreditation.

Date Issued: 03-May-18 Technical signatory (Name) : H.P. du Preez Signature:

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Reg No. 1995/12513/07
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♦ Polokwane ♦ Bloemfontein ♦ Mbombela (Nelspruit) ♦ Tzaneen ♦ eMalahleni (Witbank) ** ♦ Mashishing (Lydenburg)

Tel. No: 087 285 0816 **e-mail :** letaba@letabalab.co.za www.letabalab.co.za

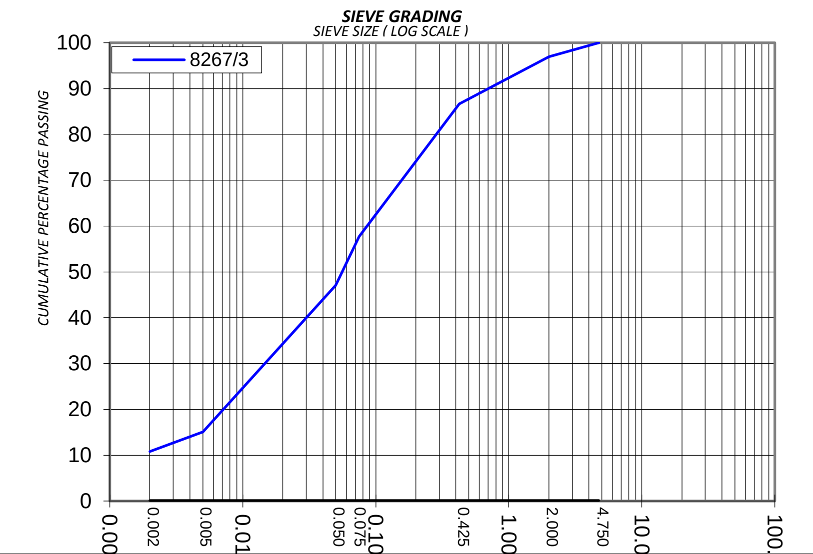
GRAVEL, SOIL AND SAND ANALYSIS

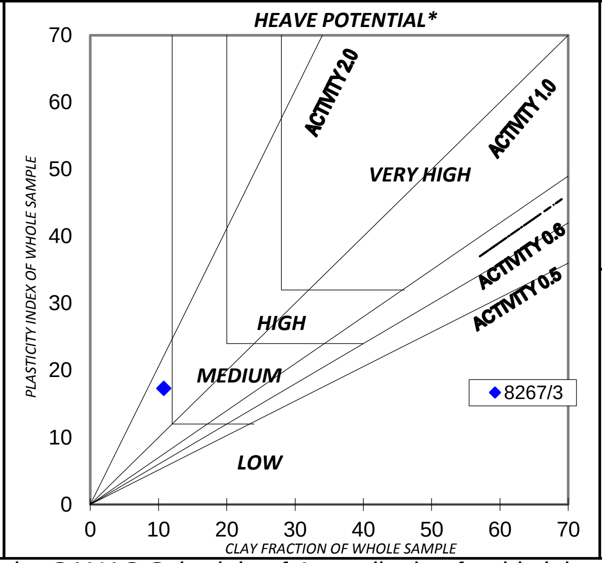
TMH 1:1986
Method A1-A6,A7, A8 & A9*

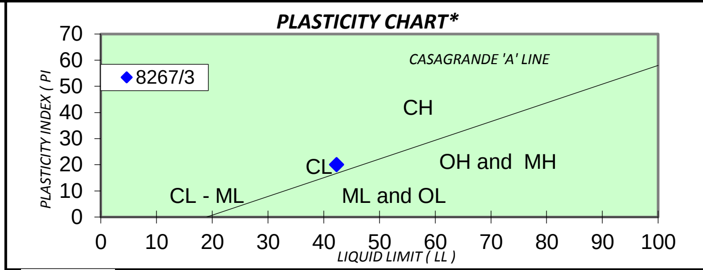
Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park
Contract : **LL3034 - Majuba Power Station**
Description : **TP 5 DS5A from 0.1-0.3 m below existing ground level**

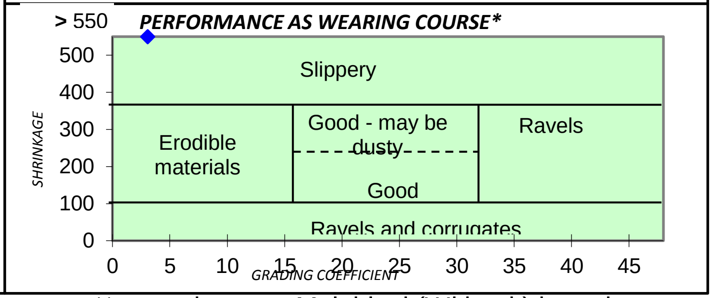
Date Sampled: 13-Apr-18
Doc No: 8267/3(i)
Date Tested: 13-Apr-18

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Soil Mortar Analysis % of mat. <2,00 mm*: Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications*: Unified Soil	COLTO	US.Highway	Group Index
0.1-0.3	8267/3	drk Olive Inorganic clay						100	97	87	58	47.1	15.1	10.8	10.6	29.9	33.0	15.5	<0.002	85.9	2.5	0.59	42	20	10.1	CL	N/A	A-7-6	9









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch

THIS MATERIAL IS NOT SUITABLE FOR WEARING COARSE AS THE SHRINKAGE PRODUCT IS GREATER THAN 550

pH =6.8 , Electrical Conductivity =0.6237 mS/cm Moisture Content = 26.6%

Please note that test results are only relevant to the sample delivered to the lab by the client. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any opinions and interpretations expressed fall outside the scope of our accreditation.

Date Issued: 3/May/18 *Technical signatory (Name) :* **H.P. du Preez** *Signature:*

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Reg No. 1995/12513/07
Vat No. 4630157248

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Tel. No: 087 285 0816 **e-mail :** letaba@letabalab.co.za www.letabalab.co.za

GRAVEL, SOIL AND SAND ANALYSIS

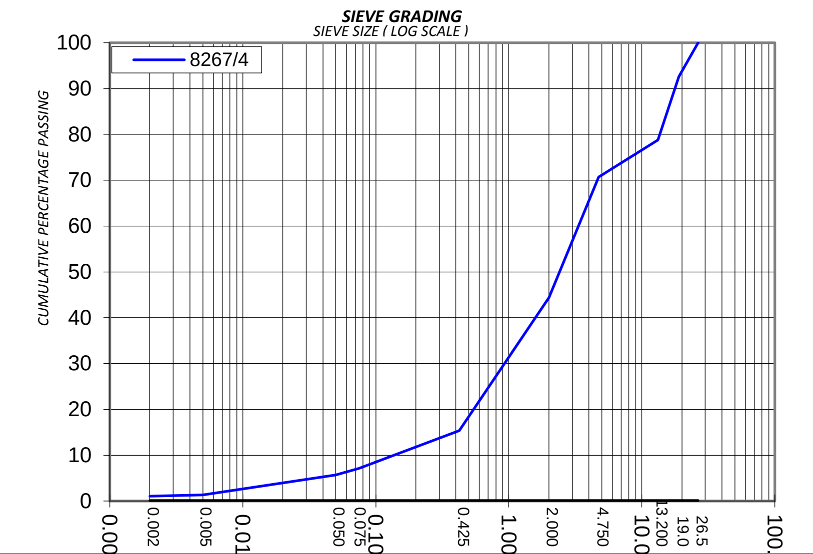
TMH 1:1986
Method A1-A6,A7, A8 & A9*

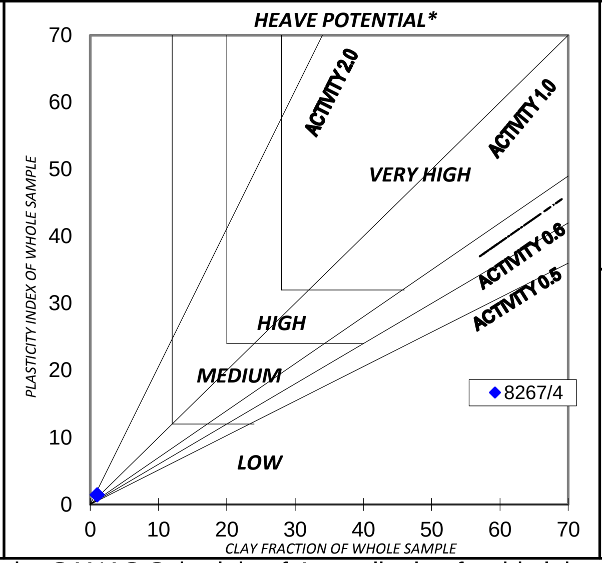
Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park | **Date Sampled: 13-Apr-18**

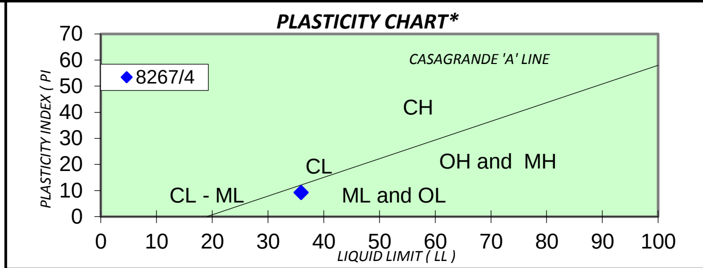
Contract : **LL3034 - Majuba Power Station** | **Doc No:** 8267/4(i)

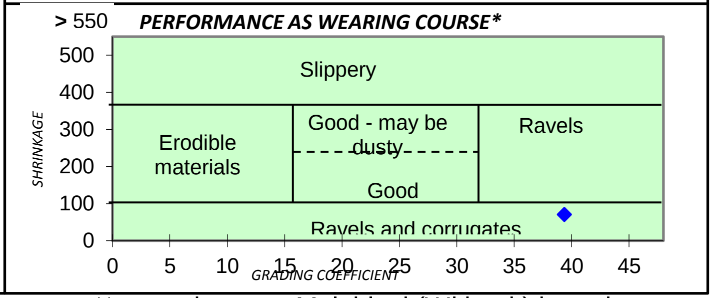
Description : **TP 5 DS5B from 0.3-0.9 m below existing ground level** | **Date Tested: 13-Apr-18**

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm*				Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits			Classifications*			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	COLTO	US.Highway	Group Index
0.3-0.9	8267/4	drk Olive Well graded clayey sand			100	93	79	71	44	15	7	5.7	1.3	1.1	65.4	18.5	9.8	2.9	0.138	24.2	1.9	2.33	36	9	4.6	sw/sc	N/A	A-2-4	0









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch

pH =7.88 , Electrical Conductivity =0.5923 mS/cm Moisture Content = 7.5%

Date Issued: 3/May/18 *Technical signatory (Name) :* **H.P. du Preez** *Signature:*

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Tel. No: 087 285 0816 **e-mail :** letaba@letabalab.co.za www.letabalab.co.za

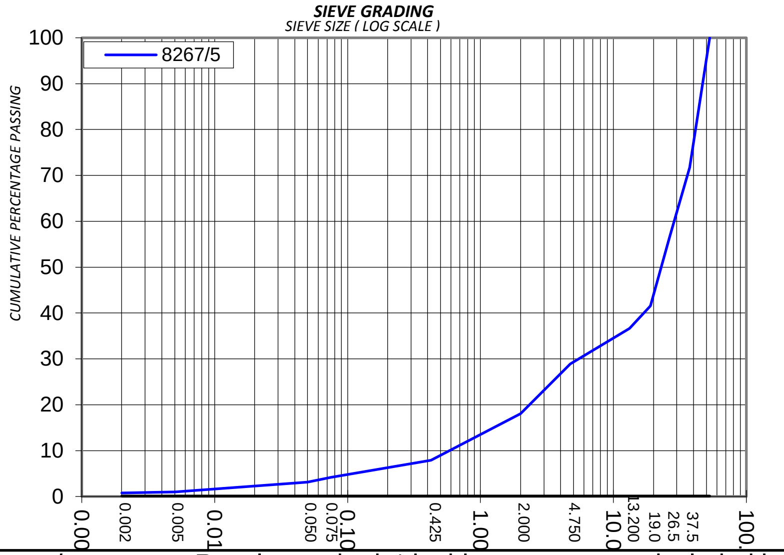
GRAVEL, SOIL AND SAND ANALYSIS

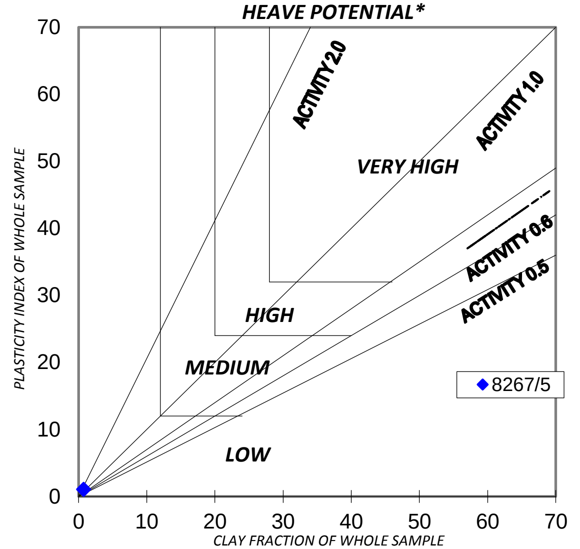
TMH 1:1986
Method A1-A6,A7, A8 & A9*

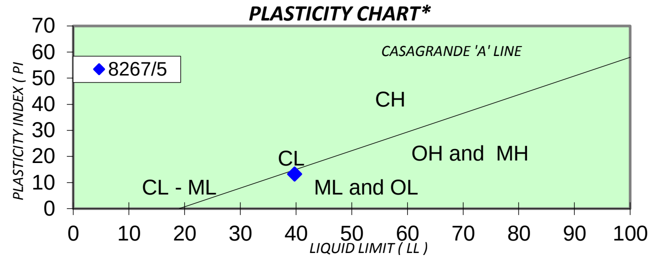
Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park
Contract : **LL3034 - Majuba Power Station**
Description : **TP 5 DS5C from 0.9-2.1 m below existing ground level**

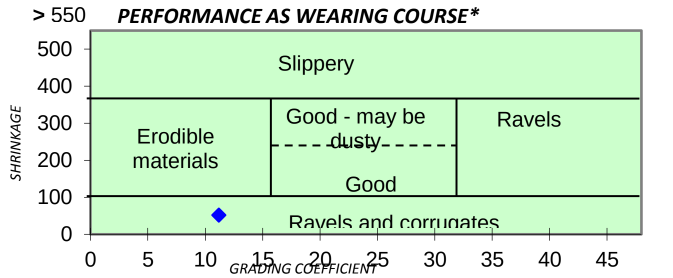
Date Sampled: 13-Apr-18
Doc No: 8267/5(i)
Date Tested: 13-Apr-18

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis – Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Soil Mortar Analysis % of mat. <2,00 mm*: Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications*: Unified Soil	COLTO	US.Highway	Group Index
0.9-2.1	8267/5	drk Olive Well graded gravel	100	72	57	42	37	29	18	8	4	3.1	1.0	0.8	56.3	20.6	11.7	5.5	0.586	48.8	1.8	2.70	40	13	6.6	GW	N/A	A-2-6	0









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch

pH =7.84 , Electrical Conductivity =0.879 mS/cm Moisture Content = 7.9%

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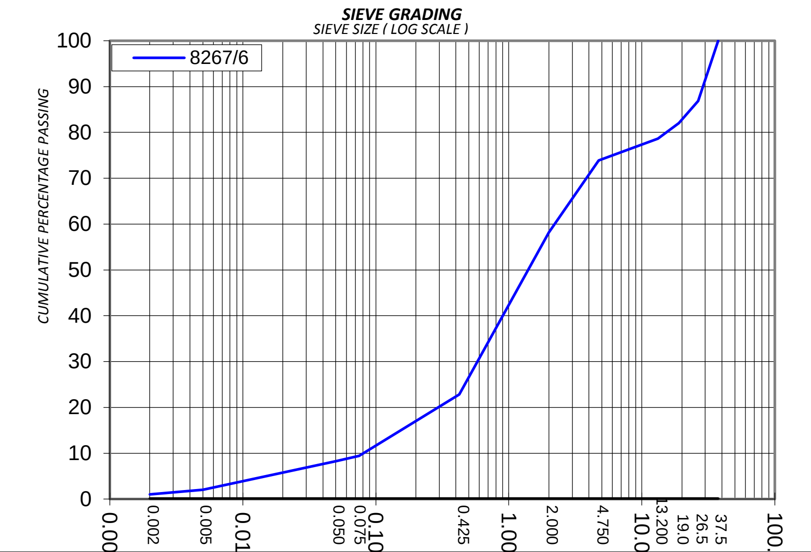
GRAVEL, SOIL AND SAND ANALYSIS

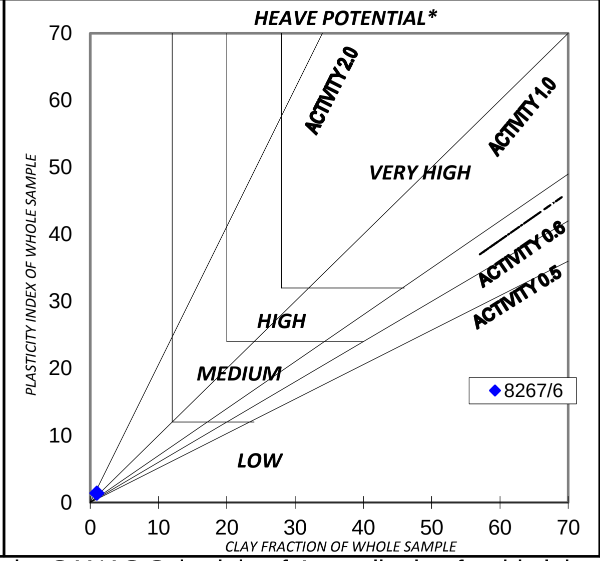
TMH 1:1986
Method A1-A6,A7, A8 & A9*

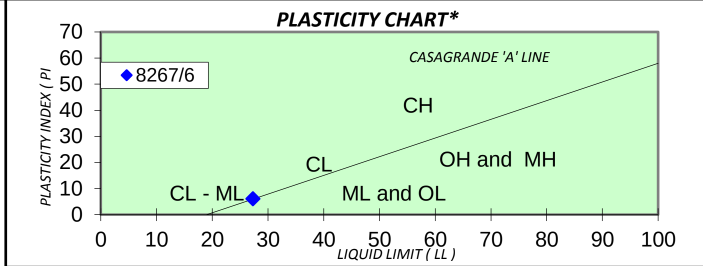
Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park
Contract : **LL3034 - Majuba Power Station**
Description : **TP 6 DS6A from 0.4-0.9 m below existing ground level**

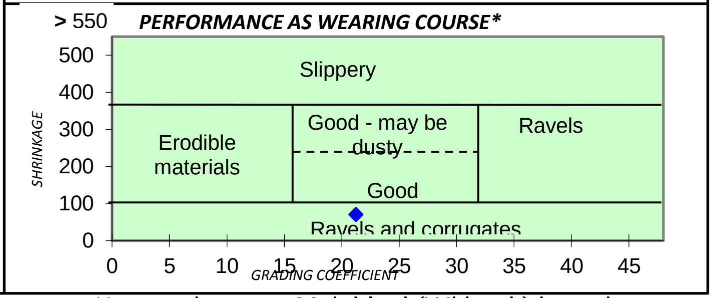
Date Sampled: 13-Apr-18
Doc No: 8267/6(i)
Date Tested: 13-Apr-18

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis – Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Soil Mortar Analysis % of mat. <2,00 mm*: Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications*: Unified Soil	COLTO	US.Highway	Group Index
0.4-0.9	8267/6	drk Olive Well graded silty/clayey sand		100	87	82	79	74	58	23	9	8.3	2.0	1.0	60.8	23.0	10.8	3.4	0.081	27.4	1.9	2.10	27	6	3.1	sw/sm/sc	G8	A-1-b	0









