MBOMBELENI AND MCWILI TOWNSHIP DEVELOPMENT

PRELIMINARY SHALLOW SOIL ENGINEERING GEOLOGICAL INVESTIGATION FOR PLANNING PURPOSES, MBOMBELENI AND MCWILI VILLAGES, UMTATA REGION, EASTERN CAPE PROVINCE

Basic Shallow Soil Investigation for Residential Planning

Project number: WF14066 **17 September 2014**

WSM LESHIKA CONSULTING (PTY) LTD

PO BOX 39942
MORELETA PARK
PRETORIA
0044
TEL: (012) 997-6769
E-mail: mvanrensburg@wsmleshika.co.za

623 RUBENSTEIN STREET
MORELETA PARK
PREOTIRA
0044
FAX: (012) 997-6768
ENQUIRIES: M van Rensburg

PRELIMINARY SHALLOW SOIL ENGINEERING GEOLOGICAL INVESTIGATION FOR PLANNING PURPOSES, MBOMBELENI AND MCWILI VILLAGES, UMTATA REGION, EASTERN CAPE PROVINCE

Client:	Mmaeshibe General Trade cc
Contact person:	Thabang Lamola
Project number:	**WF14066**
Project leader:	Jan Fanoy
Fieldwork conducted by:	Michael van Rensburg Engineering Geologist
Report compiled by:	Michael van Rensburg Engineering Geologist
Report reviewed by:	DH Wessels
Date completed:	**17 September 2014**
Report version:	Report Version 1

TABLE OF CONTENTS **Page no:**

LIST OF APPENDICES

LIST OF FIGURES:

LIST OF TABLES:

PRELIMINARY SHALLOW SOIL ENGINEERING GEOLOGICAL INVESTIGATION FOR PLANNING PURPOSES, MBOMBELENI AND MCWILI VILLAGES, UMTATA REGION, EASTERN CAPE PROVINCE

1. INTRODUCTION

WSM Leshika Consulting (Pty) Ltd. was appointed to conduct a basic shallow soil geotechnical assessment for the proposed housing units to be erected in the villages known as Mbombeleni and Mcwili, Umtata Region, Eastern Cape Province.

The area of interest is depicted in Figure 1 and Figure 2, Appendix A.

This report discusses the method of investigation, geotechnical conditions encountered with on-site material characteristics, recommendations and general considerations.

The level of information provided in this report is deemed suitable for planning purposes.

2. OBJECTIVES OF THE INVESTIGATION

The main objectives of the investigation were to:

- Identify and discuss the main on-site geotechnical constraints;
- Obtain the basic data concerning the use of in situ material;
- Comment on the excavation characteristics of the site soils;
- Comment on the potential for shallow seepage water conditions;
- Define the general ground conditions and provide site classifications including detailed soil profile and groundwater occurrences within the zone of influence of foundation work;
- Comment on the founding conditions;
- Provide the geotechnical basis for **planning** and **preliminary design** purposes.

3. INFORMATION USED DURING THE STUDY

The following information was available at the time of writing this report:

- Locality map;
- Approximate site boundaries;
- 1:50 000-scale 3129AC Topographical map;
- 1:250 000-scale 3128 UMTATA Geological Sheet;
- Existing GoogleEarth images.

Laboratory test results conducted on selectively retrieved soil horizons were also available at the time of writing this report. The laboratory tests consist of basic index tests and compaction tests conducted on a limited number of samples.

Localities for proposed units were not available and no tests for heave and/or collapse or consolidation quantification were conducted for the purposes of this basic investigation.

4. METHOD OF INVESTIGATION

The method of investigation can be summarized as:

- Desk study of available databases such as, aerial images and geological sheets;
- Field walkover survey;
- Excavation of a limited number of test pits with a TLB;
- Detailed soil profile descriptions;
- Soil profile photograph recordings;
- Selective soil sampling;
- Basic soil testing;
- Laboratory test results interpretation;
- Compilation of report with findings and recommendations.

12 Test pits were excavated by means of a JCB 3CX TLB in the area of interest down to refusal or to near refusal excavation conditions. The test pit positions are depicted in Figure 3, Appendix A.

A suitably qualified engineering geologist positioned and inspected the test pits. The soil profiles were recorded using the standard procedures as per the SANS633:2012 standards. The individual soil profile descriptions are attached as Appendix B with photographs attached as Appendix C.

Disturbed samples were selectively retrieved in order to determine the soil grading, compaction characteristics and general material properties. The samples were submitted to an SANAS accredited laboratory, ControLab South Africa (Pty) Ltd. for testing. The test results are attached as Appendix D.

5. GEOLOGY

5.1 Regional Geology

According to the 1:250 000-scale geological sheet 3128 Umtata, the area of interest is underlain by:

- "Jd" – Dolerite.
- "Pa" – Grey and brownish-red mudstone, sandstone.

The onsite rock/geology was interpreted as shale/siltstone.

The site is not underlain by potentially soluble dolomitic formations and a specialized dolomite stability investigation **is not required**.

The geology is depicted in Figure 4, Appendix A.

5.2 Site Specific Geology

12 Test pits were excavated by means of a TLB and terminated at between 1.15 to 3.00 m bngl (meters below natural ground level) in completely to highly weathered shale and residual shale. Soft excavation conditions were encountered down to termination depth.

The villages of Mcwili and Mbomboleni is covered with a moderately thick fine sandy silty clayey open structured stiff to very stiff colluvium down to between 0.30 m to 0.80 m bngl.

The colluvial layer is underlain in test pits Mc02, Mc06, and Mb04 by a medium dense open structured silty clayey gravel pebble marker down to 0.45 m to 1.40 m bngl.

