SITE SELECTION STUDY FOR
THE PROPOSED NEW TRANSMISSION SUBSTATION
NEAR MAKOpane IN THE NORTHERN REGION

GEOTECHNICAL REPORT

PRELIMINARY GEOTECHNICAL INVESTIGATION
FOR THE SELECTION OF A SITE FOR THE
PROPOSED NEW BURUTHO 400/132kV SUBSTATION

May 2010
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TITLE: GEOTECHNICAL REPORT

PRELIMINARY GEOTECHNICAL INVESTIGATION
FOR THE SELECTION OF A SITE FOR THE
PROPOSED NEW BURUTHO 400/132kV SUBSTATION

PREPARED BY: Specialist Consultant Geotechnical Investigations
Transmission Technology

CLIENT: Land and Rights
Transmission

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Soillab

REPORT NO: GR03-08

DATE: May 2010

Approved:

F A Grové
Senior Specialist Consultant
Geotechnical Investigations
1.0 INTRODUCTION

Eskom plans to construct a new 400/132 kV Substation near Makopane in the Northern Region.

It was requested by Transmission System Planning to carry out a site selection study for the proposed new Burutho, 400/132kV Substation, near Makopane in the Northern Region.

PROPOSED STUDY AREA FOR THE NEW BURUTHO 400/132kV SUBSTATION
(Previously referred to Makopane Substation)

Figure-I

A Site for the planned development is required in the area near Makopane. The first phase of this investigation included extensive desk studies, where a total number of three most suitable study areas were identified for the substation. For the selection of these study areas during the desk studies, factors such as the geology, topography, farming activities, mining activities, Eskom installations and power line servitude routes were considered.

Information collected during this investigation is suitable for site selection purposes, and once the final design is required, a Detailed Geotechnical Investigation will be required to provide design parameters and confirm findings of this investigation.

2.0 THE NATURE OF THE PROJECT

The project comprises the construction of a new Substation in the Mashashane area, approximately 35km to the north of Mokopane town in the Limpopo Province.

The development would include the installation of typical equipment such as:

- Electrical transformers
- Circuit breakers or line termination structures
- High-voltage switchgear
- Low voltage switchgear
- Surge & lightning protection equipment
- Control and metering equipment
- Access roads and buildings
3.0 OBJECTIVES OF THE INVESTIGATION

The objectives of this investigation were defined as follows:

- Conduct intensive desk studies of the area to identify a total number of three most suitable sites for the proposed new substation
- Obtain geotechnical information during a Preliminary Geotechnical Investigation of selected sites to confirm findings of the desk study for suitability evaluation of sites

4.0 DESK STUDY

4.1 Maps Consulted

An attempt was made to collect as much information as possible of the study area demarcated by Transmission System Planning, for the proposed new substation during the desk study. For this purpose the following maps were consulted:

i) Topographical Maps – 2328DD LIMBURG; 2329CC MASHASANE
ii) Ortho Photos – Covering the area
iii) Geological Map – Geological Map 2328 Pietersburg
iv) Mining - Mineral Map of the Bushveld Complex – South Africa
   With Special reference to Platinum and Chrome Simplified Geology,
   Selected Mines and Mineral Deposits – South Africa, Lesotho and Swaziland

4.2 Aerial Photographic Interpretation

In principle the following features are being studied, information being obtained and interpreted when studying aerial photographs for geotechnical purposes:

- Reflection of the action of nature in creating the existing conditions
- Grouping of materials according to certain patterns
- Definition of various boundaries and linear features of significance
- Field checking by visual inspection

Stereo-interpretation has a great advantage over interpretation of a single photograph, because it is better able to identify topographical and erosion features, grey tones, and textures have greater requisite clarity contrasts. Basically, two aspects of the air photo image are revealed in the stereo-model of a given area, and these are surface form and grey tone, which could be subdivided as:

a) Elements of Surface Form
   - Topographic form
   - Drainage form
   - Erosion form

b) Elements of Grey tone and Texture of:
   - vegetation
   - due to land use
   - soil and rock material

Geotechnical information obtained in this way was correlated with Geological Map data.