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch

pH =8 , Electrical Conductivity =0.4863 mS/cm Moisture Content = 9.2%

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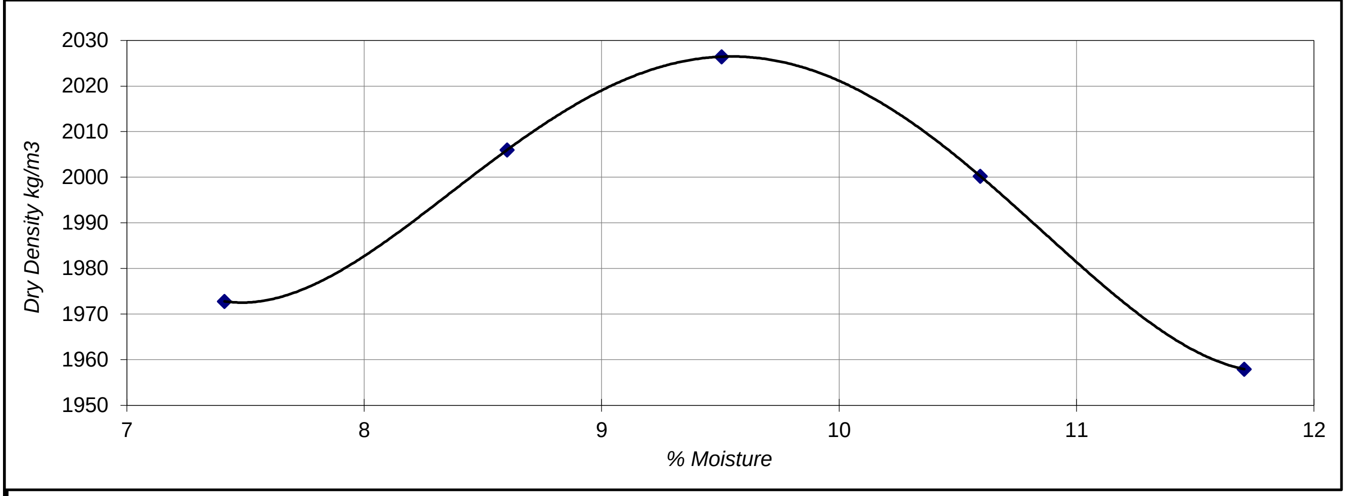
Date Issued: 3/May/18 *Technical signatory (Name) :* **H.P. du Preez** *Signature:*

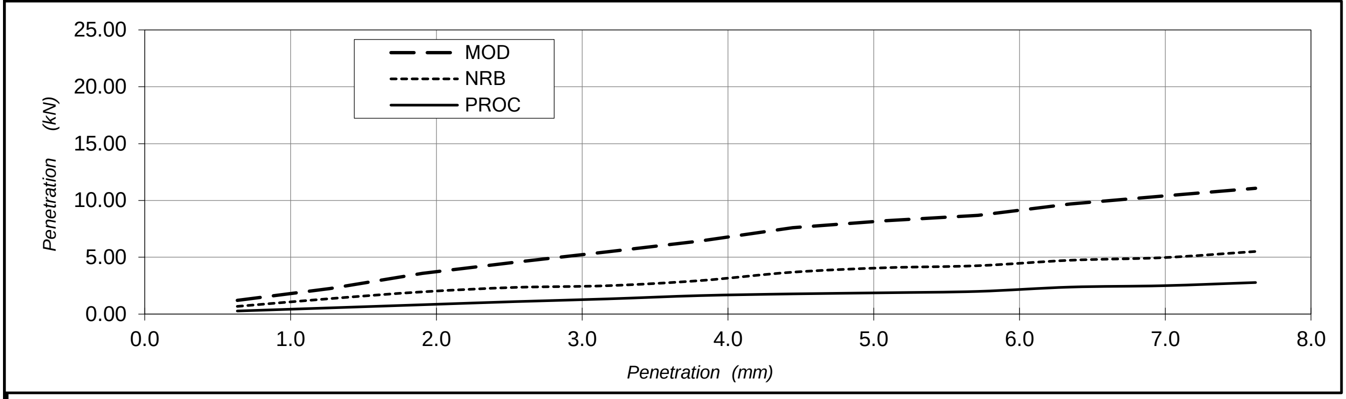
LETABA LAB
CBR and Modified A.A.S.H.T.O Density data

Client:	***Engeolab CC*** Doc No: 8267/6(ii)	*Date:*	**13-Apr-18**
Contract :	***LL3034 - Majuba Power Station***	*Sample no:*	***8267/6***
Description:	***TP 6 DS6A from 0.4-0.9 m below existing ground level***		

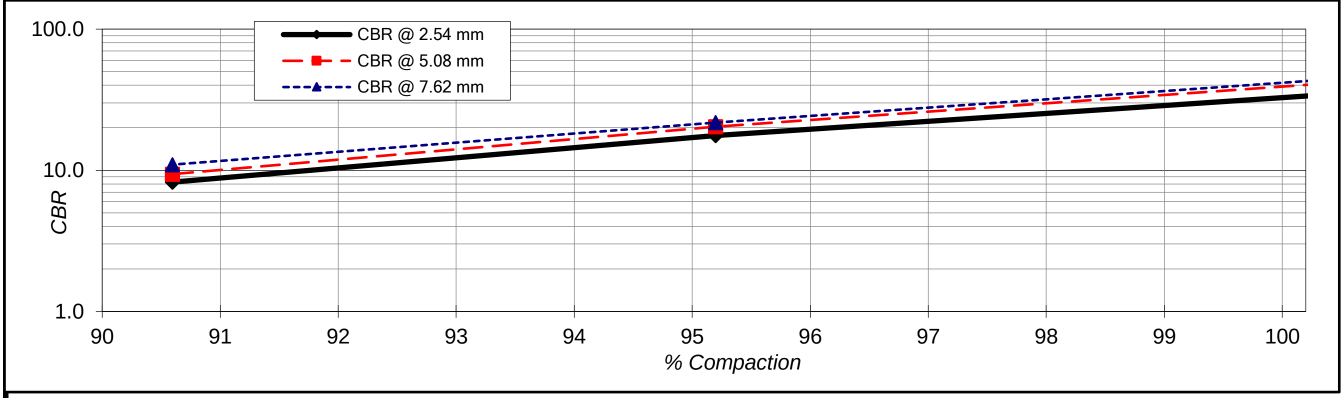
Maximum dry density =	**2026 kg/m³**
Optimum moisture content =	**9.5 %**



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	**100**	**98**	**97**	**95**	**93**	**90**
CBR of 13.344 kN	**33**	**25**	**22**	**17**	**12**	**7**

Briquette Info	***Mod***	***N.R.B.***	***Proc.***
Dry Density (kg/m³)	**2033**	**1929**	**1835**
Compaction Moisture (%)	**9.5**	**9.4**	**9.4**
Compaction (%)	**100.3**	**95.2**	**90.6**
% Swell	**0.38**	**0.71**	**1.21**

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Date Issued: 03-May-18 Technical signatory (Name) : H.P. du Preez Signature:

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GRAVEL, SOIL AND SAND ANALYSIS

TMH 1:1986
Method A1-A6,A7, A8 & A9*

Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park

Date Sampled: 13-Apr-18

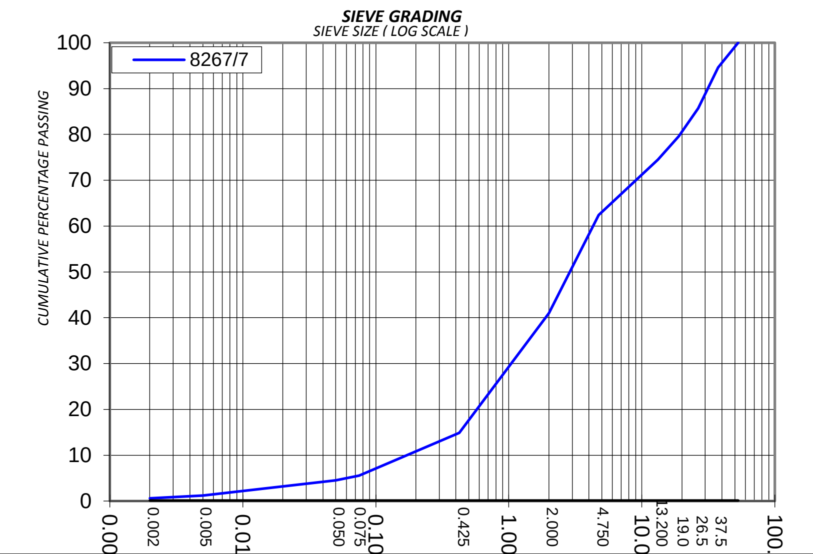
Contract : **LL3034 - Majuba Power Station**

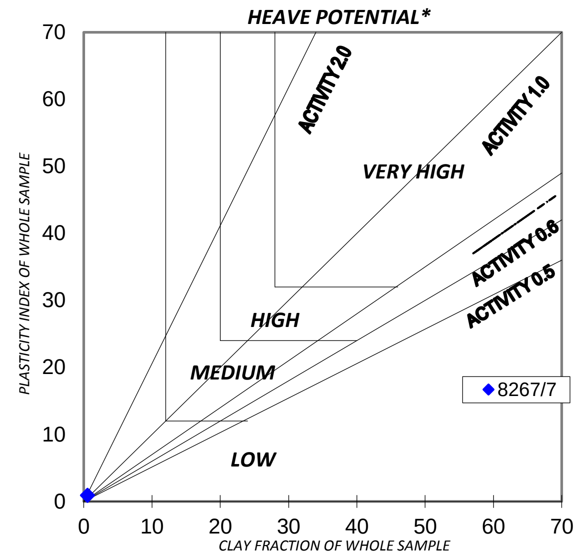
Doc No: 8267/7(i)

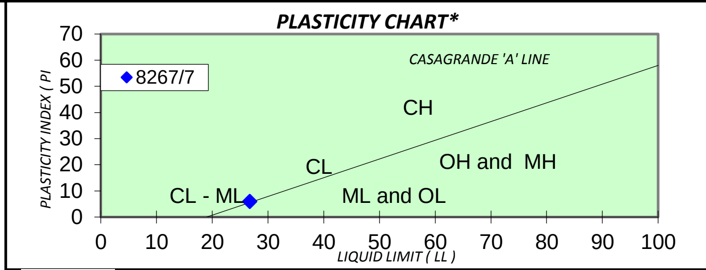
Description : **TP 6 DS6B from 0.9-1.8 m below existing ground level**

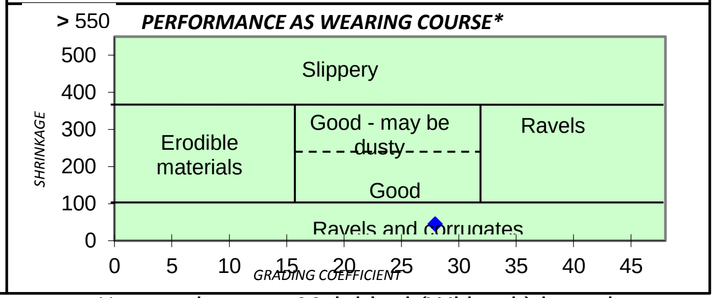
Date Tested: 13-Apr-18

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm*				Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits			Classifications*			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	COLTO	US.Highway	Group Index
0.9-1.8	8267/7	drk Olive Well graded silty/clayey sand	100	95	86	80	74	62	41	15	6	4.5	1.2	0.6	63.8	22.7	8.1	2.9	0.172	25.0	1.5	2.39	27	6	3.0	sw/sm/sc	G6	A-1-a	0









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch

pH =7.94 , Electrical Conductivity =0.4483 mS/cm Moisture Content = 6.1%

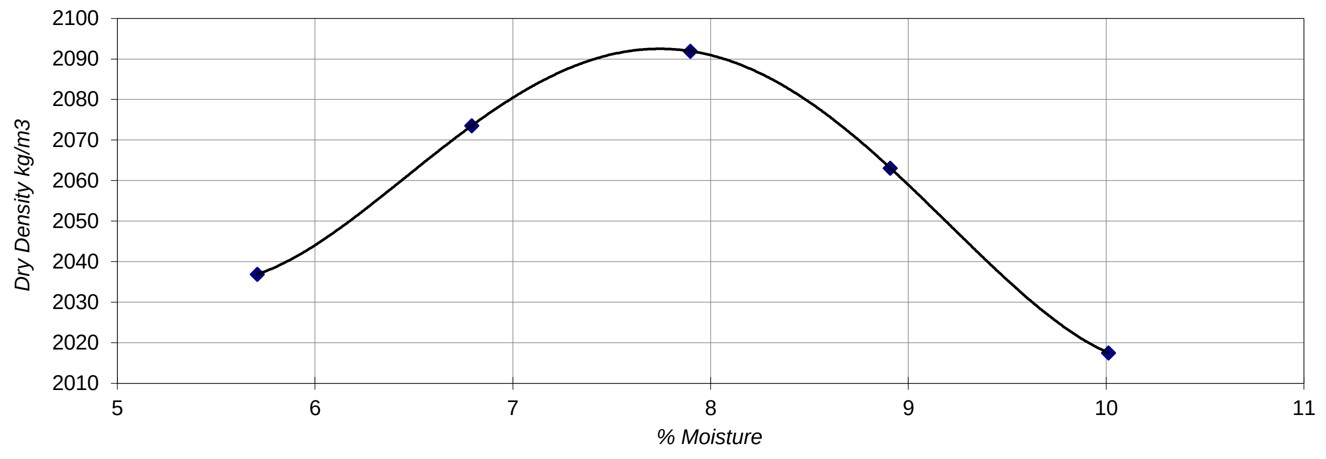
Please note that test results are only relevant to the sample delivered to the lab by the client. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any opinions and interpretations expressed fall outside the scope of our accreditation.

Date Issued: 3/May/18 *Technical signatory (Name) :* **H.P. du Preez** *Signature:*

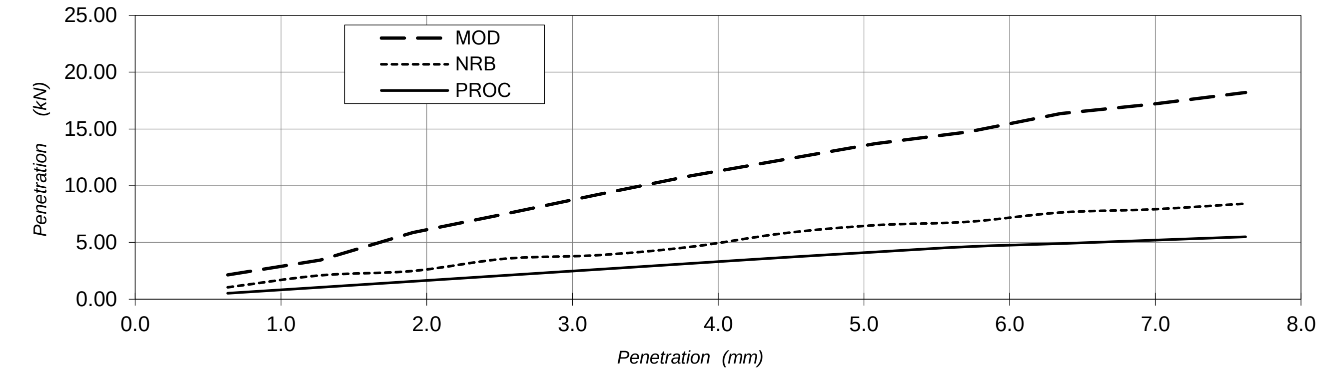
LETABA LAB — CBR and Modified A.A.S.H.T.O Density data

Client:	***Engeolab CC***	Doc No: 8267/7(ii)	*Date:* **13-Apr-18**
Contract :	***LL3034 - Majuba Power Station***		*Sample no:* ***8267/7***
Description:	***TP 6 DS6B from 0.9-1.8 m below existing ground level***		

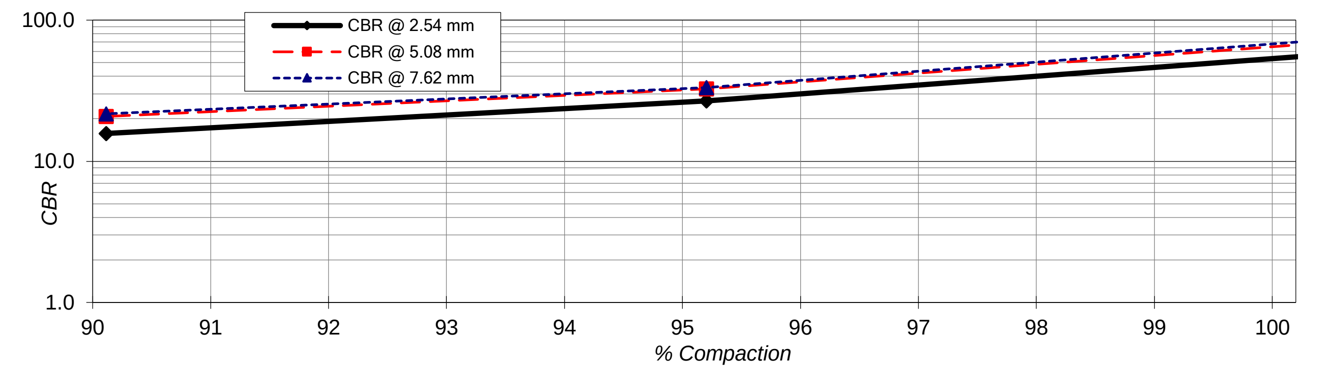
Maximum dry density =	**2092 kg/m³**
Optimum moisture content =	**7.8 %**



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	**100**	**98**	**97**	**95**	**93**	**90**
CBR of 13.344 kN	**53**	**40**	**35**	**26**	**21**	**16**

Briquette Info	***Mod***	***N.R.B.***	***Proc.***
Dry Density (kg/m³)	**2100**	**1992**	**1885**
Compaction Moisture (%)	**7.9**	**8.0**	**8.0**
Compaction (%)	**100.4**	**95.2**	**90.1**
% Swell	**0.19**	**0.33**	**0.63**

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Date Issued: 03-May-18 Technical signatory (Name) : H.P. du Preez Signature:

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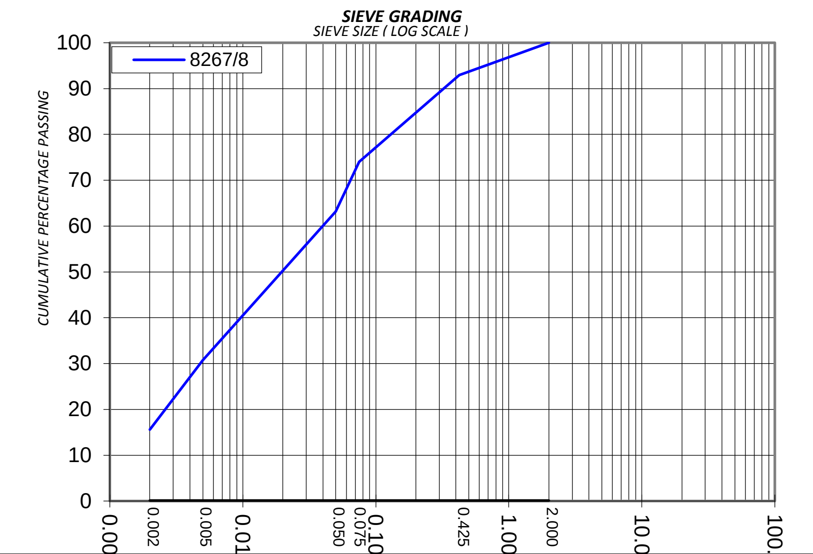
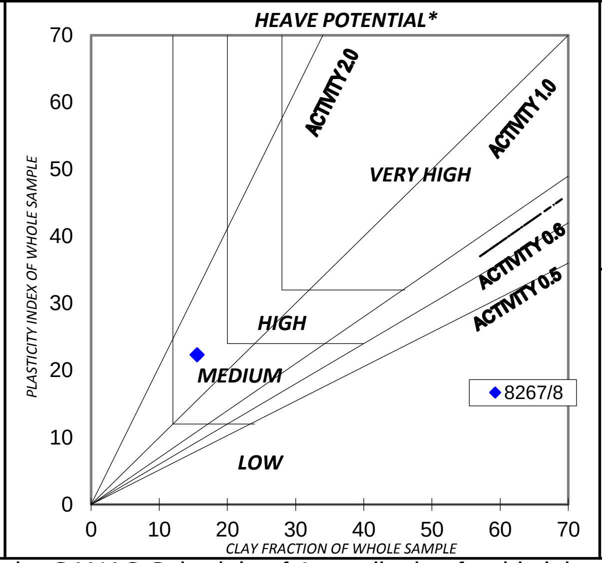
GRAVEL, SOIL AND SAND ANALYSIS

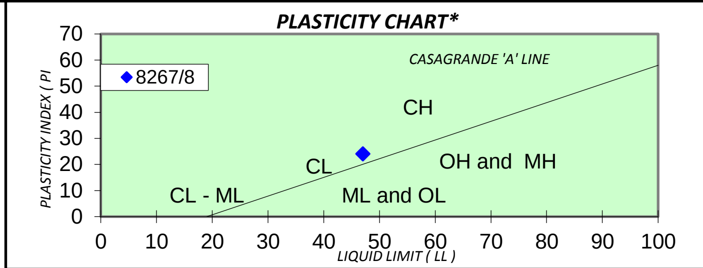
TMH 1:1986
Method A1-A6,A7, A8 & A9*

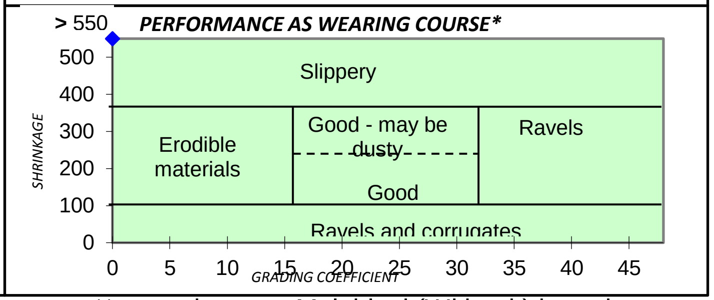
Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park	**Date Sampled: 13-Apr-18**
Contract : **LL3034 - Majuba Power Station**	**Doc No:** 8267/8(i)
Description : **TP 9 DS9A from 0.1-0.7 m below existing ground level**	**Date Tested: 13-Apr-18**

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Soil Mortar Analysis % of mat. <2,00 mm*: Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications*: Unified Soil	COLTO	US.Highway	Group Index
0.1-0.7	8267/8	drk Grey Inorganic clay							100	93	74	63.2	30.7	15.6	7.0	19.0	32.5	30.7	<0.002	39.9	0.6	0.33	47	24	11.9	CL	N/A	A-7-6	15









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch

THIS MATERIAL IS NOT SUITABLE FOR WEARING COARSE AS THE SHRINKAGE PRODUCT IS GREATER THAN 550

pH =8.31 , Electrical Conductivity =0.9687 mS/cm Moisture Content = 29.5%

Please note that test results are only relevant to the sample delivered to the lab by the client. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any opinions and interpretations expressed fall outside the scope of our accreditation.