The colluvial layer and pebble marker is underlain by a medium dense to dense to stiff slightly open to open structured clayey silty residual shale down to 1.15 m to 3.00 m bngl. Some of the test pits were terminated in residual shale. For five test pits the residual layer is underlain by layered and jointed very dense completely weathered to highly weathered shale down to 1.15 m to 2.70 m bngl which excavates to silt and rock fragments.

Test pit MC07 were positioned on the dolerite and consist of a stiff open structured silty clay/clayey silt colluvium down to 0.50 m bngl. This colluvial layer is underlain by a medium dense to firm open and pinholed structured sandy silty clay/clayey silt residual dolerite down to 2.50 m bngl. The layer contains scattered dolerite cobbles.

A summary of the soil profiles are provided in Table 1a and Table 1b. The detailed soil profiles are attached as Appendix B with the relevant profile photographs as Appendix C.

Table 1a: Soil profiles summary (co-ordinates and soil textures)

TP	Latitude	Longitude	Elevation	Clay	Silt	Sand	Gravel
Mdina							
Mc01	-31.449768°	29.092371°	918	0.00-1.60	0.00-3.00	1.60-3.00	-
Mc02	-31.451195°	29.096097°	931	0.00-1.10	0.00-1.10	0.30-0.55	0.30-0.55
Mc03	-31.448902°	29.098465°	904	0.00-2.30	0.00-2.60	-	2.30-2.60
Mc04	-31.448604°	29.095218°	904	0.45-2.00	0.45-3.00	2.00-3.00	0.00-0.45
Mc05	-31.452821°	29.096210°	932	0.00-1.30	0.40-1.40	-	0.00-0.40
Mc06	-31.454645°	29.098477°	912	0.00-0.45	0.00-1.40	0.60-1.40	-
Mc07	-31.452310°	29.090579°	933	0.00-2.50	0.00-2.50	-	-
Mbombeleni							
Mb01	-31.454203°	29.110599°	888	0.00-2.60	0.00-2.60	-	-
Mb02	-31.451567°	29.109080°	863	0.00-2.00	0.00-2.20	-	-
Mb03	-31.453724°	29.107148°	884	0.00-2.80	0.55-2.80	0.00-0.55	-
Mb04	-31.452185°	29.101503°	889	0.00-2.90	0.00-2.90	0.50-0.90	0.50-0.90
Mb05	-31.450050°	29.101156°	900	0.00-2.50	0.00-2.70	-	2.50-2.70

Table 1b: Soil profiles summary (soil horizons and excavation)

TP	Colluvium	Pebble marker	Residuum	Completely Weathered Rock	Highly weathered rock	Termination depth	Excavatability up to termination depth	Excavatability at termination depth	Seepage
Mdina									
Mc01	0.00-0.80	-	0.80-3.00	-	-	3	Soft	Soft	No
Mc02	0.00-0.30	0.30-0.55	0.55-1.10	0.55-1.10	1.10-1.15	1.15	Soft	Hard	No
Mc03	0.00-0.80	-	0.80-2.30	1.60-2.30	2.30-2.80	2.8	Soft	Intermediate	No
Mc04	-	0.00-0.45	0.45-3.00	-	-	3	Soft	Soft	No
Mc05	0.00-0.40	-	0.40-1.30	-	1.30-1.40	1.4	Soft	Hard	No
Mc06	0.00-0.60	0.60-1.40	0.60-1.40	-	-	1.4	Soft	Intermediate	No
Mc07	0.00-0.50	-	0.50-2.50	-	-	2.5	Soft	Intermediate	No
Mbombeleni									
Mb01	0.00-0.60	-	0.60-2.60	-	-	2.6	Soft	Soft	No
Mb02	0.00-0.65	-	-	0.65-2.00	2.00-2.20	2.2	Soft	Intermediate	No
Mb03	0.00-0.55	-	0.55-2.80	-	-	2.8	Soft	Soft	No
Mb04	0.00-0.50	0.50-0.90	0.90-2.90	-	-	2.9	Soft	Soft	No
Mb05	0.00-0.60	-	0.60-1.15	1.15-2.50	2.50-2.70	2.7	Soft	Intermediate	No

6. SITE DESCRIPTION

6.1 Locality and Size

The site is situated approximately 33 km north-east of the town of Umtata and approximately 12 km from Libode in the villages of Mcwili and Mbomboleni. The approximate size of the investigated area is 170 ha; Mcwili is 86 ha and Mbomboleni is 84 ha.

The approximate centre coordinates of the investigated area is as follows (Decimal Degrees, Datum: WGS84):

Mcwili	**Mbhobheleni**
Latitude: -31.450111°	Latitude: -31.452475°
Longitude: 29.094787°	Longitude: 29.105118

The locality is depicted in Figure 1 and Figure 2, Appendix A.

6.2 Vegetation, Topography, Drainage and Existing Structures

The site is mainly covered with natural grass, small to medium sized trees and informal mud houses. The remainder of the site is fairly open with steep slopes surrounding the village. No detailed contour map was provided/available at the time of writing this report. The regional topography as per the 1:50 000-scale topographical sheet is attached as Figure 5, Appendix A. The village is located a large hill with steep slopes from the center of the village decreasing to the borders of the site, the regional slope direction is towards the KuKancolo River situated to the north-east of the village. The steepest incline is on the south side of the village outside the village boundaries. A drainage feature is located in the center of the Mbomboleni village area in the low lying valley draining to the north-east towards the Kukancolo River. See the elevation profile of the site from west to east in Figure 1 portraying the valley in the center of the village Mbomboleni and from south-west to north-east in Figure 2 below portraying the general slope across the village. Drainage channels are located in the valleys at the bases of these slopes.

Figure R1: Elevation profile from west to east portraying the valleys in the center of the village.

Figure R2: Elevation profile from south-west to north-east depicting the general slope across the village.