4.3 Review of Desk Study and Selection of Sites

The size of the substation platform is 338m x 354.2m. For the purpose of flexibility site areas selected are of the order of 700mx700m. The region is known for its platinum and chrome mining activities. It has been confirmed by the EIA studies that
the sites selected for this study are not located in future mining fields. It should be noticed that the load centre area is limited in site options due to extreme topographical constraints.

4.4 Seismic Zoning

The South African loading code, SANS 10160 – 1969 (Figure-IIa and IIb), shows that the proposed sites for this study are situated in an area where the peak ground acceleration with a 10% probability of being exceeded in a 50 year period is between 50cm/sec² and 100cm/sec². Figure-IIb also show the zones where detailed seismic design (Zone-I) and compliance with minimum requirements (Zone-II) are specified by the code. The proposed Burutho sites fall outside of these Zones.
More recent data produced by the Council of Geoscience place the sites within the zone where the minimum seismic event, with a 10% probability of being exceeded in a 50 year period, falls in the range of 0.07g to 0.10g (Figure-III). This data however, still needs to be verified.

5.0 LOCALITY OF SITES INITIALLY SELECTED
It should be noted that options for suitable sites are limited in the Study Area due to extreme topographical constraints, which entails hillocks, water ways, perennial and non-perennial water streams and no road infrastructure.

For this reason, considering costs to develop Site-A, Site-A was rejected at an early stage due to extreme access and topographical difficulties and related costs. It was obvious to have geotechnical studies carried out for only Site-B and Site-C.

Site-C can easily be accessed from the N11 as indicated in Figure-V. To access Site-B will require a further investigation to obtain approval for road servitude options as indicated (Option-I and Option-II). Both these route options should be topographically surveyed and be evaluated in terms of flood lines and construction costs.

The identification and evaluation of the preferred access route does not form part of this preliminary Geotechnical Investigation.

Site-B and Site-C are located on the farms Noord Braband 774 LR and Zuid Holland 773 LR respectively. Site coordinates are:

Site-B  S 23˚ 53’ 42” E 28˚ 58’ 30.4”
Site-C  S 23˚ 52’ 21.8” E 28˚ 55’ 34.4”

6.0 REGIONAL ENVIRONMENT

6.1 Geography

6.1.1 Topography and Drainage

Waving topography with the presence of hillocks, hills and water ways forms features of the region. The two sites selected for final evaluation purposes are located within a 6 km radius. Site-B is located on a high, well drained and has no risk of flooding. Site-C is partly located within the 1:50 year flood line, and subject to a risk of being flooded. Access to Site-B is problematic since a road servitude needs to be located without a risk of flooding. This access road will cross a non-perennial water way which will require careful design.
The slope traversing Site-B in a north to south direction away from the hillock is ±2.5% and Site-C is located on a gentle, south western slope, of ±2.0%.

6.1.2 Flood –line

Flood line studies carried out indicate Site-C to have a risk of being flooded with a 1:50 year flood. Site-B has no risk of flooding. (See Appendix-A)

6.1.3 Climate

N-Value

The "Weinert N-Value", that describes the climatic environment, is approximately 4 for the area. Where "N" is more than "5", disintegration is the prominent form of weathering, and where "N" is less than "5", decomposition affects those rocks whose minerals are liable to change chemically under atmospheric conditions.

Rainfall

The average annual rainfall of the study areas is 505.3mm

Vegetation

Both sites are covered with typical indigenous bush of the area, re grass, bush and trees.

6.2 Geology

The regional geology comprises Gneiss, Migmatite and Leucogranite. The solid geology of the sites investigated is masked by transported silty sands at shallow depths. The solid geology is considered decomposed to highly weathered at shallow depths, Gneiss. (Geological Map 2328 Pietersburg)

6.3 Water Table

No evidence of a shallow water table was observed on any of the sites.