Date Issued: 15/May/18 *Technical signatory (Name) :* **H.P. du Preez** *Signature:*

LETABA LAB (Pty) Ltd
CIVIL ENGINEERING MATERIALS LABORATORY

Reg No. 1995/12513/07
Vat No. 4630157248

♦ Polokwane
♦ Bloemfontein
♦ Mbombela (Nelspruit) **
♦ Tzaneen
♦ eMalahleni (Witbank)
♦ Mashishing (Lydenburg)

Tel. No: 087 285 0816 **e-mail :** letaba@letabalab.co.za www.letabalab.co.za

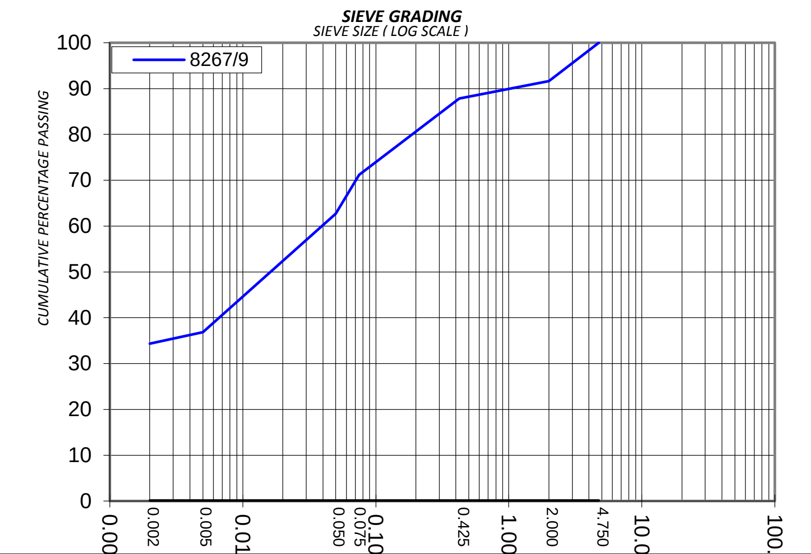
GRAVEL, SOIL AND SAND ANALYSIS

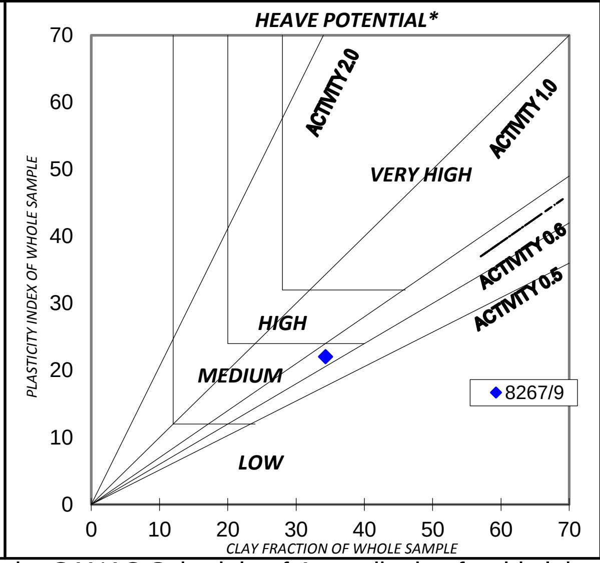
TMH 1:1986
Method A1-A6,A7, A8 & A9*

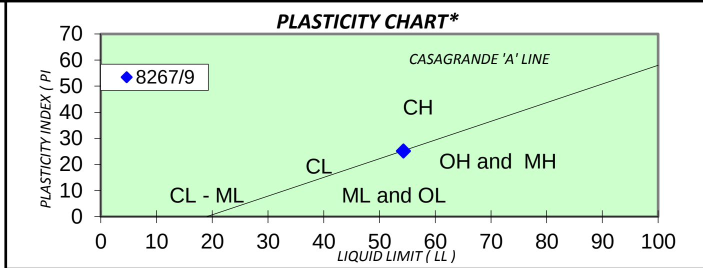
Client : **Engeolab CC** Address: 4 Corridor Crescent, N4 Business Park
Contract : **LL3034 - Majuba Power Station**
Description : **TP 9 DS9B from 0.7-2.2 m below existing ground level**

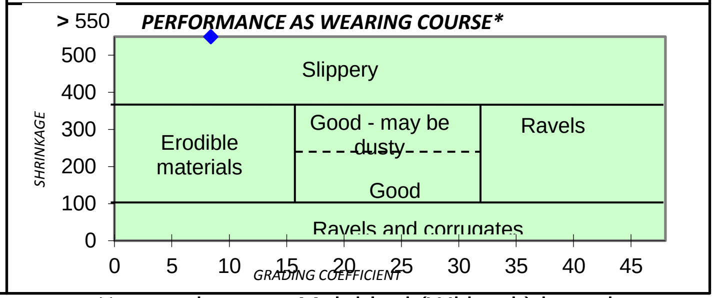
Date Sampled: 13-Apr-18
Doc No: 8267/9(i)
Date Tested: 13-Apr-18

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis – Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm*				Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits			Classifications*			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Coarse - sand <2,0 >0,425mm	Fine-sand <0,425>0,075mm	Silt <0,05>0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	COLTO	US.Highway	Group Index
0.7-2.2	8267/9	lt Grey Inorganic silt						100	92	88	71	62.7	36.8	34.3	4.1	18.2	28.2	40.2	<0.002	39.3	2.5	0.49	54	25	12.5	MH	N/A	A-7-6	16









Remarks: Results marked * in this report are not included in the SANAS Schedule of Accreditation for this laboratory ** tests done at eMalahleni (Witbank) branch
THIS MATERIAL IS NOT SUITABLE FOR WEARING COARSE AS THE SHRINKAGE PRODUCT IS GREATER THAN 550

pH =8.41 , Electrical Conductivity =1.108 mS/cm Moisture Content = 29.0%

Please note that test results are only relevant to the sample delivered to the lab by the client. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any opinions and interpretations expressed fall outside the scope of our accreditation.

Date Issued: 15/May/18 *Technical signatory (Name) :* **H.P. du Preez** *Signature:*

TYPICAL SOIL STRENGTH CHARACTERISICS

COHESIONLESS SOILS					**Relative**	**Soil Modulus E (MPa)**		
Description	**Dry Density (kg/m^3)**		**N - Value**		**Density**	Sand Gravel	Sand	Sandy Silt
Very Loose	0	1 450	0	5	<0.2	25	12	6
Loose	1 450	1 600	5	10	0.2 - 0.4	50	25	12
Medium Dense	1 600	1 750	10	30	0.4 - 0.6	100	50	25
Dense	1 750	1 900	30	50	0.6 - 0.8	200	100	50
Very Dense	1 900	2 400	50	100	>0.8	400	200	100

COHESIVE SOILS	**Undrained Shear**				**Soil Modulus E (MPa)**		
Description	**Strength (kN/m^3)**		**N - Value**		Sandy Silt	Silt	Silty Clay
Very Soft	0	20	0	2	6	3	2
Soft	20	40	2	4	12	6	3
Firm	40	80	4	8	25	12	6
Stiff	80	150	8	15	50	25	12
Very Stiff	150	350	15	30	100	50	25
	UCS = 2 C_u		C_u = Undrained shear strength				

COMPRESSIBILITY & COLLAPSE

Carter, M and Bentley, S. P., Correlations of Soil Properties, 1991.

	Coeff vol. Compr. m_v (m^2/kN)		**Trouble Index**	**Collapse Potential**		
V.High Compressibility		1.50E-03	Very Severe	> 20.1%		V.Highly Collapsible
High Compressibility	1.50E-03	3.00E-04	Severe	10.1%	20.0%	Highly Collapsible
Mod. Compressibility	3.00E-04	1.00E-04	Trouble	5.1%	10.0%	Mod. Collapsible
Low Compressibility	1.00E-04	3.00E-05	Mod. Trouble	1.1%	5.0%	Slightly Collapsible
V.Low Compressibilty	3.00E-05	1.00E-05	No problem	< 1%		V.Slightly Collapsible

TYPICAL ROCK/SOIL PROPERTIES & ESTIMATED BEARING CAPACITES

Rock / Soil Density Description	**UCS (MPa)**	**Bearing Capacity**	**Mod. Ratio**	**E_d (MPa)**	**Friction Angle φ'**	**Cohesion Cu / C'**	**N-Value**	**Dry Unit Wt kg/m^3**
Extremely hard rock	200	Function of UCS & jointing intensity (j)	600	120 000	Rock joint / structure friction	Rock joint / structure cohesion	Refer to Schmidt hardness or point load index	> 40
Very hard rock	150		450	67 500				35 - 40
Hard rock	100		375	37 500				30 - 35
Medium hard rock	50		325	16 250				27 - 30
Soft rock	10		300	3 000	Rock mass friction	Rock mass cohesion		25 - 27
Very soft rock	1		275	275				23 - 25
Very hard soil/decomp.	0.5		250	125			> 80	21.5 - 23
Very dense sand/gravel		400	250	100	44	-	50 - 80	19.5-21.5
Very dense silt/sand		300	225	68	40	-		
Very stiff clay/silt		200	200	40	22	80 / 15	15-30	17.5
Dense sand/gravel		300	225	68	40	-	30-50	17.5-19.5
Dense silt/sand		200	200	40	36	-		
Stiff clay/silt		150	175	26	20	40 / 10	8 - 15	15.5-17.5
Medium dense sand/gravel		200	200	40	36	-	10 - 30	15.5-17.5
Medium dense silt/sand		150	175	26	32	-		
Firm clay/silt		75	150	11	18	20 / 5	4 - 8	14.0-15.5
Loose sand/gravel		150	175	26	32	-	5 - 10	14.0-15.5
Loose silt/sand		75	150	11	28	-		
Soft clay/silt		35	125	4	17	10 / 2	2 - 4	12.5-14.0
Very loose sand/gravel		75	150	11	28	-	<5	<14.0
Very loose silt/sand		35	125	4	24	-		
Very soft clay/silt		20	100	2	16	<5 / 0	<2	<12.5

TYPICAL PROPERTIES of COMPACTED SOILS

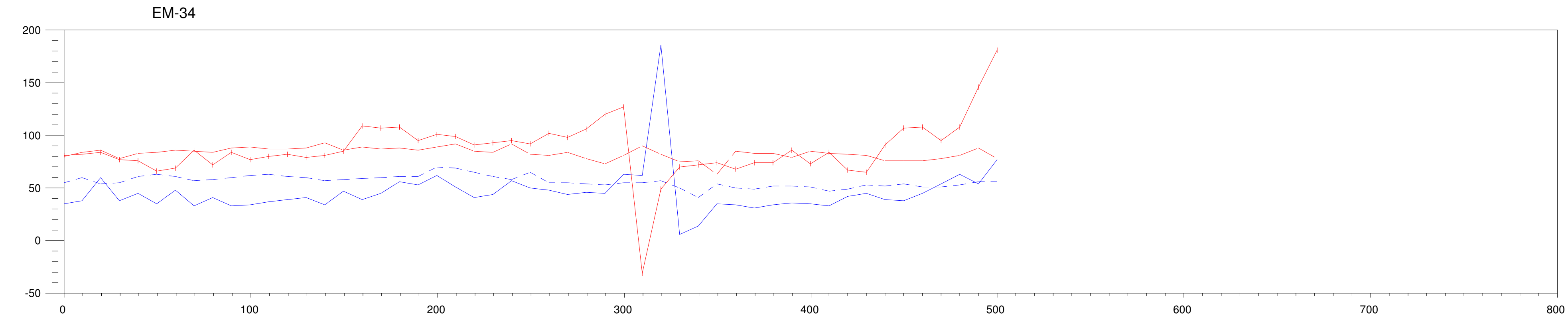
Soil Type		USC Symbol	AASHTO *Symbol	Description	LL min	LL max	PI min	PI max	LS min	LS max	Range Max D Density kN/m3		Opt. Moisture %		C' kPa Nat	C' kPa Sat	Ø '	Permeability K cm/s		CBR min	CBR max
Coarse Grained Soils	*Gravel & Gravelly Soils*	GW	A-1-a	Well graded clean gravels, gravel-sand mixtures	NP						19.6	21.2	11	8	NA	NA	>38		>10-2	40	80
		GP	A-1-a A-1-b	Poorly graded clean gravels, gravel-sand mixtures	NP						18.1	19.6	14	11	NA	NA	>37		>10-2	30	60
		GM	A-1-b / A-2-4 A-2-5 / A-2-7	Silty gravels, poorly graded, gravel-sand-silt mixtures	NP						18.9	21.2	12	8	NA	NA	>34	1.E-03	1.E-06	20	40
		GC	A-2-6 A-2-7	Clayey gravels, poorly graded, gravel-sand-clay mixtures	<30						18.1	20.4	14	9	NA	NA	>31	1.E-06	1.E-08	20	40
	Sands & Sandy Soils	SW	A-1-b	Well graded clean sands, gravelly sands	NP						17.3	20.4	16	9	NA	NA	38		>10-3	20	40
		SP	A-1-b A-3	Poorly graded clean sands, sand-gravel mixtures	NP						15.7	18.9	21	12	NA	NA	37		>10-3	10	40
		SM	A-1-b / A-2-4 A-2-5 / A-2-7	Silty sands, poorly graded, sand-silt mixtures	10	30					17.3	19.6	16	11	50	20	34	1.E-03	1.E-06	10	40
		SM-SC	A-2-4 A-2-5 A-2-6 A-2-7	Sand-silt-clay mixes with slightly plastic fines	10	20					17.3	20.4	15	11	50	14	33	5.E-05	1.E-07	5	30
		SC	A-2-4 A-2-6 A-2-7	Clayey sands, poorly graded, sand-clay mixtures	10	20	7	12	<6		16.5	19.6	19	11	74	11	31	1.E-06	1.E-08	5	20
Fine Grained Soils	*Silts & Clays LL<50*	ML	A-4 A-5	Inorganic silts and clayey silts	20	<50	<20		<6		14.9	18.9	24	12	67	9	32	1.E-03	1.E-06	<15	
		ML-CL	A-4 A-5 A-6 A-7-6	Mixtures of inorganic silts and clays							15.7	18.9	22	12	65	22	32	5.E-05	1.E-07		
		CL	A-6 A-7-6	Inorganic clays of low to medium plasticity	20	<50	6	25	<10		14.9	18.9	24	12	86	13	28	1.E-06	1.E-08	<15	
	Silts & Clays LL> 50	OL	A-4 A-5	Organic silts and silt-clay mixes, low plasticity	20	>50	<20		<6		12.6	15.7	33	21				1.E-04	1.E-06	<5	
		MH	A-5 A-7-5	Inorganic silts, micaceous fine sandy silts, elastic silts		>50	<30		<12		11.0	14.9	40	24	72	20	25	1.E-04	1.E-06	<10	
		CH	A-7-6	Inorganic clays with high plasticity	50	100	20	50	8	15	11.8	16.5	36	19	103	11	19	1.E-06	1.E-08	<15	
		OH	A-5 A-7-5	Organic clays with mediumto high plasticity		>50	<30		<12		10.2	15.7	45	21				1.E-06	1.E-08	<5	