7. SHALLOW GROUNDWATER OR SEEPAGE WATER

Signs of seasonal shallow seepage water conditions are evident in the soil profiles excavated. Severe shallow seasonal seepage water are expected. Seepage is expected to occur mainly but not limited to on the contact between the upper soils and lower less permeable completely to highly weathered shale. Concentration of flow will be from the south-west and west of the village down the general slope north-west towards and along the drainage channels in the valley in the center of the Mbomboleni village towards the main KuKancolo River on the north-east of the village.

Seasonal seepage water of less than 1.00 m b ngl will be a reality throughout the majority of the site. Localised areas of surface ponding conditions can also be expected and should be identified from the detailed ground contour survey data.

Typical seepage areas are generally more prominent in lower-lying areas. The site is situated on a watershed. Seepage is expected to mainly occur for after heavy and/or prolonged rainfall events.

8. EXCAVATION CONDITIONS

Excavatability of materials can be classified in five different categories according to the SABS 1200 D-1988 standards. Table 2 below is a summary of the SABS standards (refer to SABS 1200D-1988 document for detailed classification):

Table 2: 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

Sample Position	Simplified description of typical material properties
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 .

The trial pits were excavated by means of a JCB 3CX TLB and the TLB excavatability in the upper excavated material and at termination depths with SABS excavatability correlations are summarized in Table 1b.

The test pits were excavated down to between 1.15 to 3.00 m bngl with an average excavation depth of approximately 2.37 m bngl with a standard deviation of 0.67 m.

Refusal conditions were encountered in only two test pits, Mc02 and Mc05, within highly weathered shale at 1.15 m and 1.40 m respectively. Hard excavation conditions were encountered at these termination depths where refusal conditions were experienced on jointed and layered soft rock shale. Progressive refusal occurred in five tests pits whereby intermediate excavation occurred in residual and highly weathered shale.

Excavation took place with a TLB in a confined trench; deeper excavation could be possible with a TLB in unconfined trenches and there is a possibility that the material may be rippable due to bedding and jointing. The materials are however expected to be excavatable with a larger excavator down to at least 2 m bngl in confined trenches in the highly weathered shale.

Soft excavation was encountered down to termination depths for all the test pits.

The bedrock conditions are expected to be undulating with depths varying of 0.00 m to 3.00 m bngl over short distances due to the change in slope and location on the slope and the presence of a dolerite outcrop that was encountered at test pit Mc07.

9. LABORATORY RESULTS AND GENERAL MATERIAL PROPERTIES

A number of disturbed soil samples were selectively retrieved and submitted to Controlab South Africa (Pty) Ltd. Umtata for testing.

Grading analysis, compaction testing, Atterberg Limit tests were conducted in order to determine the basic material properties for evaluation purposes. The laboratory test results are attached as Appendix D. The USCS (unified soil classification system) was not provided by the laboratory; the classifications used below where interpreted from the results received and should be used with caution as the classification may differ slightly.

9.1 Material Classifications and General Material Properties and Ratings

The material encountered and tested generally classifies as "**SM**", "**SC**" and "**CL**" according to the Unified Soil Classification System. The majority of the samples classify as "**SM**". The Foundation Indicator test results conducted on selectively retrieved samples are summarized in Table 3.

TABLE 3: Foundation Indicator Test Results

Test pit no	Sample depth (m)	Material description	Soil composition				Atterberg Limits		LS (%)	GM	Class (USCS)	Class (USCS) 2
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)	LL (%)	PI (%)				
Mc02	0.20-0.40	Colluvium and Pebble marker	4	15.4	64.6	16	25	8	3	0	SC	SM
Mc03	1.80-2.30	Residual to completely weathered shale	7	37.5	39.5	16	34	13	5.5	0	SM	SC
Mc04	1.00-2.20	Residual shale	4	29.3	65.7	1	26	9	4	0.79	SM	0
Mc04	2.50-3.00	Residual shale	4	27.4	67.6	1	2	8	3	0	SM	0
Mc06	0.80-1.20	Residual shale	7	22.6	70.4	0	40	12	6	0	SM	0
Mc07	1.20-1.80	Residual dolerite	4	20.1	55.9	20	23	7	3	0	SM	SC
Mb01	1.50-2.50	Residual shale	6	42.5	51.5	0	47	16	8	0.67	SM	SC
Mb02	1.30-2.10	Completely weathered shale	5	35.2	55.8	4	30	9	4	0.83	SM	SC
Mb03	0.70-1.00	Residual shale	4	36.9	58.1	1	40	12	6	0	SM	SC
Mb03	1.50-2.00	Residual shale	4	35.1	60.9	0	34	13	6	0	SM	SC
Mb04	1.60-2.60	Residual shale	4	36.7	54.3	5	34	9	3.5	0.82	SM	SC
Mb05	0.80-1.10	Residual shale	30	46.4	23.6	0	36	17	9	0	CL	0
Mb05	1.50-2.50	Completely weathered shale	6	34.7	46.3	13	30	11	11	1.12	SC	0

The following general descriptions can be assigned to the soil classes:

SM → Silty sands, poorly graded silt-sand mixtures.

SC → Clayey sands, poorly graded sand-clay mixtures.

CL → Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.

Typical material properties for the above classifications are summarized in Table E1 and Table E2, Appendix F for guideline purposes.

10. GEOTECHNICAL EVALUATION

10.1 Soil Heave

The potential expansiveness of the material was evaluated based on the indicative laboratory test results and field observations. This included using the Plasticity Index and Linear Shrinkage of the material, Van der Merwe's Method and the material structure to evaluate the potential heave of the material. The potential expansiveness of the materials is visually depicted in Chart 1.