7.0 THE INVESTIGATION

7.1 Topographical Survey

Topographical surveys of sites were carried out to enable preliminary geometric designs. This forms an important part of the geotechnical evaluation of sites, since ground elevations will be altered, due to the cut to fill operations during construction of the platform.

7.2 Geometric Design

Preliminary geometric designs were carried out for all three sites, at positions considering the optimisation of the topography and existing and future power line routes. These designs expose valuable information in terms of construction costs.

7.3 Exploratory Work

Test pits were excavated randomly to maximum reach or refusal, to confirm findings of the desk study, in terms of geotechnical properties.
SITE-B   TEST PIT POSITIONING

The average soil profile was found uniformly present over the sites, with discrepancies regarding the material occurrences and physical properties with depth.

SITE-C   TEST PIT POSITIONING

The exception was that the profile of Site-B was found less weathered with depth than Site-C, with rock outcropping in places.

7.4 Laboratory Testing

Laboratory tests on soil samples were primarily conducted to determine Geotechnical properties of the soil, confirming findings during profiling.

The following tests were carried out:
- Grading (Mechanical and Hydrometer)
- Atterberg Limits
8.0 GEOTECHNICAL EVALUATION

8.1 Soil Profile

The soil profiles of both sites investigated (Site-B & Site-C) are similar, with shallowly weathered rock near surface. However the difference in topography will have a remarkable influence on the cost of the construction of the substation platform on each site.

8.2 Geology Influences on Construction

It is believed that the combination of ground conditions and topography of Site-B and C will have a great affect on conventional construction methods. Both sites are shallowly underlain by SOFT ROCK. However, the steeper sloping of the topography of Site-B will have a vast influence on the difference in construction costs of the platform. In addition the construction of an access road of at least 5km is required to access Site-B.

8.3 Topography - Preliminary Substation Positioning and Geometry (Earthworks Volumes)

An attempt was made to optimise the positioning of the substation platform on both sites, considering topography and power line locality (See Appendix-D)

Topographical features and present soil information of each site were taken into account during this exercise. The following volumes for earthworks were obtained during this exercise for each site:
<table>
<thead>
<tr>
<th>Site</th>
<th>Strip m³</th>
<th>Cut m³</th>
<th>Fill m³</th>
<th>Special Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site-A</td>
<td>15 570</td>
<td>168 370</td>
<td>151 135</td>
<td>Construction of Access Road ± 10km</td>
</tr>
<tr>
<td>Site-B</td>
<td>13 655</td>
<td>42635</td>
<td>33 305</td>
<td>Borrow material required to Construct the Substation Platform + 5km Access Road</td>
</tr>
<tr>
<td>Site-C</td>
<td>13 165</td>
<td>14 555</td>
<td>11 455</td>
<td>None – Access Road 600m</td>
</tr>
</tbody>
</table>

From the preliminary quantities it is clear that **Site-C will be the most cost effective** site to develop, ignoring the risk of flooding and the costs to develop **Site-A** is abnormally high. Considering all costs to develop sites and risks involved **Site-B** would be the most suitable site to develop.

Attached to this report are preliminary geometric designs, indicating optimised platform positioning for each site (Appendix-D). Combining the geometry of the topography with the ground conditions of each site (only Site-B & Site-C) it is clear that a vast quantity of rock will be excavated from **Site-B**, during a cut to fill operation. This will result in the need to import borrow material to replace unsuitable rock from cut. It is estimated with information at hand that a minimum of 15 000m³ of rock from cut will be unsuitable for the construction of the fill.

### 8.4 Flood Line Studies

Flood line studies have revealed that Site-A and Site-B have no risk of flooding but Site-C has an apparent risk of being flooded during a 1:50 year flood.