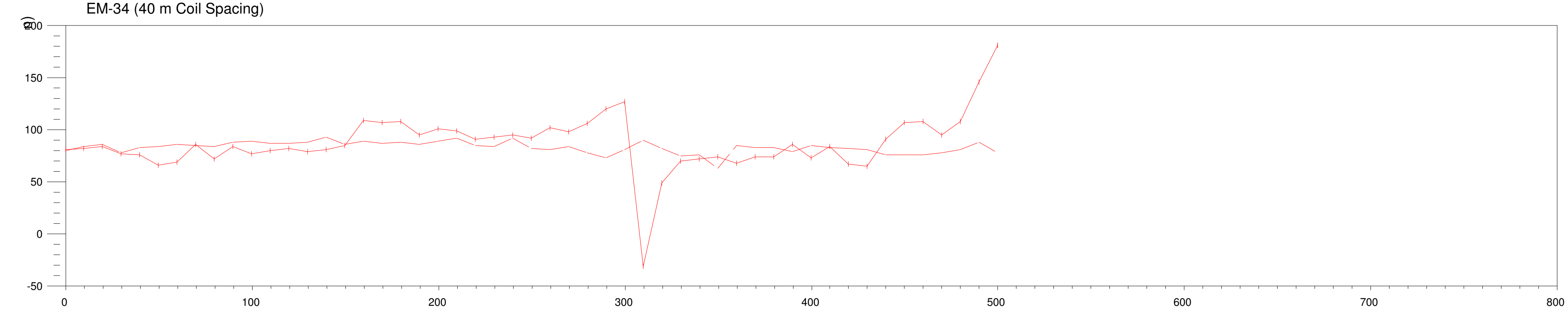
* Most probable symbol class

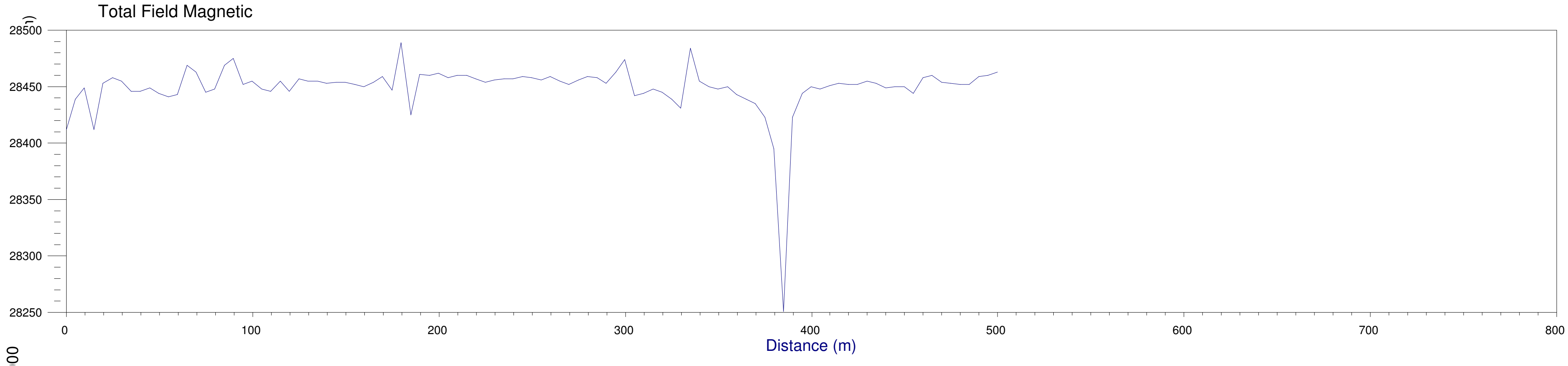
Table from NAVFAC DM7

Appendix C
Geophysical Data

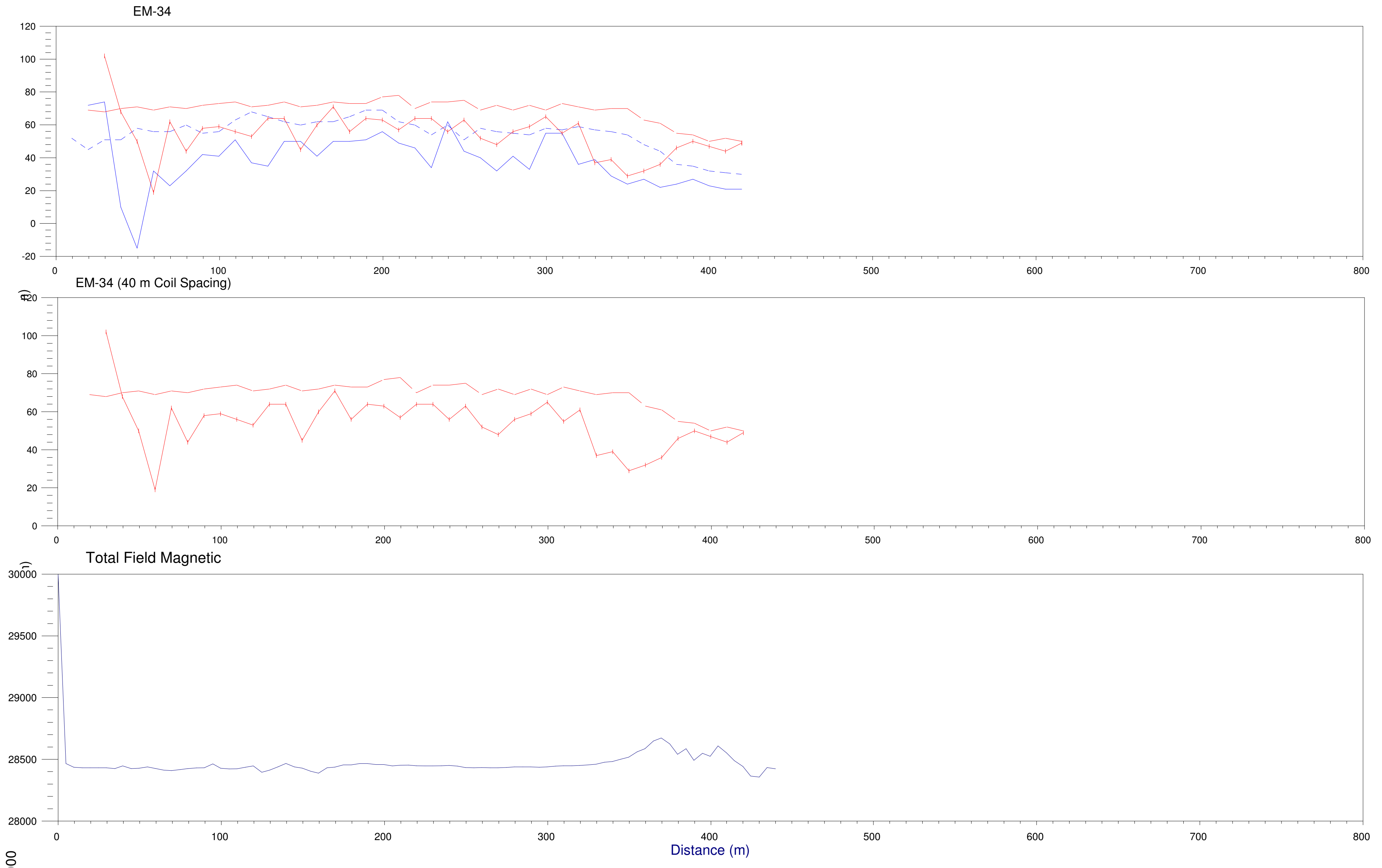
ENGEOLAB CC MAJUBA PS-1







CLIENT:							
BOREHOLE NO:	MAJUBA PS-1	DISTRICT :		DIR:	SW-NE	LINE :	MAJUBA PS-1
REGION:	MPUMALANGA	VILLAGE:		LINE START	S27 07' 09.3" E29 46' 09.5"	DRILL SITE:	
		SITE:	500	LINE END	S27 07' 02.1" E29 46' 25.5"		

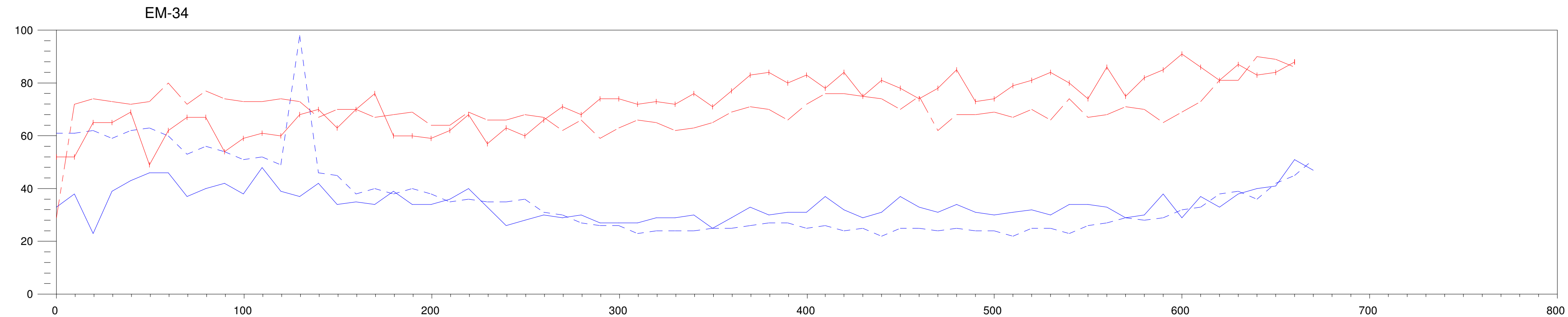


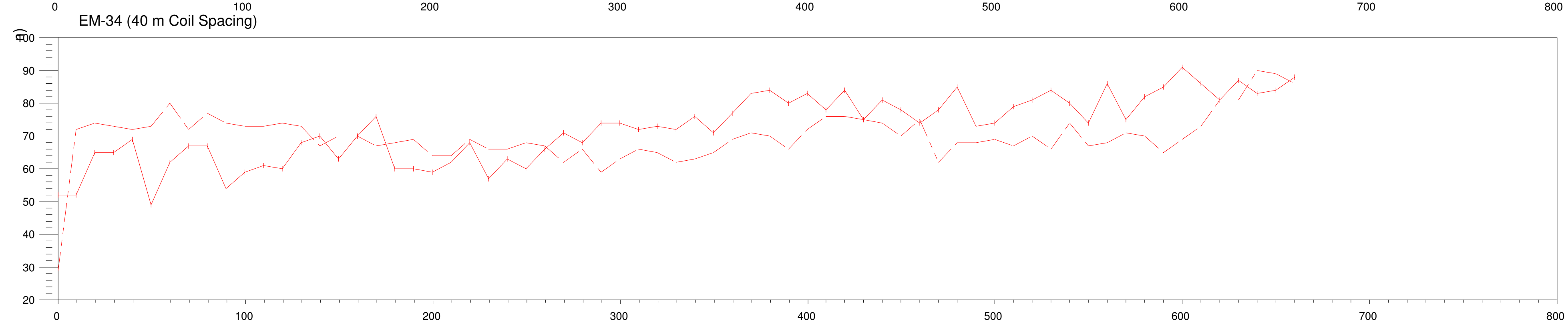
CLIENT:

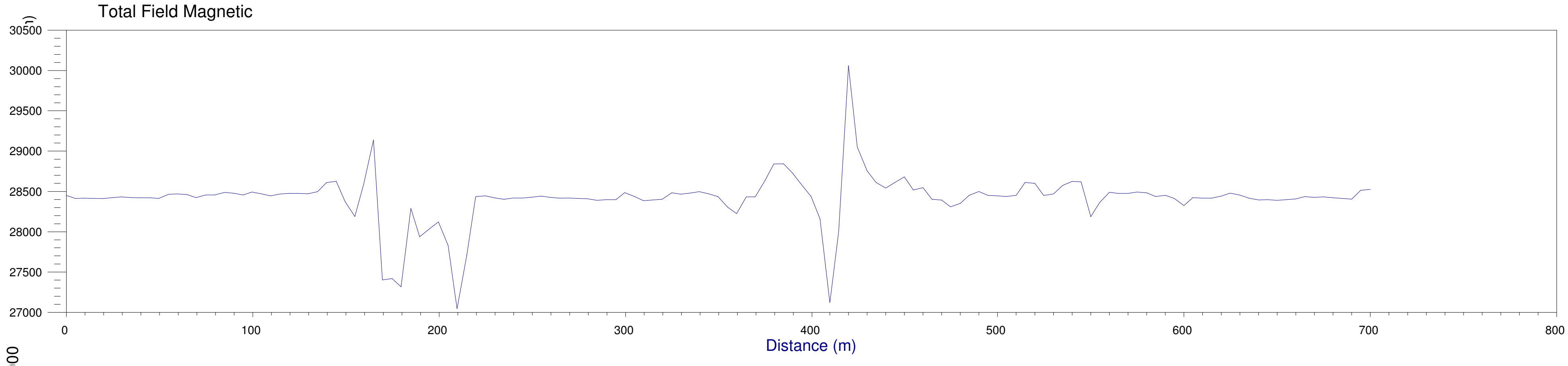
BOREHOLE NO:	MAJUBA PS-2	DISTRICT :		DIR:	N-S	LINE :	MAJUBA PS-2
REGION:	MPUMALANGA	VILLAGE:		LINE START	S27 07' 02.4" E29 46' 33.0"	DRILL SITE:	
		SITE:	410	LINE END	S27 07' 15.3" E29 46' 37.0"		

ENGEOLAB CC

MAJUBA PS-3



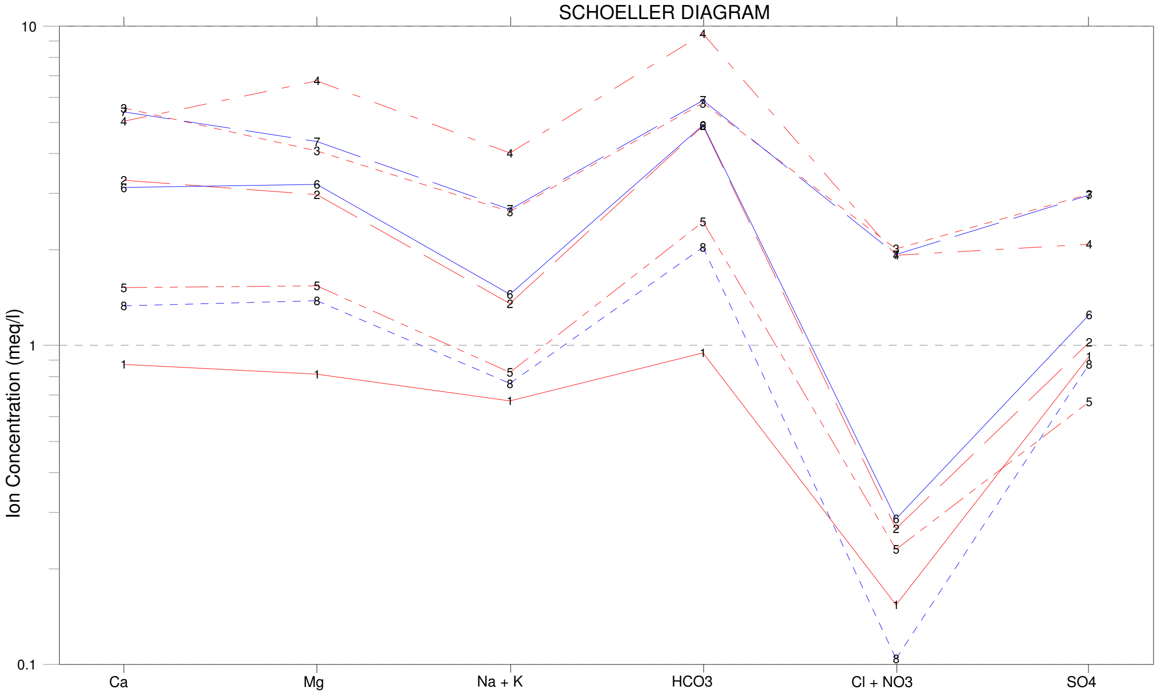




CLIENT:							
BOREHOLE NO:	MAJUBA PS-3	DISTRICT :		DIR:	E-W	LINE :	MAJUBA PS-3
REGION:	MPUMALANGA	VILLAGE:		LINE START	S27 07' 15.0" E29 46' 33.8"	DRILL SITE:	
		SITE:	660	LINE END	S27 07' 15.6" E29 46' 09.5"		

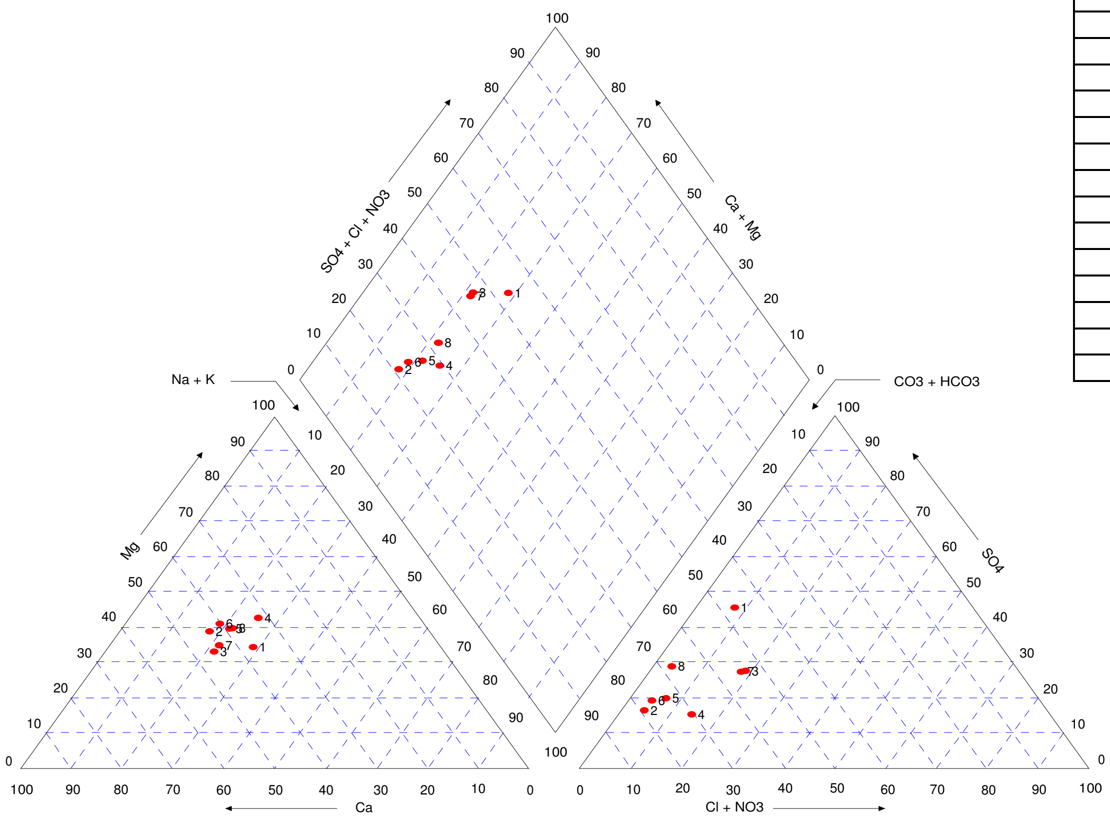
Appendix D
Water Test Data

SCHOELLER DIAGRAM



Plot ID	Sample ID
1	Spring Water (SpEngeo 1)
2	Spring Water (SpEngeo 2)
3	Borehole (SpEngeo 3)
4	Dam Water (SpEngeo 4)
5	Spring Water (SpEngeo 5)
6	Spring Water (SpEngeo 6)
7	Spring Water (SpEngeo 7)
8	Spring Water (SpEngeo 8)

PIPER DIAGRAM



QUALITY ANALYSIS

Borehole No.: Spring Water (SP Engeo 1)

CO-ORDINATES

Project No.: LL3034

Lat:

Project Name: Eskom Majuba

Long:

District:

INPUT INFORMATION			DWAF		SANS 241:2011	WATER TREATMENT		
SUBSTANCE	UNIT OF MEASURE	TEST VALUE	COMMENTS		COMMENTS	Home	Conventional treatment	Advanced
Aldrin & Dieldrin								
Alkalinity		57.8						
Aluminium		10			Class 1, Acceptable			
Ammonia (N) **	mg/l NH3	0.45	Class 0: Water of an ideal quality		Class 1, Acceptable			
Ammonia (NH3)	mg/l NH3							
Appearance								
Arsenic (As) *	mg/l As							
Cadmium (Cd) *	mg/l Cd							
Calcium (Ca)	mg/l Ca	17.5	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	Precipitation with sodium carbonate	Ion exchange
Calcium (CaCo3)	mg/l CaCO3	203	Class 2: Water which is safe for short term use only					
Chloride (Cl)*	mg/l Cl	4.9	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Chlorine (Free)								
Chlorine (Total)								
Chloroform								
Colour								
Copper(Cu)								
Cyanide								
Electrical conductivity EC *	mS/m	23.7	Class 0: Water of an ideal quality		Class 1, Acceptable	---	No treatment available	Desalination by ion exchange or reverse osmosis
Faecal coliform *	counts/100 ml							
Fluoride (F) *	mg/l F	0.19	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	No treatment available	No treatment available	Ion exchange, Reverse osmosis or Adsorption or activated alumina
Iron (Fe) *	mg/l Fe	0.11	Class 1: Water of a good quality	#VALUE!	Class 1, Acceptable	Add bleach and filter	Normal coagulation and flocculation sedimentation and filtration Oxidation by aeration and pH adjustment or addition of chemical oxidants, followed by sedimentation	Ion exchange
Lead								
Magnesium (Mg)	mg/l Mg	9.88	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	Lime treatment	Ion exchange
Magnesium (MgCo3) *	mg/l MgCO3	40.7						
Manganese (Mn) *	mg/l Mn	0.53	Class 2: Water which is safe for short term use only	#VALUE!	Class II, Maximum Allowable for 7 years	Add bleach solution or pool "chlorine" granules let stand to settle and filter	Normal coagulation, sedimentation and sand filtration Coagulation and/or oxidation by chlorine compounds or aeration	Coagulation and/or oxidation by chlorine compounds or potassium permangate or ozone or air. Zeolite softening
Mercury								
Nitrate (as N) *	mg/l N							
Nitrate (as NO3) *	mg/l N							
Nitrite (Soluble)		0.55			Class 1, Acceptable	No treatment available	No treatment available	Anaerobic biological reduction, reverse osmosis or other desalination techniques
Odour & Taste								
Organic carbon(sol)								
pH *	pH units	6.4	Class 0: Water of an ideal quality		Class 1, Acceptable	Neutralization with marble chips	pH adjustment by controlled addition of alkali such as lime sodium carbonate, carbon dioxide	Controlled addition of a suitable acid/alkali
Phenols								
Potassium (K) *	mg/l K	2.94	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Precipitation Potential								
Selenium								
Sodium (Na) *	mg/l Na	13.7	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Standard plate count								
Sulphate (SO4) *	mg/l SO4	44.4	Class 0: Water of an ideal quality			No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Total Alkalinity	mg/l							
Total Coliforms								
Total Dissolved Solids (TDS) *	(mg/l)	132	Class 0: Water of an ideal quality		Class 1, Acceptable			
Total Hardness **	mg CaCO3/l	84.4	Class 0: Water of an ideal quality	Moderately soft		---	Lime treatment	Ion exchange
Trihalomethanes								
Turbidity	NTU	50	Class 3: Water of an unacceptable quality	The presence of turbidity is one of the indicators of microbiological water quality and of inefficient water treatment.	Unacceptable	Flocculation and filtration	Slow sand filtration or flocculation, settlement and filtration	Same as conventional
Zinc (Zn) *	mg/l Zn							

QUALITY ANALYSIS

Borehole No.: Spring Water (SP Engeo 2)

Project No.: LL3034

Project Name: Eskom Majuba

District:

CO-ORDINATES

Lat:

Long:

INPUT INFORMATION			DWAF		SANS 241:2011	WATER TREATMENT		
SUBSTANCE	**UNIT OF MEASURE**	**TEST VALUE**	**COMMENTS**		**COMMENTS**	**Home**	**Conventional treatment**	**Advanced**
Aldrin & Dieldrin								
Alkalinity		298						
Aluminium		20			Class 1, Acceptable			
Ammonia (N) **	mg/l NH3	0.45	Class 0: Water of an ideal quality		Class 1, Acceptable			
Ammonia (NH3)	mg/l NH3							
Appearance								
Arsenic (As) *	mg/l As							
Cadmium (Cd) *	mg/l Cd							
Calcium (Ca)	mg/l Ca	66	Class 2: Water which is safe for short term use only	No health effects. Some scaling.	Class 1, Acceptable	No treatment available	Precipitation with sodium carbonate	Ion exchange
Calcium (CaCo3)	mg/l CaCO3	203	Class 3: Water of an unacceptable quality	No health effects. Some scaling.				
Chloride (Cl)*	mg/l Cl	8.91	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Chlorine (Free)								
Chlorine (Total)								
Chloroform								
Colour								
Copper(Cu)								
Cyanide								
Electrical conductivity EC *	mS/m	65.2	Class 0: Water of an ideal quality		Class 1, Acceptable	---	No treatment available	Desalination by ion exchange or reverse osmosis
Faecal coliform *	counts/100 ml							
Fluoride (F) *	mg/l F	0.17	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	No treatment available	No treatment available	Ion exchange, Reverse osmosis or Adsorption or activated alumina
Iron (Fe) *	mg/l Fe	0.07	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach and filter	Normal coagulation and flocculation sedimentation and filtration Oxidation by aeration and pH adjustment or addition of chemical oxidants, followed by sedimentation	Ion exchange
Lead								
Magnesium (Mg)	mg/l Mg	36.1	Class 1: Water of a good quality		Class 1, Acceptable	No treatment available	Lime treatment	Ion exchange
Magnesium (MgCo3) *	mg/l MgCO3	149						
Manganese (Mn) *	mg/l Mn	0.01	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach solution or pool "chlorine" granules let stand to settle and filter	Normal coagulation, sedimentation and sand filtration Coagulation and/or oxidation by chlorine compounds or aeration	Coagulation and/or oxidation by chlorine compounds or potassium permangate or ozone or air. Zeolite softening
Mercury								
Nitrate (as N) *	mg/l N							
Nitrate (as NO3) *	mg/l N							
Nitrite (Soluble)		0.55			Class 1, Acceptable	No treatment available	No treatment available	Anaerobic biological reduction, reverse osmosis or other desalination techniques
Odour & Taste								
Organic carbon(sol)		YE						
pH *	pH units	8.17	Class 0: Water of an ideal quality		Class 1, Acceptable	Neutralization with marble chips	pH adjustment by controlled addition of alkali such as lime sodium carbonate, carbon dioxide	Controlled addition of a suitable acid/alkali
Phenols								
Potassium (K) *	mg/l K	3.67	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Precipitation Potential								
Selenium								
Sodium (Na) *	mg/l Na	28.9	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Standard plate count								
Sulphate (SO4) *	mg/l SO4	49.2	Class 0: Water of an ideal quality			No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Total Alkalinity	mg/l							
Total Coliforms								
Total Dissolved Solids (TDS) *	(mg/l)	374	Class 0: Water of an ideal quality		Class 1, Acceptable			
Total Hardness **	mg CaCO3/l	313	Class 3: Water of an unacceptable quality	Very hard		---	Lime treatment	Ion exchange
Trihalomethanes								
Turbidity	NTU	13	Class 3: Water of an unacceptable quality	The presence of turbidity is one of the indicators of microbiological water quality and of inefficient water treatment.	Unacceptable	Flocculation and filtration	Slow sand filtration or flocculation, settlement and filtration	Same as conventional
Zinc (Zn) *	mg/l Zn							

QUALITY ANALYSIS

Borehole No.:	Spring Water (SP Engeo 3)	**CO-ORDINATES**	
Project No.:	LL3034	**Lat:**	
Project Name:	Eskom Majuba	**Long:**	
District:			

INPUT INFORMATION			DWAF		SANS 241:2011	WATER TREATMENT		
SUBSTANCE	UNIT OF MEASURE	TEST VALUE	COMMENTS		COMMENTS	Home	Conventional treatment	Advanced
Aldrin & Dieldrin								
Alkalinity		351						
Aluminium		10			Class 1, Acceptable			
Ammonia (N) **	mg/l NH3	0.45	Class 0: Water of an ideal quality		Class 1, Acceptable			
Ammonia (NH3)	mg/l NH3							
Appearance								
Arsenic (As) *	mg/l As							
Cadmium (Cd) *	mg/l Cd							
Calcium (Ca)	mg/l Ca	111	Class 3: Water of an unacceptable quality	No health effects. Severe scaling problems.	Class 1, Acceptable	No treatment available	Precipitation with sodium carbonate	Ion exchange
Calcium (CaCo3)	mg/l CaCO3	203	Class 3: Water of an unacceptable quality	No health effects. Severe scaling problems.				
Chloride (Cl)*	mg/l Cl	69.6	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Chlorine (Free)								
Chlorine (Total)								
Chloroform								
Colour								
Copper(Cu)								
Cyanide								
Electrical conductivity EC *	mS/m	108	Class 1: Water of a good quality		Class 1, Acceptable	---	No treatment available	Desalination by ion exchange or reverse osmosis
Faecal coliform *	counts/100 ml							
Fluoride (F) *	mg/l F	0.09	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	No treatment available	No treatment available	Ion exchange, Reverse osmosis or Adsorption or activated alumina
Iron (Fe) *	mg/l Fe	0.09	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach and filter	Normal coagulation and flocculation sedimentation and filtration Oxidation by aeration and pH adjustment or addition of chemical oxidants, followed by sedimentation	Ion exchange
Lead								
Magnesium (Mg)	mg/l Mg	49.5	Class 1: Water of a good quality		Class 1, Acceptable	No treatment available	Lime treatment	Ion exchange
Magnesium (MgCo3) *	mg/l MgCO3	204						
Manganese (Mn) *	mg/l Mn	0.05	Class 1: Water of a good quality	#VALUE!	Class 1, Acceptable	Add bleach solution or pool "chlorine" granules let stand to settle and filter	Normal coagulation, sedimentation and sand filtration Coagulation and/or oxidation by chlorine compounds or aeration	Coagulation and/or oxidation by chlorine compounds or potassium permangate or ozone or air. Zeolite softening
Mercury								
Nitrate (as N) *	mg/l N							
Nitrate (as NO3) *	mg/l N							
Nitrite (Soluble)		1.55			Class 1, Acceptable	No treatment available	No treatment available	Anaerobic biological reduction, reverse osmosis or other desalination techniques
Odour & Taste								
Organic carbon(sol)								
pH *	pH units	7.19	Class 0: Water of an ideal quality		Class 1, Acceptable	Neutralization with marble chips	pH adjustment by controlled addition of alkali such as lime sodium carbonate, carbon dioxide	Controlled addition of a suitable acid/alkali
Phenols								
Potassium (K) *	mg/l K	1.81	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Precipitation Potential								
Selenium								
Sodium (Na) *	mg/l Na	59.3	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Standard plate count								
Sulphate (SO4) *	mg/l SO4	143	Class 0: Water of an ideal quality			No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Total Alkalinity	mg/l							
Total Coliforms								
Total Dissolved Solids (TDS) *	(mg/l)	652	Class 1: Water of a good quality		Class 1, Acceptable			
Total Hardness **	mg CaCO3/l	481	Class 3: Water of an unacceptable quality	Very hard		---	Lime treatment	Ion exchange
Trihalomethanes								
Turbidity	NTU	19.2	Class 3: Water of an unacceptable quality	The presence of turbidity is one of the indicators of microbiological water quality and of inefficient water treatment.	Unacceptable	Flocculation and filtration	Slow sand filtration or flocculation, settlement and filtration	Same as conventional
Zinc (Zn) *	mg/l Zn							

QUALITY ANALYSIS

Borehole No.: Spring Water (SP Engeo 4)

Project No.: LL3034

Project Name: Eskom Majuba

District:

CO-ORDINATES

Lat:

Long:

INPUT INFORMATION			DWAF		SANS 241:2011	WATER TREATMENT		
SUBSTANCE	**UNIT OF MEASURE**	**TEST VALUE**	**COMMENTS**		**COMMENTS**	**Home**	**Conventional treatment**	**Advanced**
Aldrin & Dieldrin								
Alkalinity		579						
Aluminium		330			Class II, Maximum Allowable for 1 year			
Ammonia (N) **	mg/l NH3	0.45	Class 0: Water of an ideal quality		Class 1, Acceptable			
Ammonia (NH3)	mg/l NH3							
Appearance								
Arsenic (As) *	mg/l As							
Cadmium (Cd) *	mg/l Cd							
Calcium (Ca)	mg/l Ca	101	Class 3: Water of an unacceptable quality	No health effects. Severe scaling problems.	Class 1, Acceptable	No treatment available	Precipitation with sodium carbonate	Ion exchange
Calcium (CaCo3)	mg/l CaCO3	203	Class 3: Water of an unacceptable quality	No health effects. Severe scaling problems.				
Chloride (Cl)*	mg/l Cl	67.3	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Chlorine (Free)								
Chlorine (Total)								
Chloroform								
Colour								
Copper(Cu)								
Cyanide								
Electrical conductivity EC *	mS/m	132	Class 1: Water of a good quality		Class 1, Acceptable	---	No treatment available	Desalination by ion exchange or reverse osmosis
Faecal coliform *	counts/100 ml							
Fluoride (F) *	mg/l F	0.17	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	No treatment available	No treatment available	Ion exchange, Reverse osmosis or Adsorption or activated alumina
Iron (Fe) *	mg/l Fe	0.27	Class 2: Water which is safe for short term use only	#VALUE!	Class 1, Acceptable	Add bleach and filter	Normal coagulation and flocculation sedimentation and filtration Oxidation by aeration and pH adjustment or addition of chemical oxidants, followed by sedimentation	Ion exchange
Lead								
Magnesium (Mg)	mg/l Mg	82	Class 2: Water which is safe for short term use only	Diarrhoea in sensitive users.	Class II, Maximum Allowable for 7 years	No treatment available	Lime treatment	Ion exchange
Magnesium (MgCo3) *	mg/l MgCO3	338						
Manganese (Mn) *	mg/l Mn	0.04	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach solution or pool "chlorine" granules let stand to settle and filter	Normal coagulation, sedimentation and sand filtration Coagulation and/or oxidation by chlorine compounds or aeration	Coagulation and/or oxidation by chlorine compounds or potassium permangate or ozone or air. Zeolite softening
Mercury								
Nitrate (as N) *	mg/l N							
Nitrate (as NO3) *	mg/l N							
Nitrite (Soluble)		0.61			Class 1, Acceptable	No treatment available	No treatment available	Anaerobic biological reduction, reverse osmosis or other desalination techniques
Odour & Taste								
Organic carbon(sol)								
pH *	pH units	8.06	Class 0: Water of an ideal quality		Class 1, Acceptable	Neutralization with marble chips	pH adjustment by controlled addition of alkali such as lime sodium carbonate, carbon dioxide	Controlled addition of a suitable acid/alkali
Phenols								
Potassium (K) *	mg/l K	5.04	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Precipitation Potential								
Selenium								
Sodium (Na) *	mg/l Na	89.1	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Standard plate count								
Sulphate (SO4) *	mg/l SO4	99.6	Class 0: Water of an ideal quality			No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Total Alkalinity	mg/l							
Total Coliforms								
Total Dissolved Solids (TDS) *	(mg/l)	795	Class 1: Water of a good quality		Class 1, Acceptable			
Total Hardness **	mg CaCO3/l	590	Class 3: Water of an unacceptable quality	Very hard		---	Lime treatment	Ion exchange
Trihalomethanes								
Turbidity	NTU	45.5	Class 3: Water of an unacceptable quality	The presence of turbidity is one of the indicators of microbiological water quality and of inefficient water treatment.	Unacceptable	Flocculation and filtration	Slow sand filtration or flocculation, settlement and filtration	Same as conventional
Zinc (Zn) *	mg/l Zn							

QUALITY ANALYSIS

Borehole No.: Spring Water (SP Engeo 5)

CO-ORDINATES

Project No.: LL3034

Lat:

Project Name: Eskom Majuba

Long:

District:

INPUT INFORMATION			DWAF		SANS 241:2011	WATER TREATMENT		
SUBSTANCE	UNIT OF MEASURE	TEST VALUE	COMMENTS		COMMENTS	Home	Conventional treatment	Advanced
Aldrin & Dieldrin								
Alkalinity		149						
Aluminium		20			Class 1, Acceptable			
Ammonia (N) **	mg/l NH3	0.45	Class 0: Water of an ideal quality		Class 1, Acceptable			
Ammonia (NH3)	mg/l NH3							
Appearance								
Arsenic (As) *	mg/l As							
Cadmium (Cd) *	mg/l Cd							
Calcium (Ca)	mg/l Ca	30.4	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	Precipitation with sodium carbonate	Ion exchange
Calcium (CaCo3)	mg/l CaCO3	203	Class 2: Water which is safe for short term use only					
Chloride (Cl)*	mg/l Cl	7.6	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Chlorine (Free)								
Chlorine (Total)								
Chloroform								
Colour								
Copper(Cu)								
Cyanide								
Electrical conductivity EC *	mS/m	36.7	Class 0: Water of an ideal quality		Class 1, Acceptable	---	No treatment available	Desalination by ion exchange or reverse osmosis
Faecal coliform *	counts/100 ml							
Fluoride (F) *	mg/l F	0.23	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	No treatment available	No treatment available	Ion exchange, Reverse osmosis or Adsorption or activated alumina
Iron (Fe) *	mg/l Fe	0.18	Class 1: Water of a good quality	#VALUE!	Class 1, Acceptable	Add bleach and filter	Normal coagulation and flocculation sedimentation and filtration Oxidation by aeration and pH adjustment or addition of chemical oxidants, followed by sedimentation	Ion exchange
Lead								
Magnesium (Mg)	mg/l Mg	18.7	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	Lime treatment	Ion exchange
Magnesium (MgCo3) *	mg/l MgCO3	77						
Manganese (Mn) *	mg/l Mn	0.01	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach solution or pool "chlorine" granules let stand to settle and filter	Normal coagulation, sedimentation and sand filtration Coagulation and/or oxidation by chlorine compounds or aeration	Coagulation and/or oxidation by chlorine compounds or potassium permangate or ozone or air. Zeolite softening
Mercury								
Nitrate (as N) *	mg/l N							
Nitrate (as NO3) *	mg/l N							
Nitrite (Soluble)		0.55			Class 1, Acceptable	No treatment available	No treatment available	Anaerobic biological reduction, reverse osmosis or other desalination techniques
Odour & Taste								
Organic carbon(sol)								
pH *	pH units	6.96	Class 0: Water of an ideal quality		Class 1, Acceptable	Neutralization with marble chips	pH adjustment by controlled addition of alkali such as lime sodium carbonate, carbon dioxide	Controlled addition of a suitable acid/alkali
Phenols								
Potassium (K) *	mg/l K	4.82	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Precipitation Potential								
Selenium								
Sodium (Na) *	mg/l Na	16.1	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Standard plate count								
Sulphate (SO4) *	mg/l SO4	32	Class 0: Water of an ideal quality			No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Total Alkalinity	mg/l							
Total Coliforms								
Total Dissolved Solids (TDS) *	(mg/l)	203	Class 0: Water of an ideal quality		Class 1, Acceptable			
Total Hardness **	mg CaCO3/l	153	Class 2: Water which is safe for short term use only	Moderately hard		---	Lime treatment	Ion exchange
Trihalomethanes								
Turbidity	NTU	102	Class 3: Water of an unacceptable quality	The presence of turbidity is one of the indicators of microbiological water quality and of inefficient water treatment.	Unacceptable	Flocculation and filtration	Slow sand filtration or flocculation, settlement and filtration	Same as conventional
Zinc (Zn) *	mg/l Zn							

QUALITY ANALYSIS

Borehole No.: Spring Water (SP Engeo 6)

Project No.: LL3034

Project Name: Eskom Majuba

District:

CO-ORDINATES

Lat:

Long:

INPUT INFORMATION			DWAF		SANS 241:2011	WATER TREATMENT		
SUBSTANCE	UNIT OF MEASURE	TEST VALUE	COMMENTS		COMMENTS	Home	Conventional treatment	Advanced
Aldrin & Dieldrin								
Alkalinity		299						
Aluminium		30			Class 1, Acceptable			
Ammonia (N) **	mg/l NH3	0.45	Class 0: Water of an ideal quality		Class 1, Acceptable			
Ammonia (NH3)	mg/l NH3							
Appearance								
Arsenic (As) *	mg/l As							
Cadmium (Cd) *	mg/l Cd							
Calcium (Ca)	mg/l Ca	62.7	Class 2: Water which is safe for short term use only	No health effects. Some scaling.	Class 1, Acceptable	No treatment available	Precipitation with sodium carbonate	Ion exchange
Calcium (CaCo3)	mg/l CaCO3	203	Class 3: Water of an unacceptable quality	No health effects. Some scaling.				
Chloride (Cl)*	mg/l Cl	10	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Chlorine (Free)								
Chlorine (Total)								
Chloroform								
Colour								
Copper(Cu)								
Cyanide								
Electrical conductivity EC *	mS/m	66.6	Class 0: Water of an ideal quality		Class 1, Acceptable	---	No treatment available	Desalination by ion exchange or reverse osmosis
Faecal coliform *	counts/100 ml							
Fluoride (F) *	mg/l F	0.14	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	No treatment available	No treatment available	Ion exchange, Reverse osmosis or Adsorption or activated alumina
Iron (Fe) *	mg/l Fe	0.07	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach and filter	Normal coagulation and flocculation sedimentation and filtration Oxidation by aeration and pH adjustment or addition of chemical oxidants, followed by sedimentation	Ion exchange
Lead								
Magnesium (Mg)	mg/l Mg	38.9	Class 1: Water of a good quality		Class 1, Acceptable	No treatment available	Lime treatment	Ion exchange
Magnesium (MgCo3) *	mg/l MgCO3	160						
Manganese (Mn) *	mg/l Mn	0.01	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach solution or pool "chlorine" granules let stand to settle and filter	Normal coagulation, sedimentation and sand filtration Coagulation and/or oxidation by chlorine compounds or aeration	Coagulation and/or oxidation by chlorine compounds or potassium permangate or ozone or air. Zeolite softening
Mercury								
Nitrate (as N) *	mg/l N							
Nitrate (as NO3) *	mg/l N							
Nitrite (Soluble)		0.16			Class 1, Acceptable	No treatment available	No treatment available	Anaerobic biological reduction, reverse osmosis or other desalination techniques
Odour & Taste								
Organic carbon(sol)								
pH *	pH units	7.94	Class 0: Water of an ideal quality		Class 1, Acceptable	Neutralization with marble chips	pH adjustment by controlled addition of alkali such as lime sodium carbonate, carbon dioxide	Controlled addition of a suitable acid/alkali
Phenols								
Potassium (K) *	mg/l K	2.77	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Precipitation Potential								
Selenium								
Sodium (Na) *	mg/l Na	31.6	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Standard plate count								
Sulphate (SO4) *	mg/l SO4	59.9	Class 0: Water of an ideal quality			No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Total Alkalinity	mg/l							
Total Coliforms								
Total Dissolved Solids (TDS) *	(mg/l)	386	Class 0: Water of an ideal quality		Class 1, Acceptable			
Total Hardness **	mg CaCO3/l	317	Class 3: Water of an unacceptable quality	Very hard		---	Lime treatment	Ion exchange
Trihalomethanes								
Turbidity	NTU	18.2	Class 3: Water of an unacceptable quality	The presence of turbidity is one of the indicators of microbiological water quality and of inefficient water treatment.	Unacceptable	Flocculation and filtration	Slow sand filtration or flocculation, settlement and filtration	Same as conventional
Zinc (Zn) *	mg/l Zn							

QUALITY ANALYSIS

Borehole No.:	Spring Water (SP Engeo 7)	**CO-ORDINATES**	
Project No.:	LL3034	**Lat:**	
Project Name:	Eskom Majuba	**Long:**	
District:			