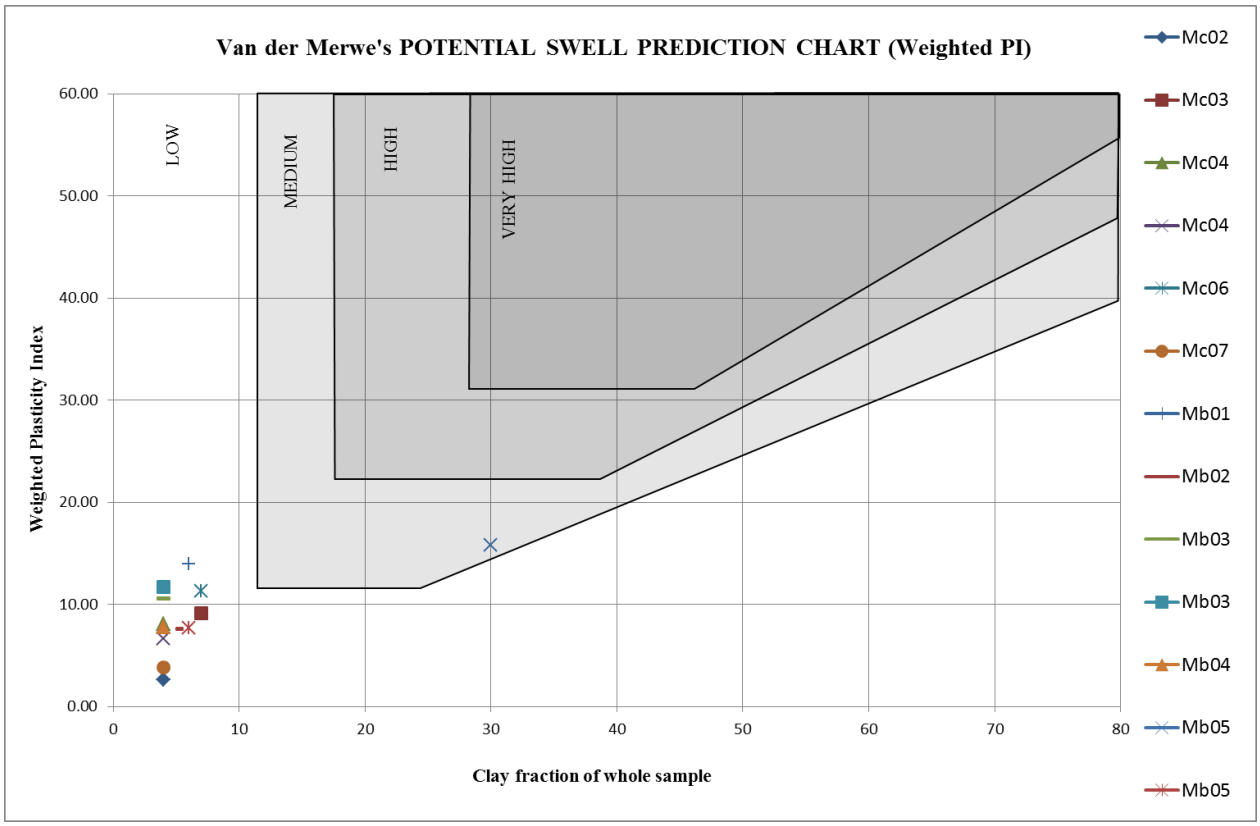


CHART 1: Swell Prediction Chart (Weighted PI and Clay Fraction of whole sample)

The indicator test results conducted on all the materials sampled indicate that the residual shale from Mb05 0.80-1.10 has a "Medium" heave potential which confirms the visual interpretations taking into consideration the clay content and soil structure. The test results indicate that the completely to highly weathered shale has a "Low" heave potential with very little amount of clay present as well as the residual shale with low level of fines has a "Low" heave potential.

The residual shale in test pits Mc04, Mb01 and Mb04 had a free swell percentage under 100 % MOD. AASHTO compaction effort of 0.98 %, 3.18 % and 1.74 % respectively. The compacted swell percentage for the completely weathered shale in test pits Mb02 and Mb05 is 2.48 % and 2.2 % respectively. The residual and completely weathered shale of test pits Mb01, Mb02 and Mb05 have the highest swell percentage of 3.18 %, 2.48 and 2.20 % respectively.

Medium soil heave corresponding to the SAICE (1995) site class designation "**H1**" (7.5 mm to 15 mm total range of expected soil movement, assumed 50% differential movement) is expected in the residual shale and dolerite layer.

Medium soil heave is only present in the overlying residual that has a high content of fines; the underlying weathered rock and residual shale with low levels of fines has a low to medium soil heave potential according to the compaction tests. The residual dolerite from test pit Mc07 also indicates low soil heave potential.

The grading analysis, Atterberg Limits and compaction test results for the materials are attached in Appendix D.

10.2 Collapsible and/or Compressible Material

The colluvium layer, pebble marker and the majority of the residual shale consist of medium amounts of fines present that can experience a degree of consolidation. These horizons have an open and pinholed structure that will result in a degree of consolidation corresponding to the SAICE class "C1".

The layered and jointed completely to highly weathered shale has a slight collapse potential as for SAICE class "C" and "S" consolidation potential.

The lower lying completely to highly weathered shale has a layered and jointed structure which may result in some settlement when loaded.

10.3 Erodability

The soils are considered to have a high susceptibility to erosion. Basic erosion protection measures will be recommended such as proper surface drainage in order to avoid concentrated water flow and potential erosion and undercutting of structures/floors and/or unwanted erosion of excavation/foundation/service trenches.

11. MAJOR GEOTECHNICAL CONSTRAINTS

Based on the conditions encountered during this investigation the major geotechnical constraints can be summarized as:

- Medium heave potential in residual shale containing high fines content;
- Low to medium heave potential in compacted residual and weathered shale;
- Severe shallow seasonal seepage water conditions and/or saturated soil profiles;
- Most favorable to intermediate steep slopes surrounding entire village 4 to 11 degrees;
- Excavation difficulty due to shallow bedrock, depending on location on slope.