### 9.0 CONCLUSIONS AND RECOMMENDATIONS

Considering the results of all the studies carried out during this investigation it is clear that **Site-C** is the most cost effective site to develop, not considering the risk of flooding. Though **Site-B** will be more costly site to develop it has no risk of being flooded.
9.0 REFERENCES

APPENDIX-A

Flood line Studies

Burotho Sites
SITE B IS SITUATED CLOSE TO A RIDGE AND THEREFORE HAS A VERY SMALL CATCHMENT WHICH DELIVERS A MAXIMUM FLOW OF 7.10 CUBIC METERS PER SECOND IN A 1:50 FLOOD. THE NEAREST WATER COURSE IS 120 METERS AWAY FROM THE SITE AND THE EXPECTED WIDTH A FLOW IS ONLY 27.5 METERS WHICH MEANS THAT THIS SITE HAS NO DANGER OF FLOODING UNDER A 1:50 YEAR FLOOD.
SITE C IS SITUATED CLOSE TO A TRIBUTARY WHICH HAS A CATCHMENT OF 4.73 SQUARE KILOMETERS WHICH DELIVERS A MAXIMUM FLOW OF 42.3 CUBIC METERS PER SECOND IN A 1:50 FLOOD. THE NEAREST WATER COURSE IS 20.4 METERS AWAY FROM THE SITE AND THE EXPECTED WIDTH A FLOW IS 51.5 METERS WHICH MEANS THAT THIS SITE HAS AN APPARENT POSSIBILITY OF FLOODING UNDER A 1:50 YEAR FLOOD.
APPENDIX - B
SOIL PROFILES
PROJECT: BURUTHO SUBSTATION SITE SELECTION-SITE-C

Done by: Specialist Consultant
Geotechnical Investigations
TRANSMISSION TECHNOLOGY

BOULDER (SA01)

GRAVEL (SA02)

SAND (SA04)

SANDY (SA05)

SILT (SA06)

SILTY (SA07)

CLAY (SA08)

CLAYEY (SA09)

GRANITE (SA17/SA44)

DISTURBED SAMPLE (SA36)

CONTRACTOR: 

MACHINE: 

DRILLED BY: 

PROFILED BY: 

TYPE SET BY: 

SETUP FILE: PROF-1.SET

DATE: 09/06/19 13:05

TEXT: C:\GEOPRED\MAIN\PROF.TXT

LEGEND

SUMMARY OF SYMBOLS

DO57 ESOM TRANSMISSION

JAW
Dry, light grey, shattered, sandy CLAY with roots and organic material. Transported

Dry, light yellowish olive, very dense, intact, micaceous, fine gravel in a clayey SILT
Residual Gneiss

Refusal on SOFT ROCK GRANITE GNEISS

NOTES
1) Area covered with dense indigenous grass bush and trees.
PROJECT: BURUTHO SUBSTATION SITE SELECTION-SITE-C
Done by: Specialist Consultant
Geotechnical Investigations
TRANSMISSION TECHNOLOGY

Scale: 1:10

0.00
Dry, brown, medium dense, intact, clayey SAND with roots and
organic material.
Topsoil

0.20
Dry, light greyish, very dense, intact, quartz GRAVEL in a
clayey sand.
Residual Gneiss

0.80
Dry, dark yellowish, fractured very soft ROCK GRANITE
GNEISS

0.8–1.3m

Refusal on MEDIUM HARD ROCK GNEISS

NOTES:
1) Area covered with dense indigineous grass bush and trees.
2) Disturbed Sample take at 0–0,2m
3) Disturbed Sample take at 0,8–1,3m
Dry, yellowish brown, medium dense, intact, slightly clayey silty SAND with roots and organic material. Topsoil

Dry, dark brown, dense, intact, ferruginised quartz GRAVEL in a clayey sand. Pebble Marker

Dry, dark olive, very dense, intact, ferruginised in places, GRAVEL in a silty sand. Residual Gneiss

Refusal on MEDIUM HARD ROCK GRANITE GNEISS

NOTES:

1) Area covered with dense indigenous grass bush and trees

2) Disturbed Sample take at 0.1–0.4m

3) Disturbed Sample take at 0.4–1.4m
Slightly moist, light yellowish, medium dense, intact, clayey fine SAND with roots and organic material in top 300mm. Topsoil

Dry, dark yellowish stained light grey, intact, well developed fe gravel in a slightly clayey silty sand. Transported

Dry, dark yellowish, fractured very soft ROCK Gneiss

Refusal on medium hard rock GRANITE GNEISS

NOTES

1) Area covered with dense indigineous grass bush and trees.
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Dry, light brown, medium dense, intact, silty SAND with roots and organic material. Top Soil</td>
</tr>
<tr>
<td>0.20</td>
<td>Dry, light brown, medium dense, intact, slightly clayey SAND with roots and organic material in top. Transported</td>
</tr>
<tr>
<td>0.50</td>
<td>Slightly moist to moist, dark red black mottled, very dense, intact, ferruginised quartz GRAVEL in a clayey sand. Pebble Marker</td>
</tr>
<tr>
<td>1.00</td>
<td>Dry, light brown stained black and dark yellow, very dense, intact, well cemented, GRAVEL in a silty sand. Residual Gneiss</td>
</tr>
<tr>
<td>1.40</td>
<td>Refusal on SOFT ROCK GRANITE GNEISS</td>
</tr>
</tbody>
</table>

**NOTES**

1) Area covered with dense indigineous grass bush and trees.
Dry, light brown, medium dense, intact, slightly clayey silty SAND with roots and organic material in top 200mm, with BOULDERS. Transported

Dry, speckled white, yellowish orange and light brown, dense, intact, quartz GRAVEL and BOULDERS in a slightly clayey sand. Residual Gneiss

Dry, light greyish, dense, intact, fine to medium GRAVEL in sity sand. Residual Granite

Refusal on SOFT ROCK GRANITE GNEISS

NOTES
1) Area covered with dense indigineous grass bush and trees.
Dry, light brown, medium dense, intact, quartz GRAVEL in a slightly clayey silty SAND with roots and organic material in top 200mm. Transported

Dry, speckled white red yellowish orange and light brown, very dense, intact, medium to coarse GRAVEL in a slightly clayey sand. Residual Granite

Dry, light greyish, very dense, intact, fine to medium GRAVEL in silty sand. Residual Gneiss

Refusal on SOFT ROCK GRANITE GNEISS

NOTES

1) Area covered with dense indigenous grass bush and trees.
Dry, light brown, medium dense, intact, quartz GRAVEL in a slightly clayey silty SAND with roots and organic material in top 200mm. Transformed.

Dry, speckled white, red, yellowish orange and light brown, very dense, intact, medium to coarse GRAVEL and BOULDERS in a slightly clayey sand. Pebble Marker

Dry, light greyish, very dense, intact, fine to medium GRAVEL in silty sand. Residual Gneiss

Refusal on SOFT ROCK GRANITE GNEISS

NOTES:
1) Area covered with dense indigeneus grass bush and trees.
Dry, light greyish brown, medium dense, intact, quartz GRAVEL in a slightly clayey silty SAND with roots and organic material. Transported.

Dry, light brown, very dense, intact, medium to coarse GRAVEL in a slightly clayey sand. Pebble Marker

Dry, light greyish, very dense, intact, fine to medium GRAVEL in situ sand. Residual Gneiss

Refusal on Soft Rock GRANITE GNEISS

NOTES
1) Area covered with dense indigineous grass bush and trees.
Dry, light greyish brown, medium dense, intact, quartz gravel in a slightly clayey silty sand with roots and organic material.
Transported

Dry, light brown, very dense, intact, micaceous, medium to coarse gravel in a slightly clayey sand.
Residual Granite

Refusal on SOFT ROCK GRANITE GNEISS

NOTES

1) Area covered with dense indigenous grass bush and trees.
Dry, light greyish brown, **medium dense**, intact, quartz GRAVEL in a slightly clayey silty SAND with roots and organic material. Transported

Dry, light brown, **very dense**, intact, medium to coarse GRAVEL in a slightly clayey sand. Pebble Marker

Dry, light greyish, **very dense**, intact, fine to medium GRAVEL in silty sand. Residual Granite

Refusal on **SOFT ROCK GRANITE GNEISS**

**NOTES**

1) Area covered with dense indigenous grass bush and trees.
0.00
Dry, light greyish brown, medium dense intact, quartz gravel in a slightly clayey silty sand with roots and organic material. Transformed.