INPUT INFORMATION			DWAF		SANS 241:2011	WATER TREATMENT		
SUBSTANCE	**UNIT OF MEASURE**	**TEST VALUE**	**COMMENTS**		**COMMENTS**	**Home**	**Conventional treatment**	**Advanced**
Aldrin & Dieldrin								
Alkalinity		358						
Aluminium		10			Class 1, Acceptable			
Ammonia (N) **	mg/l NH3	0.02	Class 0: Water of an ideal quality		Class 1, Acceptable			
Ammonia (NH3)	mg/l NH3							
Appearance								
Arsenic (As) *	mg/l As							
Cadmium (Cd) *	mg/l Cd							
Calcium (Ca)	mg/l Ca	108	Class 3: Water of an unacceptable quality	No health effects. Severe scaling problems.	Class 1, Acceptable	No treatment available	Precipitation with sodium carbonate	Ion exchange
Calcium (CaCo3)	mg/l CaCO3	203	Class 3: Water of an unacceptable quality	No health effects. Severe scaling problems.				
Chloride (Cl)*	mg/l Cl	67.6	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Chlorine (Free)								
Chlorine (Total)								
Chloroform								
Colour								
Copper(Cu)								
Cyanide								
Electrical conductivity EC *	mS/m	108	Class 1: Water of a good quality		Class 1, Acceptable	---	No treatment available	Desalination by ion exchange or reverse osmosis
Faecal coliform *	counts/100 ml							
Fluoride (F) *	mg/l F	0.09	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	No treatment available	No treatment available	Ion exchange, Reverse osmosis or Adsorption or activated alumina
Iron (Fe) *	mg/l Fe	0.1	Class 1: Water of a good quality	#VALUE!	Class 1, Acceptable	Add bleach and filter	Normal coagulation and flocculation sedimentation and filtration Oxidation by aeration and pH adjustment or addition of chemical oxidants, followed by sedimentation	Ion exchange
Lead								
Magnesium (Mg)	mg/l Mg	52.9	Class 1: Water of a good quality		Class 1, Acceptable	No treatment available	Lime treatment	Ion exchange
Magnesium (MgCo3) *	mg/l MgCO3	218						
Manganese (Mn) *	mg/l Mn	0.03	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach solution or pool "chlorine" granules let stand to settle and filter	Normal coagulation, sedimentation and sand filtration Coagulation and/or oxidation by chlorine compounds or aeration	Coagulation and/or oxidation by chlorine compounds or potassium permangate or ozone or air. Zeolite softening
Mercury								
Nitrate (as N) *	mg/l N							
Nitrate (as NO3) *	mg/l N							
Nitrite (Soluble)		0.74			Class 1, Acceptable	No treatment available	No treatment available	Anaerobic biological reduction, reverse osmosis or other desalination techniques
Odour & Taste								
Organic carbon(sol)								
pH *	pH units	8.02	Class 0: Water of an ideal quality		Class 1, Acceptable	Neutralization with marble chips	pH adjustment by controlled addition of alkali such as lime sodium carbonate, carbon dioxide	Controlled addition of a suitable acid/alkali
Phenols								
Potassium (K) *	mg/l K	1.81	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Precipitation Potential								
Selenium								
Sodium (Na) *	mg/l Na	60.3	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Standard plate count								
Sulphate (SO4) *	mg/l SO4	142	Class 0: Water of an ideal quality			No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Total Alkalinity	mg/l							
Total Coliforms								
Total Dissolved Solids (TDS) *	(mg/l)	651	Class 1: Water of a good quality		Class 1, Acceptable			
Total Hardness **	mg CaCO3/l	488	Class 3: Water of an unacceptable quality	Very hard		---	Lime treatment	Ion exchange
Trihalomethanes								
Turbidity	NTU	16.8	Class 3: Water of an unacceptable quality	The presence of turbidity is one of the indicators of microbiological water quality and of inefficient water treatment.	Unacceptable	Flocculation and filtration	Slow sand filtration or flocculation, settlement and filtration	Same as conventional
Zinc (Zn) *	mg/l Zn							

QUALITY ANALYSIS

Borehole No.:	Spring Water (SP Engeo 8)	**CO-ORDINATES**	
Project No.:	LL3034	**Lat:**	
Project Name:	Eskom Majuba	**Long:**	
District:			

INPUT INFORMATION			DWAF		SANS 241:2011	WATER TREATMENT		
SUBSTANCE	UNIT OF MEASURE	TEST VALUE	COMMENTS		COMMENTS	Home	Conventional treatment	Advanced
Aldrin & Dieldrin								
Alkalinity		124						
Aluminium		10			Class 1, Acceptable			
Ammonia (N) **	mg/l NH3	0.45	Class 0: Water of an ideal quality		Class 1, Acceptable			
Ammonia (NH3)	mg/l NH3							
Appearance								
Arsenic (As) *	mg/l As							
Cadmium (Cd) *	mg/l Cd							
Calcium (Ca)	mg/l Ca	26.7	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	Precipitation with sodium carbonate	Ion exchange
Calcium (CaCo3)	mg/l CaCO3	203	Class 2: Water which is safe for short term use only					
Chloride (Cl)*	mg/l Cl	3.35	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Chlorine (Free)								
Chlorine (Total)								
Chloroform								
Colour								
Copper(Cu)								
Cyanide								
Electrical conductivity EC *	mS/m	33.1	Class 0: Water of an ideal quality		Class 1, Acceptable	---	No treatment available	Desalination by ion exchange or reverse osmosis
Faecal coliform *	counts/100 ml							
Fluoride (F) *	mg/l F	0.14	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	No treatment available	No treatment available	Ion exchange, Reverse osmosis or Adsorption or activated alumina
Iron (Fe) *	mg/l Fe	0.03	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach and filter	Normal coagulation and flocculation sedimentation and filtration Oxidation by aeration and pH adjustment or addition of chemical oxidants, followed by sedimentation	Ion exchange
Lead								
Magnesium (Mg)	mg/l Mg	16.8	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	Lime treatment	Ion exchange
Magnesium (MgCo3) *	mg/l MgCO3	69.2						
Manganese (Mn) *	mg/l Mn	0.01	Class 0: Water of an ideal quality	#VALUE!	Class 1, Acceptable	Add bleach solution or pool "chlorine" granules let stand to settle and filter	Normal coagulation, sedimentation and sand filtration Coagulation and/or oxidation by chlorine compounds or aeration	Coagulation and/or oxidation by chlorine compounds or potassium permangate or ozone or air. Zeolite softening
Mercury								
Nitrate (as N) *	mg/l N							
Nitrate (as NO3) *	mg/l N							
Nitrite (Soluble)		0.35			Class 1, Acceptable	No treatment available	No treatment available	Anaerobic biological reduction, reverse osmosis or other desalination techniques
Odour & Taste								
Organic carbon(sol)								
pH *	pH units	7.43	Class 0: Water of an ideal quality		Class 1, Acceptable	Neutralization with marble chips	pH adjustment by controlled addition of alkali such as lime sodium carbonate, carbon dioxide	Controlled addition of a suitable acid/alkali
Phenols								
Potassium (K) *	mg/l K	3.16	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Reverse osmosis, electrolysis, Ion exchange
Precipitation Potential								
Selenium								
Sodium (Na) *	mg/l Na	15.6	Class 0: Water of an ideal quality		Class 1, Acceptable	No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Standard plate count								
Sulphate (SO4) *	mg/l SO4	42	Class 0: Water of an ideal quality			No treatment available	No treatment available	Desalination by ion exchange or reverse osmosis
Total Alkalinity	mg/l							
Total Coliforms								
Total Dissolved Solids (TDS) *	(mg/l)	183	Class 0: Water of an ideal quality		Class 1, Acceptable			
Total Hardness **	mg CaCO3/l	136	Class 2: Water which is safe for short term use only	Slightly hard		---	Lime treatment	Ion exchange
Trihalomethanes								
Turbidity	NTU	19.9	Class 3: Water of an unacceptable quality	The presence of turbidity is one of the indicators of microbiological water quality and of inefficient water treatment.	Unacceptable	Flocculation and filtration	Slow sand filtration or flocculation, settlement and filtration	Same as conventional
Zinc (Zn) *	mg/l Zn							

Appendix E
DCP's

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Tel: 013 656 0719
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Client:	BTW Associates	Test No:	DCP 1
Project:	Amajuba Power Station	Location:	-
Job No:	LL3034	Performed By:	Phiwa and Cyril
Typed By:	A Nolan	Testing Date	2018/04/09
Southings:		Eastings:	

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	-2	-2	110.00
5	0	0.4	110.00
10	-1	-0.2	110.00
15	1	0.4	110.00
20	2	0.2	110.00
25	12	2	110.00
30	39	5.4	51.05
35	53	2.8	110.00
40			
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70			
75			
80			
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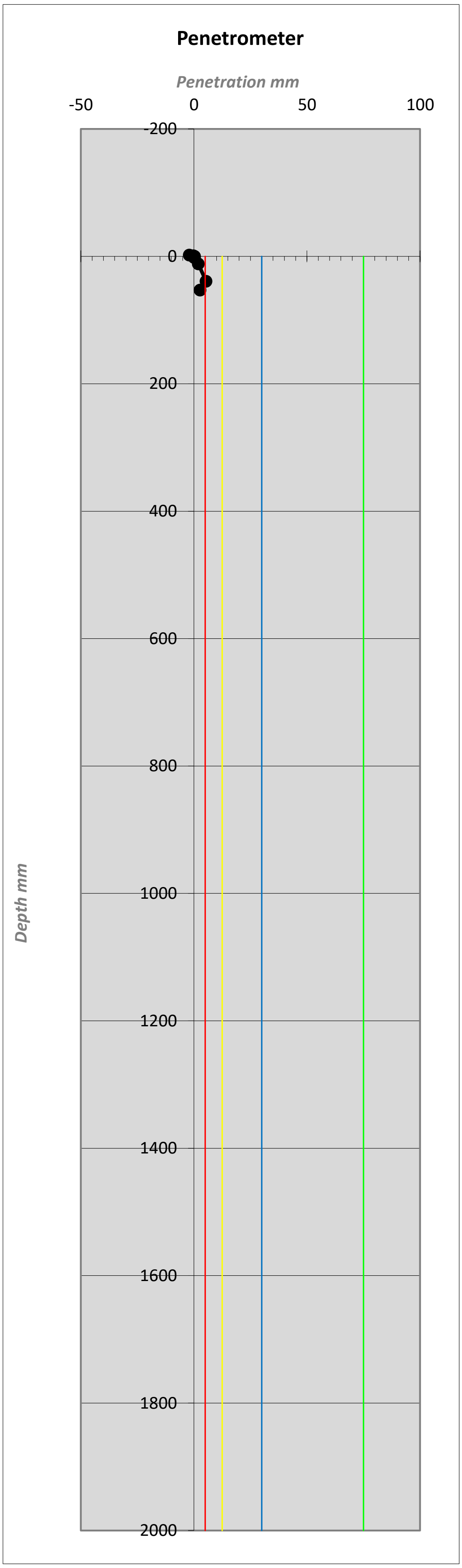

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Client: BTW Associates
Project: Amajuba Power Station
Job No: LL3034
Typed By: A Nolan
Southings:

Test No: DCP 2
Location: -
Performed By: Phiwa and Cyril
Testing Date 2018/04/09
Eastings:

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	0	0	
5	0	0	
10	1	0.2	110.00
15	3	0.4	110.00
20	5	0.4	110.00
25	9	0.8	110.00
30	15	1.2	110.00
35	22	1.4	110.00
40	27	1	110.00
45	38	2.2	110.00
50	53	3	110.26
55			
60			
65			
70			
75			
80			
85			
90			
95			
100			
105			
110			
115			
120			
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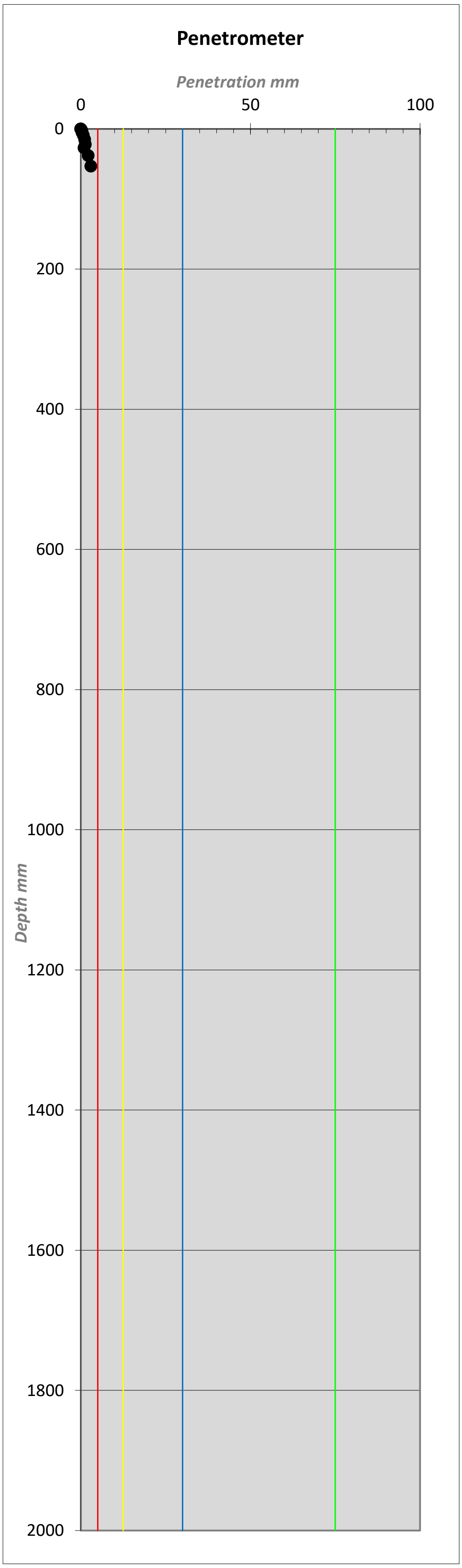

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Client: BTW Associates
Project: Amajuba Power Station
Job No: LL3034
Typed By: A Nolan
Southings:

Test No: DCP 3
Location: -
Performed By: Phiwa and Cyril
Testing Date 2018/04/09
Eastings:

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	0	0	
5	-1	-0.2	110.00
10	0	0.2	110.00
15	5	1	110.00
20	11	1.2	110.00
25	19	1.6	110.00
30	16	-0.6	110.00
35	22	1.2	110.00
40	29	1.4	110.00
45	0	-5.8	110.00
50			
55			
60			
65			
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75			
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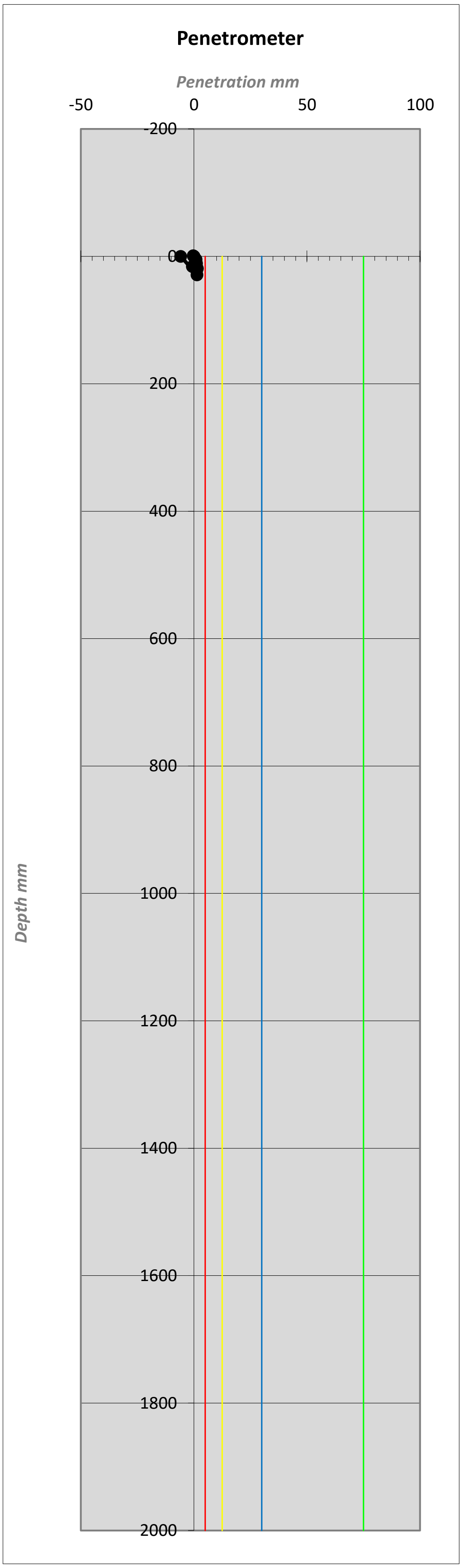

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Client: BTW Associates
Project: Amajuba Power Station
Job No: LL3034
Typed By: A Nolan
Southings:

Test No: DCP 4
Location: -
Performed By: Phiwa and Cyril
Testing Date 2018/04/09
Eastings:

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	0	0	
5	0	0	
10	-1	-0.2	110.00
15	1	0.4	110.00
20	2	0.2	110.00
25	15	2.6	110.00
30	10	-1	110.00
35	15	1	110.00
40	26	2.2	110.00
45	37	2.2	110.00
50	48	2.2	110.00
55			
60			
65			
70			
75			
80			
85			
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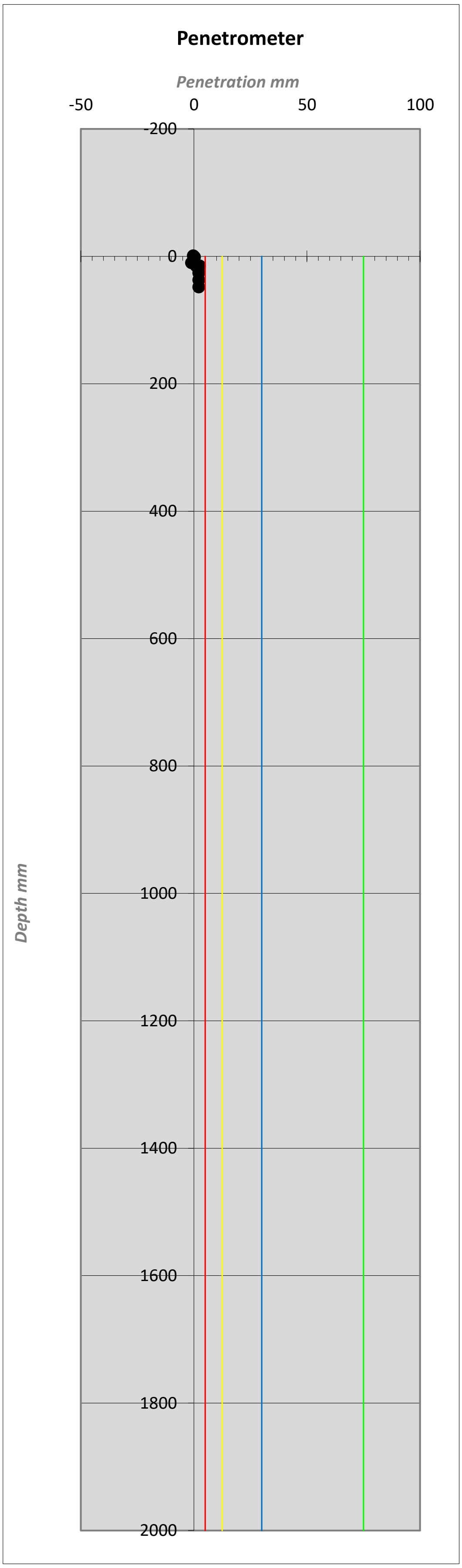

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Client: BTW Associates

Project: Amajuba Power Station

Job No: LL3034

Typed By: A Nolan

Southings:

Test No: DCP 5

Location: -

Performed By: Phiwa and Cyril

Testing Date 2018/04/09

Eastings:

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	0	0	
5	0	0	
10	-3	-0.6	110.00
15	-2	0.2	110.00
20	-1	0.2	110.00
25	2	0.6	110.00
30	6	0.8	110.00
35	9	0.6	110.00
40	12	0.6	110.00
45	12	0	
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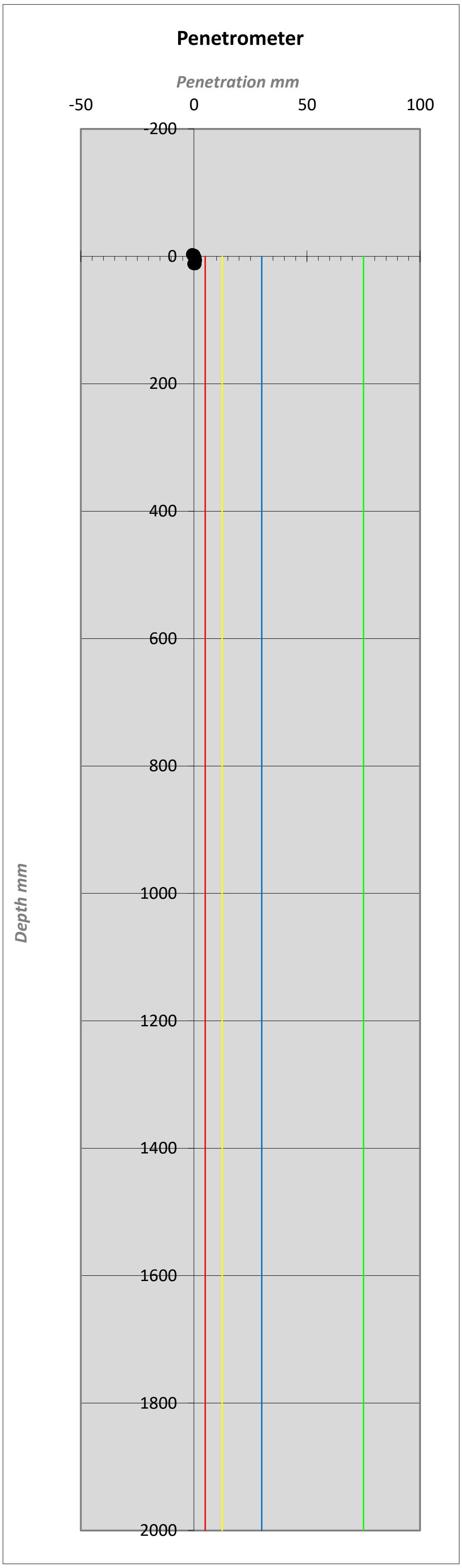