12. SITE CLASSIFICATION

The site is classified based on the different geotechnical and founding conditions as per the SAICE 1995 classification (NHBRC classification as for single story residential/small type structures) and the SANS 634:2012 document of which the applicable tables are attached in Appendix F for reference purposes.

One broad geotechnical zone has been assigned for the site for the purposes of this basic investigation:

Zone I: C1-H1 (R) / 2ABCDE (2FI)

Zone II: P (Drainage features, seepage areas and steep slopes) / 2BI (Drainage features)

Where C, S and P before the / refer to:

C - Collapse settlement;

H - Expansive soils;

(R) - Localised shallow rock.

The A-B-C-D-E-F-H-I after the / refer to:

A - Collapsible soils;

B - Seasonal shallow seepage water or saturated soil conditions;

C - Active soils;

D - Consolidation settlement;

E - Erodability of the soil horizons;

F - Excavation difficulty;

I - Steep slopes.

The classification in brackets (2FI) indicates localised occurrences for excavation difficulty and moderately steep slopes which has a highly likelihood of occurring.

Refer to Table 1, Table 2, Table 3, Table 4 and Table 5, Appendix F.

13. FOUNDATION AND GERNAL RECOMMENDATIONS

For planning purposes the following foundation types/options can be considered for potential small size residential type structures (as for class “H1” and “C1” SAICE 1995 foundation options of which the appropriate tables are attached in Appendix F):

- Modified normal construction (As for class H1).
- Soil raft construction (As for class C1 or H1).

More conservative foundation options may be:

- Stiffened or cellular raft foundations (As for class H2).
- Split construction (As for class H2).

It is recommended that stiffened or cellular raft foundations are considered for planning purposes till more detailed investigations are conducted as required by the SANS634:2012 standards and accommodated with the necessary heave and consolidation quantification tests.

Modified normal construction to even normal construction may be suitable in areas. These foundation options however can only be considered if conditions are proven with more detailed investigations.

14. CONSTRUCTION MATERIALS

14.1 Soil Mattress and General Backfill

The basic requirements for material to be used for soil mattress construction can be summarized as:

- The material needs to be workable;
- The material needs to have good compaction characteristics;
- The material needs to have a low compressibility once properly compacted;
- The material needs to exhibit a low heave once properly compacted;
- The material needs to have suitable bearing capacity once properly compacted.

The on-site material is generally silty clays in the upper residual shale, residual dolerite and colluvium. The completely to highly weathered shale crumbles to silt and rock fragments when excavated and compacted. The residual shale and completely to highly weathered shale material tested according to the USCS has the following workability rating:

- CL – Good to fair;
- SC – Good;
- SM – Fair;

The residual shale material retrieved from test pits Mc04, Mb01 and Mb04 at 1.00-2.00 m, 1.30-2.10 and 1.60-2.60 has a maximum dry density of 1 815 kg/m^3, 1 435 kg/m^3

and 1 671 kg/m^3 with an optimum moisture content of 12.5 %, 29 % and 20.5 % with a measured swell of 0.98 %, 3.18 % and 1.74 % Mod. AASHTO compaction effort respectively. The CBR of the material increases from 2 to 3 to 5; 2 to 5 to 12 and 1 to 2 to 4 at 90%, 95% and 100% Mod. AASHTO compaction efforts. The samples tested classifies as "G10" according to the TRH/COLTO classification.

The completely weathered shale material retrieved from test pits Mb02 and Mb05 at 1.30-2.10 m and 1.50-2.50 m has a maximum dry density of 1 783 kg/m^3 and 1 855 kg/m^3 with an optimum moisture content of 14.2 % and 12.8 % with a measured swell of 2.48 % and 2.20 % Mod. AASHTO compaction effort. The CBR of the material increases from 3 to 4 to 5 and 5 to 8 to 13 at 90%, 95% and 100% Mod. AASHTO compaction efforts. The samples tested classifies as "G10" according to the TRH/COLTO classification.

The material test has poor to fair compaction characteristics based on the increase in CBR values, achieved maximum dry densities and relatively low to medium percentage swell measured.

The weathered shale and residual shale with low fines are expected to have a low compressibility once properly compacted. The residual shale with high fines content and upper fines are expected to have a medium to high compressibility even when properly compacted due to the abundance of fines.

The weathered shale and residual shale with low fines are expected to have a low heave potential. The residual shale with high fines content is expected to have a medium heave potential.

The typical fill rating of the material is represented in Table 5 below.

TABLE 5: Fill and Foundation Material

Test pit	Sample depth (m)	Material description	Unified Soil Class	Typical rating for use as general fill material	Typical rating for use as fill for foundation purposes	Expected Dry Density (kg/m3) (PROCTOR)

Mc02	0.20-0.40	Colluvium and Pebblemarker	SC	Average	Good (density important)	1 840 +/- 20
Mc03	1.80-2.30	Residual to completely weathered shale	SM	Average	Good (density important)	1 830 +/- 20
Mc04	1.00-2.20	Residual shale	SM	Average	Good (density important)	1 830 +/- 20
Mc04	2.50-3.00	Residual shale	SM	Average	Good (density important)	1 830 +/- 20
Mc06	0.80-1.20	Residual shale	SM	Average	Good (density important)	1 830 +/- 20
Mc07	1.20-1.80	Residual dolerite	SM	Average	Good (density important)	1 830 +/- 20
Mb01	1.50-2.50	Residual shale	SM	Average	Good (density important)	1 830 +/- 20
Mb02	1.30-2.10	Completely weathered shale	SM	Average	Good (density important)	1 830 +/- 20
Mb03	0.70-1.00	Residual shale	SM	Average	Good (density important)	1 830 +/- 20
Mb03	1.50-2.00	Residual shale	SM	Average	Good (density important)	1 830 +/- 20
Mb04	1.60-2.60	Residual shale	SM	Average	Good (density important)	1 830 +/- 20
Mb05	0.80-1.10	Residual shale	CL	Average	Average (Swell?)	1 730 +/- 20
Mb05	1.50-2.50	Completely weathered shale	SC	Average	Good (density important)	1 840 +/- 20

The weathered shale material and residual shale with low fines in general (materials classifying as “SM” and “SC”) are considered to have a good rating for typical fill for foundation purposes. The materials with an abundance of fines (soils classifying as “CL”) are considered to have a average rating for typical fill.