0.20
Dry, light brown, very dense intact, medium to coarse gravel in a slightly clayey sand. Pebble Marker.

0.70
Dry, light greyish, very dense intact, fine to medium gravel in silty sand. Residual Granite.

1.00
Refusal on Soft Rock Granite Gneiss

NOTES
1) Area covered with dense indigenous grass bush and trees.
Dry, light greyish brown, medium dense, intact, quartz GRAVEL in a slightly clayey silty SAND with roots and organic material. Transported

Dry, light brown, very dense, intact, medium to coarse GRAVEL in a slightly clayey sand. Residual Granite

Refusal on HARD ROCK GNEISS

NOTES:
1) Area covered with dense indigineous grass bush and trees.
2) Trees 100mm to 300mm
Dry, light greyish brown, medium dense, intact, quartz GRAVEL in a slightly clayey silty SAND with roots and organic material. Transported

Dry, light brown, very dense, intact, medium to coarse quartz GRAVEL in a slightly clayey sand. Pebble Marker

Dry, light yellowish speckled brown and white, very dense, intact, fine to medium GRAVEL in silty sand. Residual Gneiss

Dry, light grey, very dense, intact, fine GRAVEL in a silty sand. Residual Gneiss

Refusal on SOFT ROCK Granite GNEISS

NOTES

1) Area covered with dense indigenous grass bush and trees.
APPENDIX - C

Laboratory Test Results
**CONDUCTIVITY**

<table>
<thead>
<tr>
<th>Soilab No</th>
<th>Sample Position</th>
<th>Sample Depth (m)</th>
<th>Electrical Conductivity S/m</th>
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</thead>
<tbody>
<tr>
<td>S10-0401-01</td>
<td>TP-M2</td>
<td>0-0.2</td>
<td>0.0456</td>
</tr>
<tr>
<td>S10-0401-02</td>
<td>TP-M2</td>
<td>0.8-1.3</td>
<td>0.0257</td>
</tr>
<tr>
<td>S10-0401-03</td>
<td>TP-M3</td>
<td>0.1-0.4</td>
<td>0.0311</td>
</tr>
<tr>
<td>S10-0401-04</td>
<td>TP-M3</td>
<td>0.4-1.4</td>
<td>0.0668</td>
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<tr>
<td>S10-0401-05</td>
<td>TP-MB4</td>
<td>0-0.3</td>
<td>0.0208</td>
</tr>
<tr>
<td>S10-0401-06</td>
<td>TP-MB4</td>
<td>0.3-0.8</td>
<td>0.0190</td>
</tr>
<tr>
<td>S10-0401-07</td>
<td>TP-MB4</td>
<td>0.8-1.1</td>
<td>0.0167</td>
</tr>
</tbody>
</table>
PARTICLE SIZE ANALYSIS

Sample No. 44932 44933
Solids Sample No. S10-6401-01 S10-6401-02
Depth (m) 0.2 0.8-1.3
Position TP M2 TP M2
Material
Description DARK BROWN QUARTZ DARK OLIVE DOLERITE
SILTY SAND GRAVELLY SAND
Moisture (%) 4.2 0.4
SS

SCREEN ANALYSIS (% PASSING) (TMH 1 A1(a) & A5)

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>63.0</th>
<th>37.5</th>
<th>26.5</th>
<th>15.0</th>
<th>12.5</th>
<th>6.35</th>
<th>0.425</th>
<th>0.075</th>
</tr>
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<tbody>
<tr>
<td>% Passing</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