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Client: BTW Associates
Project: Amajuba Power Station
Job No: LL3034
Typed By: A Nolan
Southings:

Test No: DCP 6
Location: -
Performed By: Phiwa and Cyril
Testing Date 2018/04/09
Eastings:

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	0	0	
5	0	0	
10	1	0.2	110
15	3	0.4	110
20	6	0.6	110
25	19	2.6	110
30	26	1.4	110
35	37	2.2	110
40	47	2	110
45			
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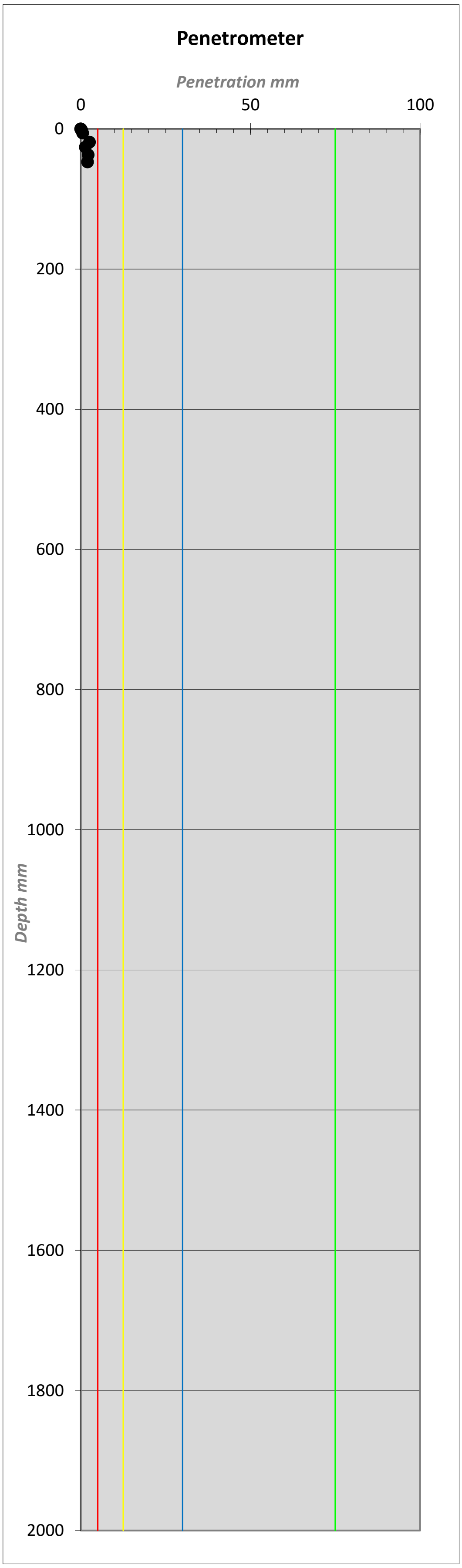

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Client: BTW Associates
Project: Amajuba Power Station
Job No: LL3034
Typed By: A Nolan
Southings:
Test No: DCP 7
Location: -
Performed By: Phiwa and Cyril
Testing Date 2018/04/09
Eastings:

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	0	0	
5	0	0	
10	3	0.6	110.00
15	7	0.8	110.00
20	24	3.4	93.59
25	28	0.8	110.00
30	45	3.4	93.59
35			
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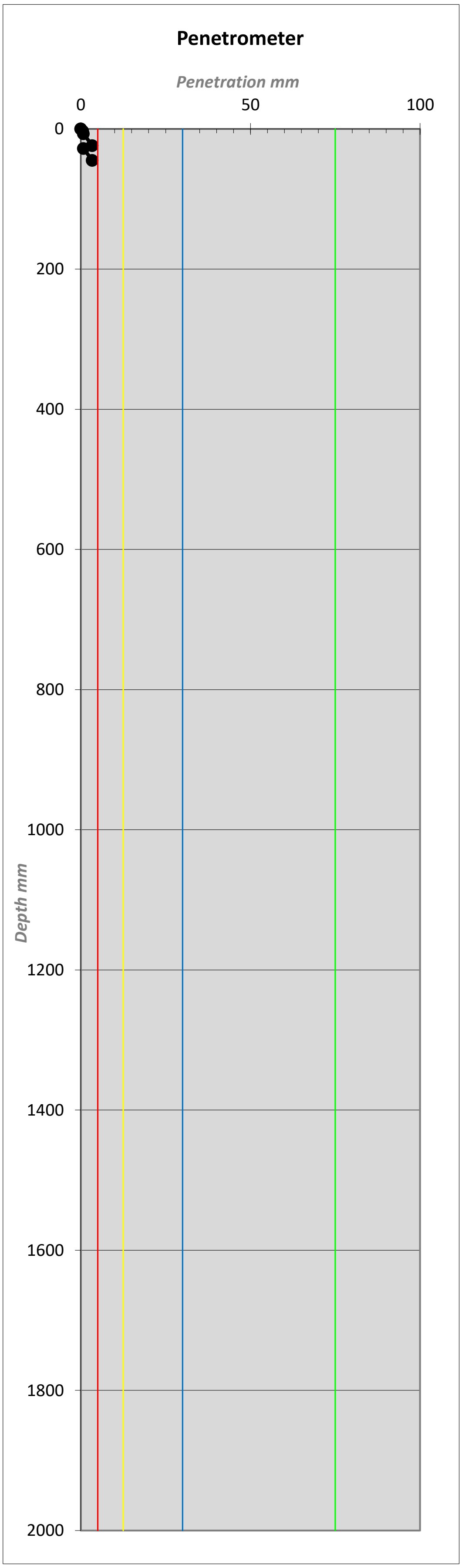

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Client: BTW Associates
Project: Amajuba Power Station
Job No: LL3034
Typed By: A Nolan
Southings:

Test No: DCP 8
Location: -
Performed By: Phiwa and Cyril
Testing Date 2018/04/09
Eastings:

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	0	0	
5	0	0	
10	0	0	
15	0	0	
20	17	3.4	93.59
25	9	-1.6	110.00
30	5	-0.8	110.00
35	3	-0.4	110.00
40	4	0.2	110.00
45	4	0	
50	48	8.8	26.93
55			
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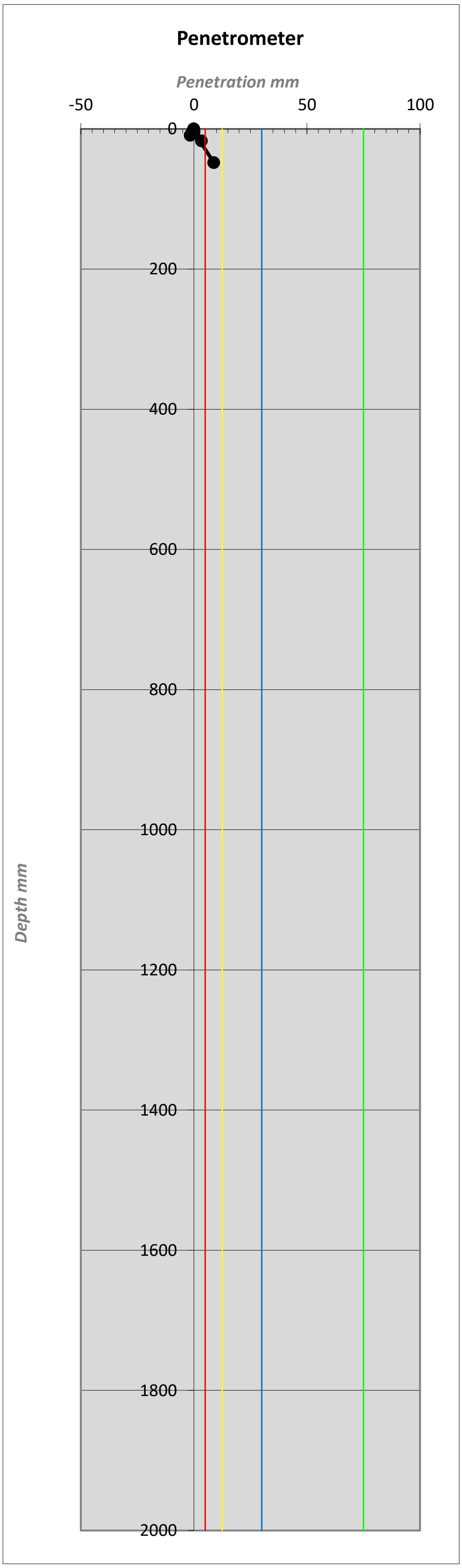

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Client: BTW Associates
Project: Amajuba Power Station
Job No: LL3034
Typed By: A Nolan
Southings:

Test No: DCP 9
Location: -
Performed By: Phiwa and Cyril
Testing Date 2018/04/09
Eastings:

Penetration mm/blow	Actual Depth mm / 5 Blows	Penetration mm/Blows	Approximate in-situ CBR
0	0	0	
5	0	0	
10	0	0	
15	1	0.2	110.00
20	4	0.6	110.00
25	4	0	
30	7	0.6	110.00
35	8	0.2	110.00
40	10	0.4	110.00
45	12	0.4	110.00
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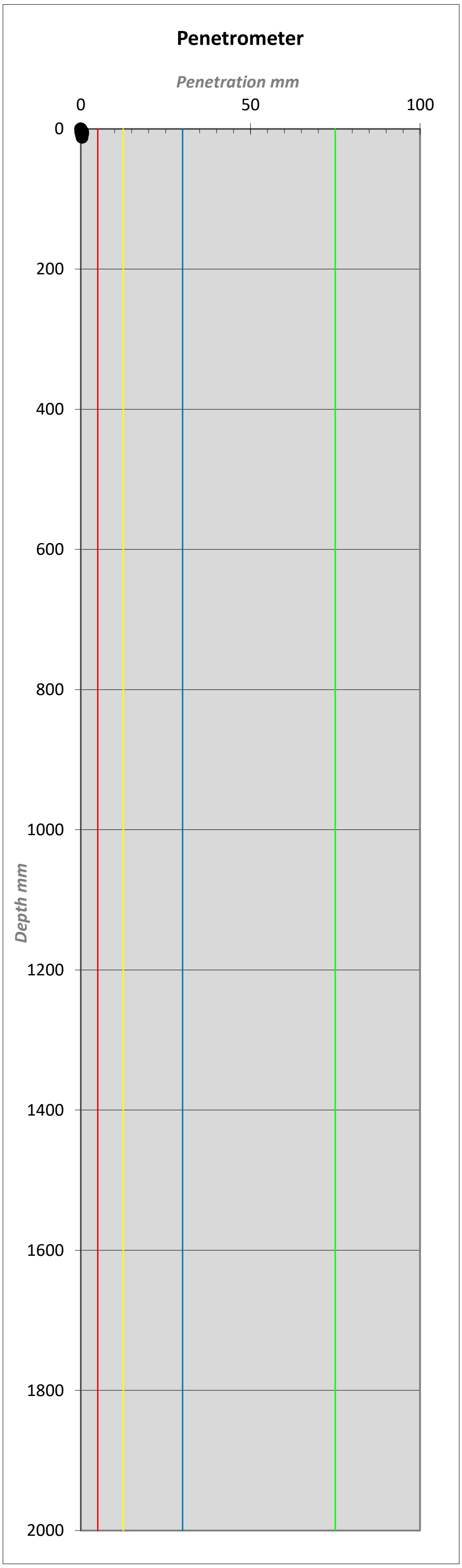

Geotechnical Investigation
Majuba General Waste Landfill Site
ESKOM Majuba Power Station

Volume 2

Project No: LL3034

Date: April 2018

Earth Science Consultants:

Engeolab

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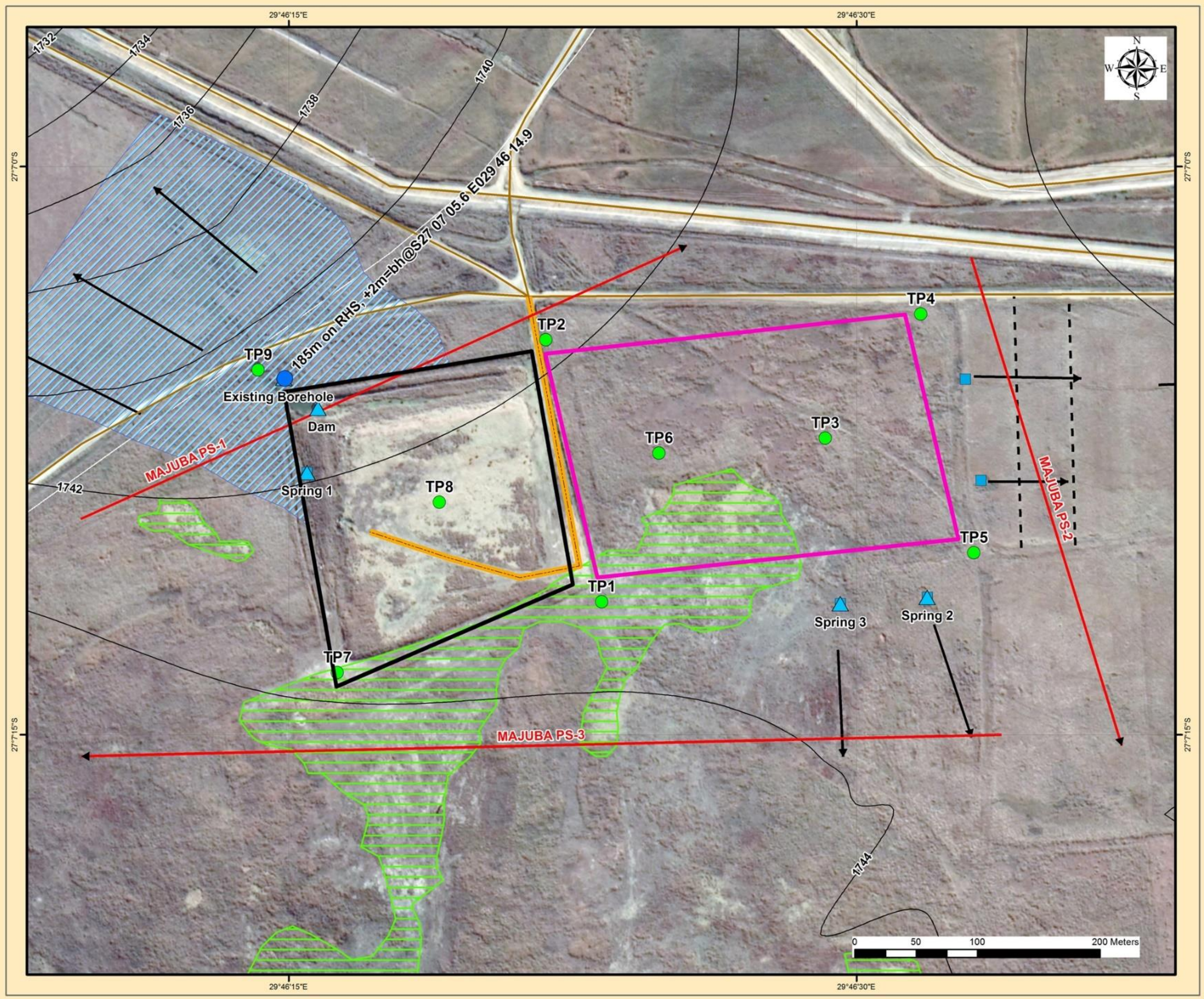

Client:

Eskom

MAJUBA POWER STATION
Feasibility Study Witkoppies Landfill Site

Fig: 2 Site Plan

- New Landfill Site
- Old Landfill Site (Fenced)
- Proposed Borehole
- Water Sample Sites
- Springs
- Testpits with Numbers
- Geophysical Traverses
- Contours (2m Intervals - Interpolated from 20m contours)
- Main Access Road
- Roads/Tracks
- Historic Surface Contours
- Drainage Direction
- Areas Stripped of Topsoil
- Wetlands

Consulting Engineers:

Celebrating 20 Years btw 1998-2018

Earth Science Consultants:

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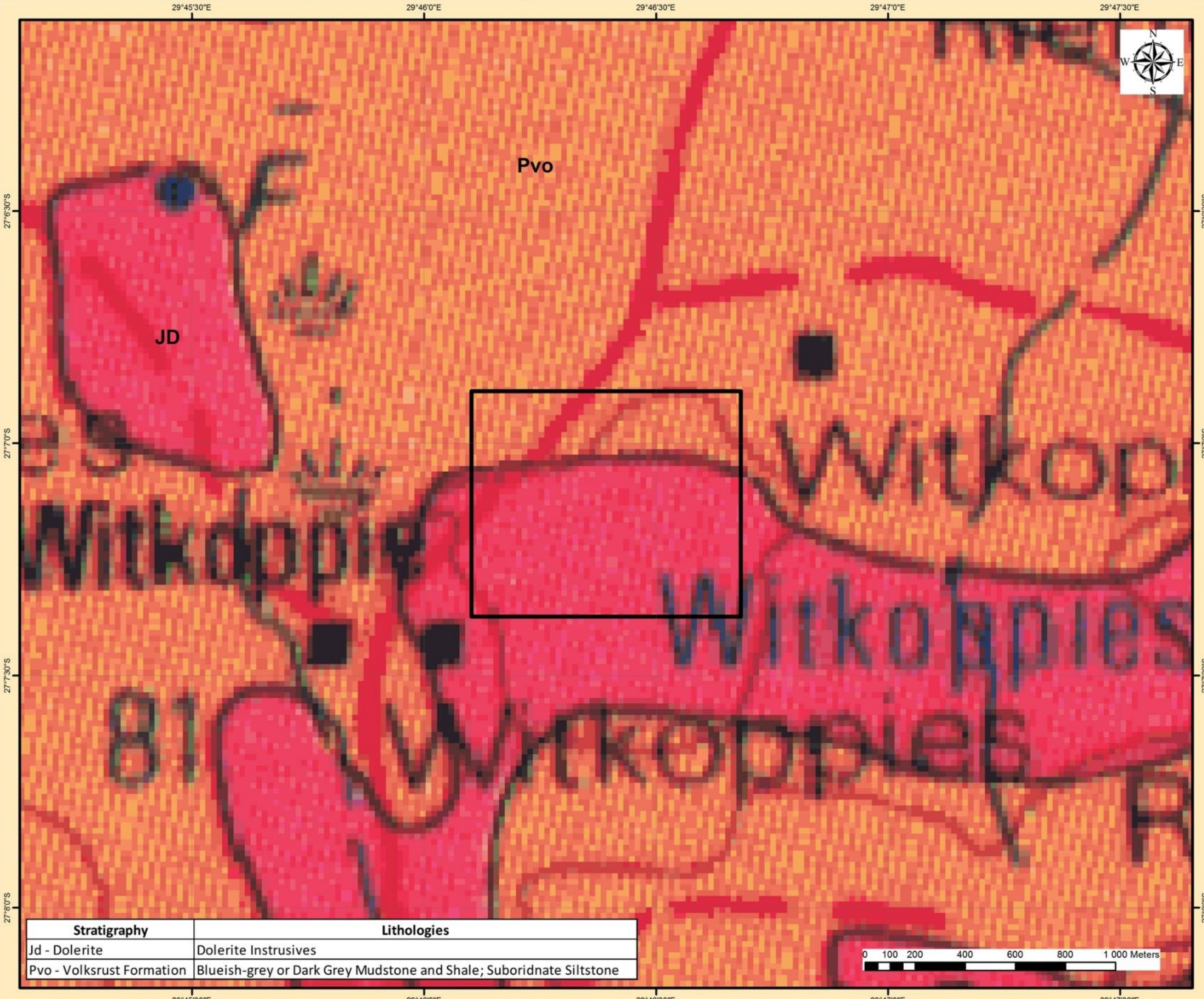
Project No: LL3034

Date: April 2018



Stratigraphy	Lithologies
Jd - Dolerite	Dolerite Instrusives
Pvo - Volksrust Formation	Blueish-grey or Dark Grey Mudstone and Shale; Suboridnate Siltstone

Client:

Eskom

MAJUBA POWER STATION
Feasibility Study Witkoppies Landfill Site

Fig: 3A Regional Geology

Site Investigated

Geology

Jd - Dolerite

Pvo - Volksrust Formation

Consulting Engineers:

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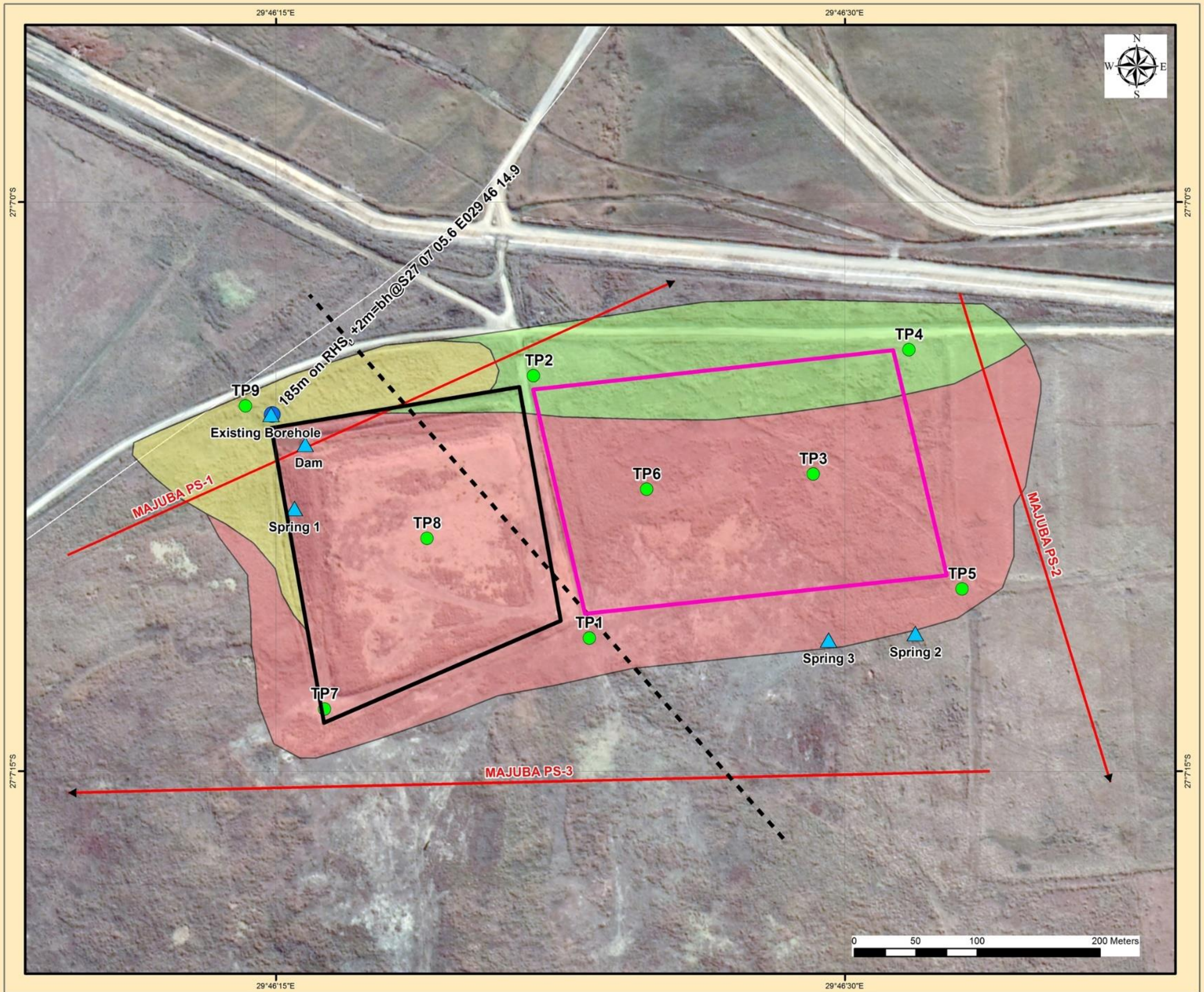
Project No: LL3034

Date: April 2018



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MAJUBA POWER STATION
Feasibility Study Witkoppies Landfill Site

Fig: 3B Site Geology

- New Landfill Site
- Old Landfill Site
- Water Sample Sites
- Testpits with Numbers
- Proposed Borehole
- Electro-magnetic Anomaly inferred from Geophysical Data
- Geophysical Traverses

Geology

- Clayey Alluvium
- Instrusive Dolerite
- Shale of the Volksrust Formation

Note:
All Geological Contacts are Inferred

Consulting Engineers:

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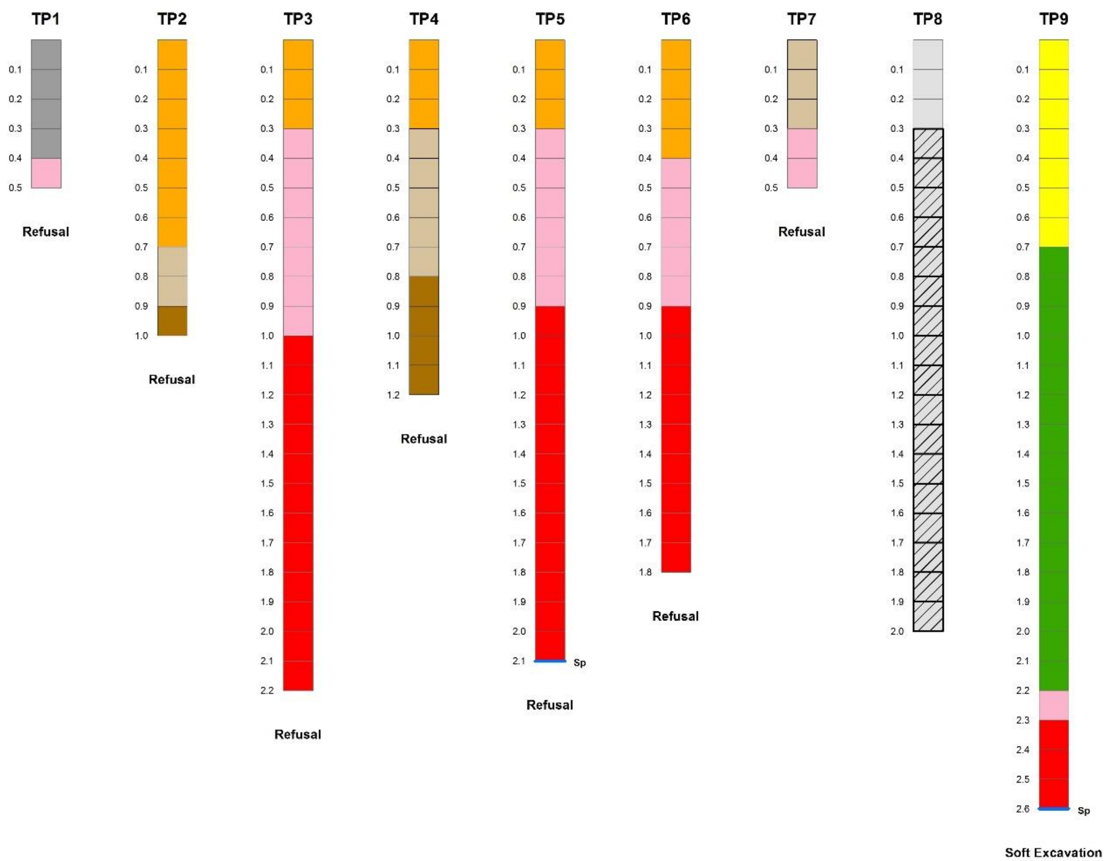
Project No: LL3034

Date: April 2018



Client:

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MAJUBA POWER STATION
Feasibility Study Witkoppies Landfill Site

Fig: 4 Profiles

Seepage (Sp)

Geology

- Imported Topsoil
- Domestic Waste Intercalated with Topsoil Layer
- Transported Soils
- Hillwash
- Alluvium (Black Firm to Stiff Clay)
- Dolerite Residuum (Sugary Textured)
- Dolerite Residuum (Green Soft Clay)
- Fractured Dolerite
- Shale Residuum
- Weathered Shale

Consulting Engineers:

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Earth Science Consultants:

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Project No: LL3034

Date: April 2018

Client:

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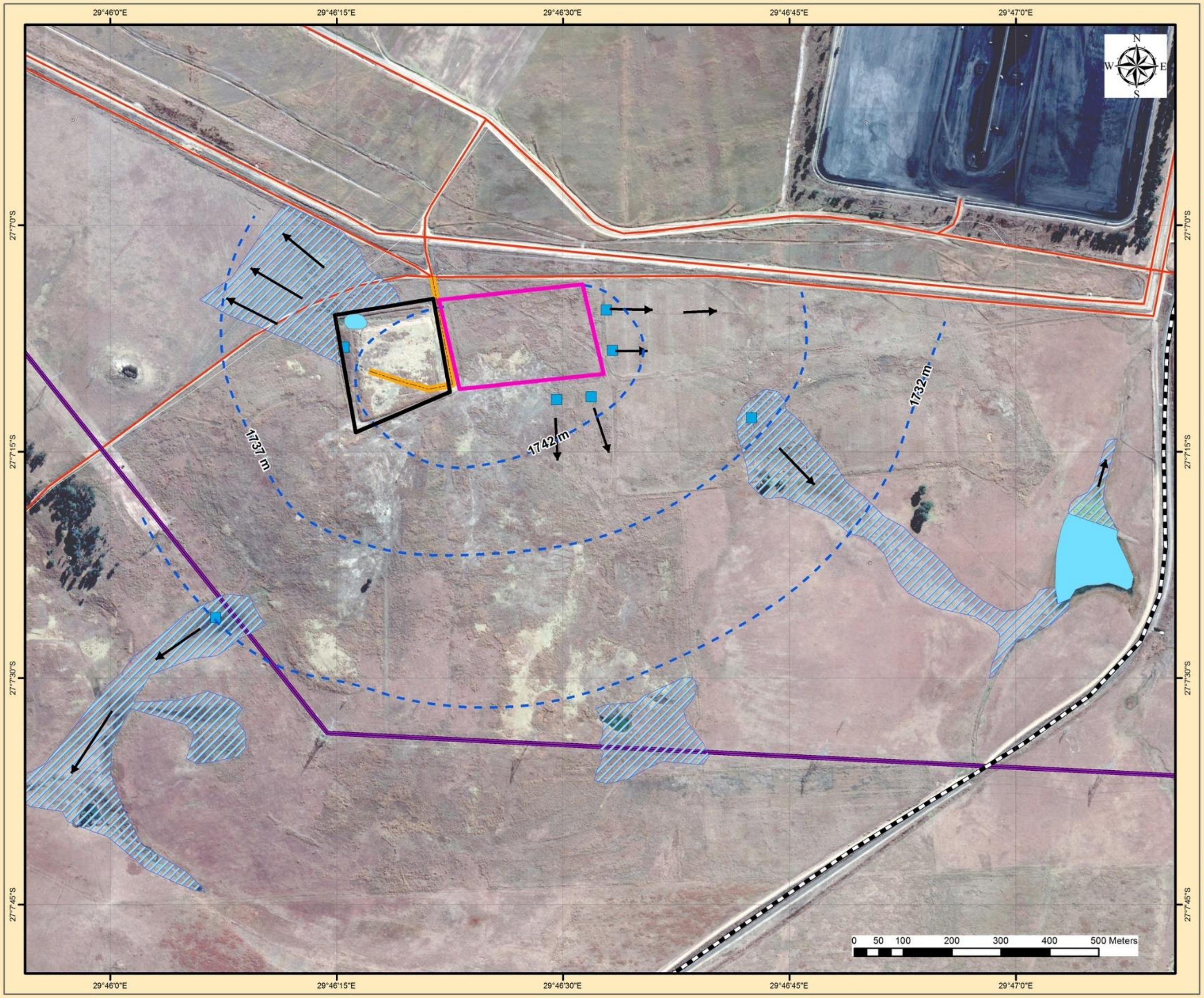
MAJUBA POWER STATION
Feasibility Study Witkoppies Landfill Site

Fig: 5 Surface Hydrology



New Landfill Site
Old Landfill Site
Inferred Spring Lines with Estimated Elevations
Drainage Direction
Springs
Wetlands
Dams
Railway
Eskom Overhead Powerline
Main Access Road
Roads/Tracks
SATS Railway Line

Consulting Engineers:

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Earth Science Consultants:

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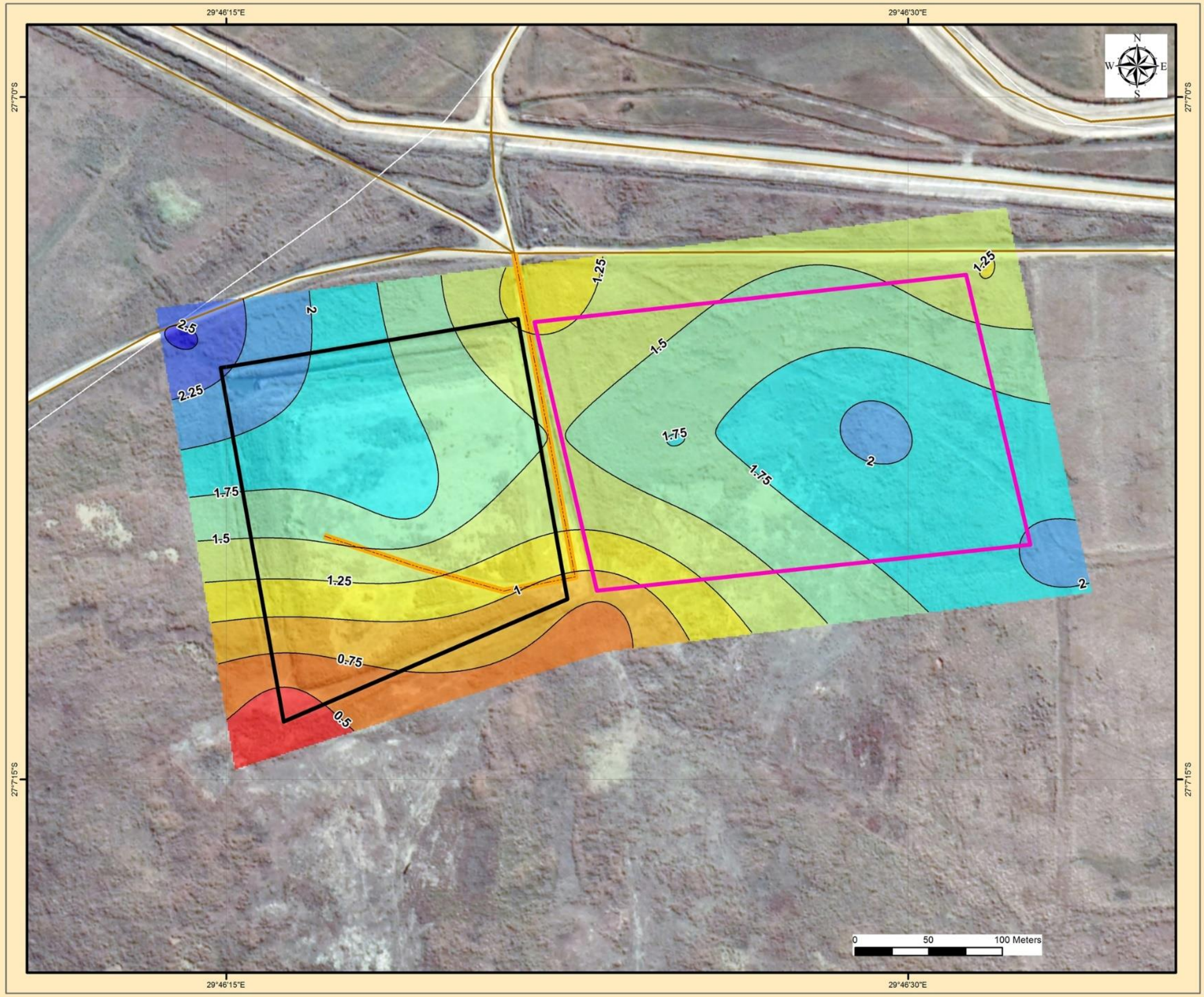
Project No: LL3034

Date: April 2018



Client:

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MAJUBA POWER STATION
Feasibility Study Witkoppies Landfill Site

Fig: 6 Excavatibility

New Landfill Site
Old Landfill Site
Excavatibility Contours (0.25m Intervals)
Main Access Road
Roads/Tracks

Excavatibility (From Surface)

0.33 - 0.50 Metres
0.51 - 0.75
0.76 - 1.00
1.01 - 1.25
1.26 - 1.50
1.51 - 1.75
1.76 - 2.00
2.01 - 2.25
2.26 - 2.50
2.51 - 2.75 Metres

Consulting Engineers:

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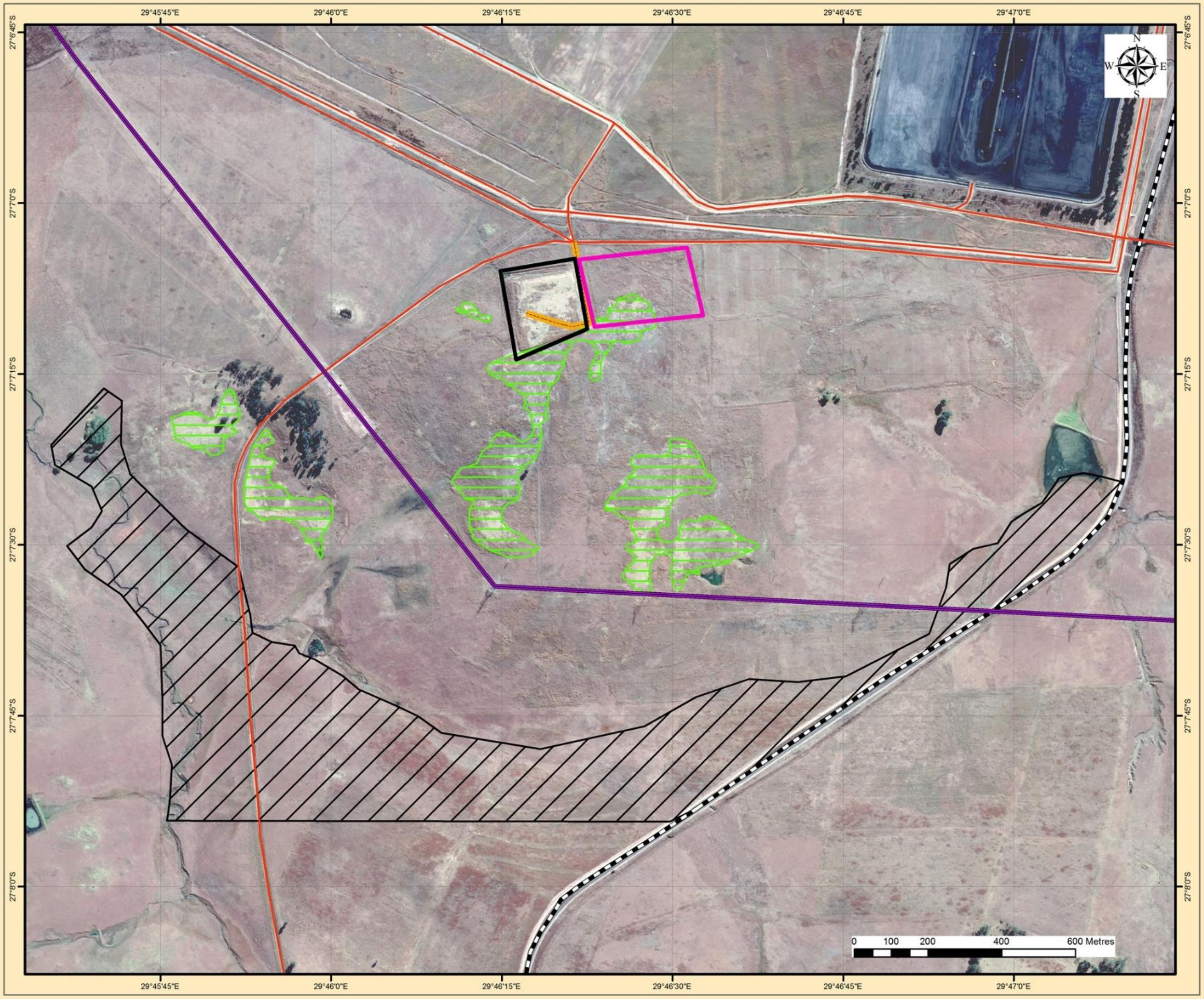
Project No: LL3034

Date: April 2018



Client:

Eskom

MAJUBA POWER STATION
Feasibility Study Witkoppies Landfill Site

Fig: 7 Other Material Sources

- New Landfill Site
- Old Landfill Site
- Eskom Overhead Powerline
- Main Access Road
- Roads/Tracks
- SATS Railway Line
- Borrow Areas
- Potential Sources of Liner and Capping Material

Consulting Engineers:

CELEBRATING 20 YEARS 1998-2018 btw

Earth Science Consultants:

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