14.2 Road Construction

A more detailed investigation should be conducted in order to comment on the suitability of the on-site materials for pavement design. The residual shale with low percentages of fines and completely weathered shale are expected to have a fair to good rating for subgrade construction and fair for sub-base and not suitable base construction. The residual shale with high fines content is expected to have a fair to poor rating for subgrade construction with a not suitable for subbase. None of the on-site materials encountered are considered suitable for base construction. It is

recommended that borrowpits is identified and that suitable materials are sourced for subbase and base construction.

15. CONCLUSIONS

The site is underlain by grey and brownish-red mudstone, sandstone; identified on site to be shale/siltstone.

No potentially soluble dolomitic or limestone formations are present and a dolomite stability investigation is not required.

The area is not undermined and no significant economic mineral deposits are indicated on the relevant geological sheet in the proposed development area that may affect the developability of the site.

One broad geotechnical zone has been assigned for the site for the purposes of this basic investigation:
Zone I: C1-H1 (R) / 2ABCDE (2FI)
Zone II: P (Drainage features, seepage areas and steep slopes) / 2BI (Drainage features)

For planning purposes one or a combination of the following foundation types/options can be considered:

- Modified normal construction (As for class H1).
- Soil raft construction (As for class C1 or H1).
- Stiffened or cellular raft foundations (As for class H2).
- Split construction (As for class H2).

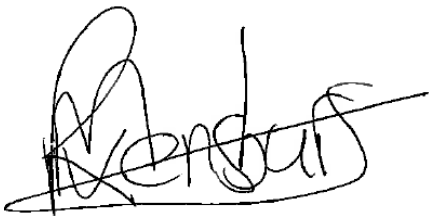
The stiffened or cellular raft foundations and split construction are considered the more conservative design approach. Proper surface, subsurface drainage and damp proofing will be essential in order to prevent or limit moisture damage to the floors and walls. Corrosion protection is recommended for any ferrous metals or services in contact with

the soils. Termite and pesticide control will be recommended below all structures. Basic erosion protection will be highly recommended in order to prevent excessive erosion and potential undercutting of structures.

The report is deemed suitable for basic planning purposes. The standard engineering geological investigations associated with residential development with reference to the minimum requirements as outlined in the SANS634:2012 standards should be conducted for detailed planning, design and enrolment purposes.

16. REPORT PROVISIONS

The report is considered a basic investigation with level of detail considered suitable for basic planning purposes only. The report should be distributed in its full context in order to avoid miss-interpretation that may result from selective data distribution. The engineering geologist assumes no responsibilities for any damages or unforeseen circumstances resulting from any geotechnical hazard if detailed planning and/or design are based on this basic evaluation.



MICHAEL van RENSBURG
Engineering Geologist

APPENDIX A

(Figures)

Figure 1: Locality map 1: Eastern Cape Housing (Mcwili and Mbhobheleni) WSM LESHIKA CONSULTING (PTY) LTD No: WF14066 © GoogleEarth 2014