HYDROMETER ANALYSIS (% PASSING) (TMH 1 A6)

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<th>Size (mm)</th>
<th>0.042</th>
<th>0.027</th>
<th>0.013</th>
<th>0.005</th>
<th>0.002</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Passing</td>
<td>18</td>
<td>16</td>
<td>13</td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

% Clay 1
% Silt 29
% Sand 53
% Gravel 11

ATTERBERG LIMITS (TMH 1 A2 - A4)

<table>
<thead>
<tr>
<th>Property</th>
<th>Liquid Limit</th>
<th>Plasticity Index</th>
<th>Liquid Shrinkage (%)</th>
<th>Plastic Shrinkage (%)</th>
<th>Plastic Index (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>20</td>
<td>3.8</td>
<td>3.0</td>
<td>A-4 (5)</td>
</tr>
<tr>
<td>Grading Modulus</td>
<td>0.96</td>
<td>1.60</td>
<td></td>
<td></td>
<td>A-1-B (4)</td>
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<tr>
<td>Classification</td>
<td>CLEAR</td>
<td>5G, 8 OM</td>
<td></td>
<td></td>
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<tr>
<td>Modified Classification</td>
<td>CLEAR</td>
<td>5G, 8 OM</td>
<td></td>
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<tr>
<td>Chart Reference</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

POSSIBLE EXPANSIVENESS

PLASTICITY CHART

CLAY SILT SAND GRAVEL

SOILLAB
(PTY) LTD
236 Allister Street
La Montagne 0164
P.O. Box 17328
Reg No: 1997/00112/07
Tel: 0112 461-9990
Fax: 0112 461-9912

Lyndene/Ridge 0040
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PARTICLE SIZE ANALYSIS

PROJECT: BUROTRO (MAYOPANE) SUBSTATION
JOB No.: S10-0401
DATE: 2010-04-22

Sample No. 44364 44365
Soil sample no. S10-0401-03 S10-0401-04
Depth (m) 0.1-0.4 0.4-1.4
Position TP-M3 TP-M3
Material Description DARK BROWN QUARTZ SANDY GRAVEL
DARK BROWN RHYOLITE SANDY GRAVEL
Moisture (%) 3.0 6.6

SCREEN ANALYSIS (% PASSING) (TMH 1 A1b) & A5)

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>63.0</th>
<th>53.0</th>
<th>26.5</th>
<th>19.0</th>
<th>15.0</th>
<th>12.5</th>
<th>9.0</th>
<th>6.0</th>
<th>3.0</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>63</td>
<td>37</td>
<td>25</td>
<td>12</td>
</tr>
</tbody>
</table>

HYDROMETER ANALYSIS (% PASSING) (TMH 1 A6)

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>0.040</th>
<th>0.027</th>
<th>0.015</th>
<th>0.005</th>
<th>0.002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

% Clay: 4
% Silt: 17
% Sand: 23
% Gravel: 57

Atterberg Limits (TMH 1 A2 - A4)

- Liquid Limit: 50
- Plasticity Index: 9 (SP)
- Linear Shrinkage (%): 4.0 (5.5)
- Plastic Index: 1.88 (2.08)
- Classification: A-2-4 (D) A-1-5 (D)
- Unified Classification: OC
- Chart Reference: -

SOILLAB
(Pty) Ltd
230 Albert Street
Lo雨ympoap Street 5144
P.O Box 7262
Tel: (012) 645 3006
Fax: (012) 645 3006
PARTICLE SIZE ANALYSIS

Sample No. 44365  44367
Builathi sample no. S13-0401-05  S13-0401-06
Depth (m) 0.6-3  0.3-5.6
Position TP MBS  TP MBS
Material Description DARK BROWN QUARTZ  DARK BROWN QUARTZ
                      SILTY SAND  SAND GRAVEL
Moisture (%) 1.1  1.5
SG