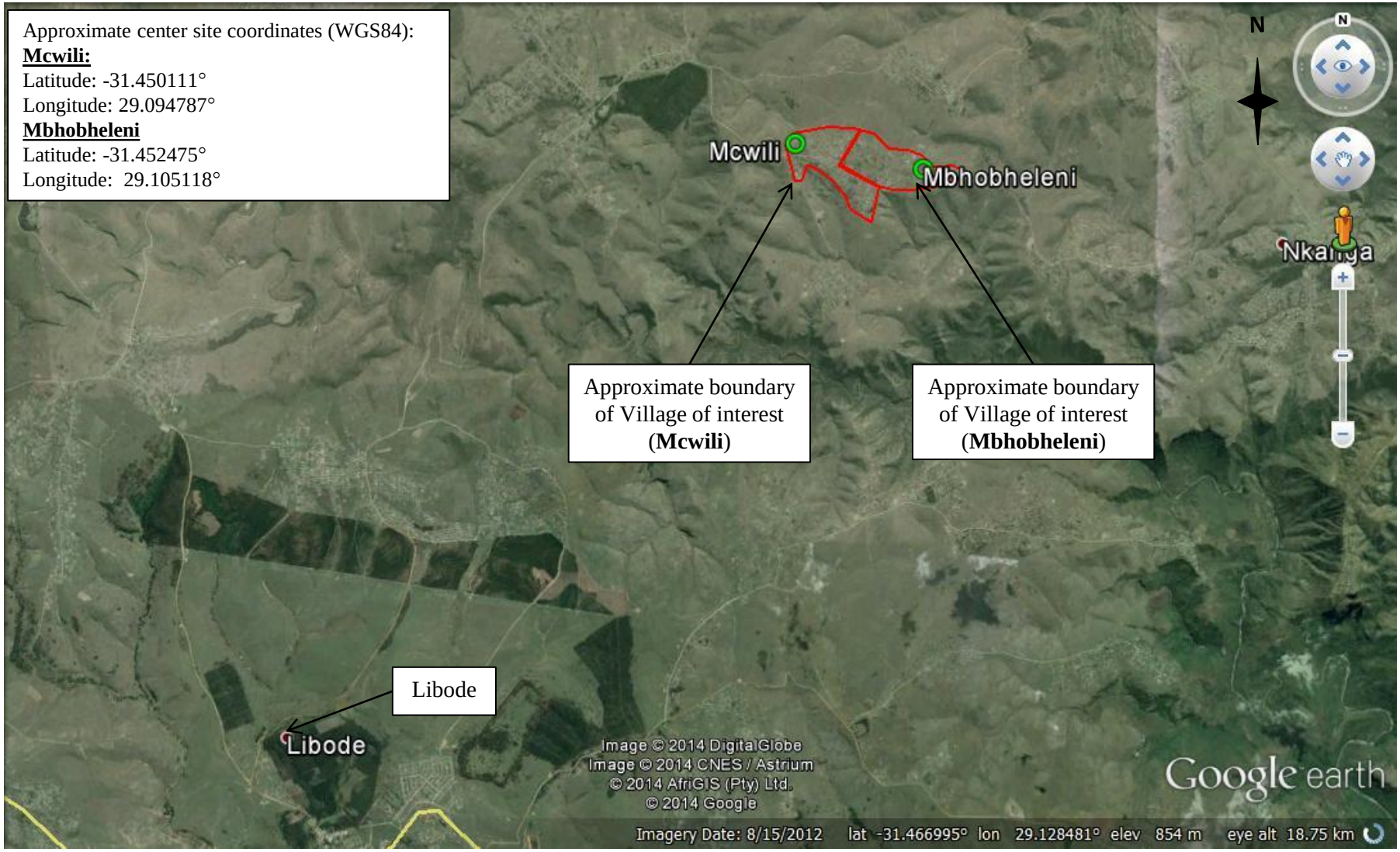


Figure 2: Locality map 2: Eastern Cape Housing (Mcwili and Mbhobheleni) WSM LESHIKA CONSULTING (PTY) LTD No: WF14066 © GoogleEarth 2014

Approximate center site coordinates (WGS84):

Mcwili:

Latitude: -31.450111°

Longitude: 29.094787°

Mbhobheleni

Latitude: -31.452475°

Longitude: 29.105118°

Approximate Area of Interest

Mcwili

Mbhobheleni

Pa

Jd

Layered structure in soft rock shale

Clayey residual shale

Highly weathered shale fragments excavated.

Jd — Dolerite ( ) Doleriet ( )

Pa — Grys en bruinrooi moddersteen, sandsteen
Grey and brownish-red mudstone, sandstone

1.443219° lon 29.16

7 km

Figure 3: Geology map: Eastern Cape Housing (Mcwili and Mbhobheleni) WSM LESHIKA CONSULTING (PTY) LTD Project No: WF14066