SCREEN ANALYSIS (% PASSING) (TMH 1 A1(iii) & A5)

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>63.0 mm</th>
<th>53.0 mm</th>
<th>37.5 mm</th>
<th>26.5 mm</th>
<th>19.0 mm</th>
<th>13.2 mm</th>
<th>7.1 mm</th>
<th>2.00 mm</th>
<th>0.425 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Passing</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>66</td>
<td>53</td>
<td>32</td>
<td>25</td>
<td>14</td>
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</tbody>
</table>

HYDROMETER ANALYSIS (% PASSING) (TMH 1 A8)

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>0.040 mm</th>
<th>0.027 mm</th>
<th>0.015 mm</th>
<th>0.005 mm</th>
<th>0.002 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Passing</td>
<td>100</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
</tbody>
</table>

ATTERBERG LIMITS (TMH 1 A2 - A4)

<table>
<thead>
<tr>
<th>Liquid Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasticity Index</td>
</tr>
<tr>
<td>Linear Shrinkage (%)</td>
</tr>
<tr>
<td>Grading Matter</td>
</tr>
<tr>
<td>Classification</td>
</tr>
<tr>
<td>Unified Classification</td>
</tr>
</tbody>
</table>

POTENTIAL EXPANSIVENESS

PLASTICITY CHART

SOILLAB (PTY) LTD
230 Alberts Blvd
P.O.Box 76982
La Montigue 1164
Lyndhurst Ridge 1440
Tel: (011) 406-3948
Fax: (011) 406-5010

Chart Reference
PARTICLE SIZE ANALYSIS

Sample No. 44568
SoilRef sample no. S10-0401-07
Depth (m) 0.6-1.1
Position TP406L
Material Description DARK BROWN QUARTZ SANDY GRAVEL

Moisture (%) 1.0

SCREEN ANALYSIS (% PASSING) (TMH 1 A3p & A5)

<table>
<thead>
<tr>
<th>Screen Size (mm)</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>63.0 mm</td>
<td>100</td>
</tr>
<tr>
<td>50.0 mm</td>
<td>100</td>
</tr>
<tr>
<td>37.5 mm</td>
<td>95</td>
</tr>
<tr>
<td>26.5 mm</td>
<td>92</td>
</tr>
<tr>
<td>19.0 mm</td>
<td>94</td>
</tr>
<tr>
<td>15.0 mm</td>
<td>76</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>70</td>
</tr>
<tr>
<td>9.50 mm</td>
<td>60</td>
</tr>
<tr>
<td>6.00 mm</td>
<td>44</td>
</tr>
<tr>
<td>4.00 mm</td>
<td>28</td>
</tr>
<tr>
<td>2.00 mm</td>
<td>20</td>
</tr>
<tr>
<td>1.00 mm</td>
<td>10</td>
</tr>
<tr>
<td>0.50 mm</td>
<td>5</td>
</tr>
</tbody>
</table>

HYDrometer ANALYSIS (% PASSING) (TMH 1 A5)

<table>
<thead>
<tr>
<th>Screen Size (mm)</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.500 mm</td>
<td>4</td>
</tr>
<tr>
<td>0.027 mm</td>
<td>3</td>
</tr>
<tr>
<td>0.010 mm</td>
<td>2</td>
</tr>
<tr>
<td>0.005 mm</td>
<td>1</td>
</tr>
<tr>
<td>0.002 mm</td>
<td>0</td>
</tr>
</tbody>
</table>

% Clay 0
% Silty 7
% Sandy 37
% Gravel 56

ATTERBERG LIMITS (TMH 1 A2 - A4)

Liquid Limit
Plasticity Index NP
Linear Shrinkage (%) 0.9
Grading MoLu 2.19
Classification A-Lu(s)
Unified Classification SW 8-SC

POTENTIAL EXPANSIVENESS

PLASTICITY CHART
APPENDIX - D

Contour Plans, Preliminary Geometric Designs and Sections