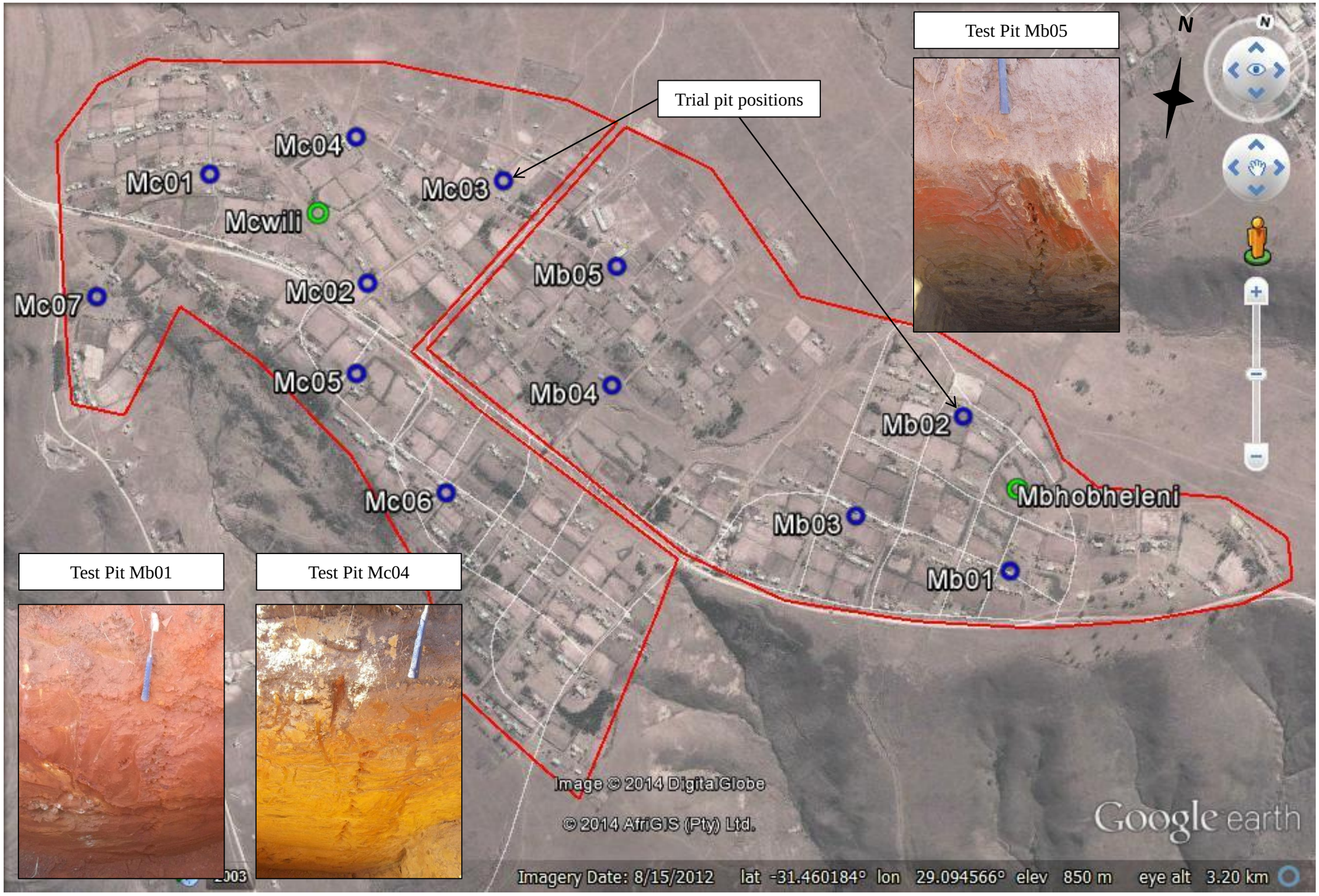


Figure 4: Test Pit Positions: Eastern Cape Housing (Mcwili and Mbhobheleni)

WSM LESHIKA CONSULTING (PTY) LTD

Project no: WF14066

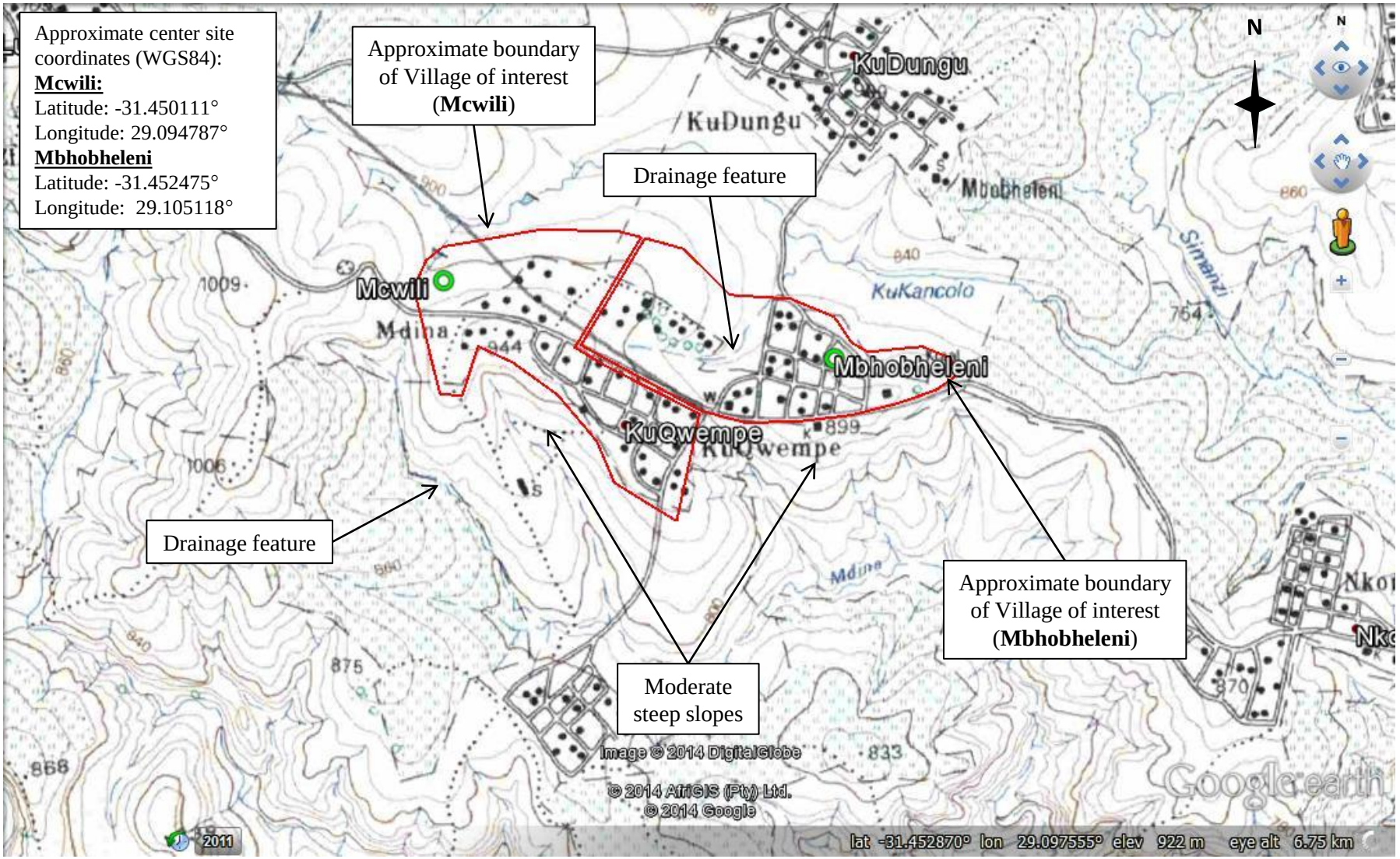


Figure 5: Topographical map: Eastern Cape Housing (Mcwili and Mbhobheleni) WSM LESHIKA CONSULTING (PTY) LTD No: WF14066 © The Government Printer

Zone
Zone I: C1 S1 H1 / A 2BCDEFI
Zone II: P (Drainage features, seepage areas and steep slopes) / 2BI (Drainage features)

Notes:
1) Refer to the report for constraints, foundation options and general recommendations.
2) Zonation needs to be confirmed during phase2 investigation excavations and environmental/flood/wetland investigation studies.

Figure 6: Geotechnical Zonation: Eastern Cape Housing (Mcwili and Mbomboleni)

WSM LESHIKA CONSULTING (PTY) LTD

Project no: WF14066

APPENDIX B

(Soil Profile Descriptions)

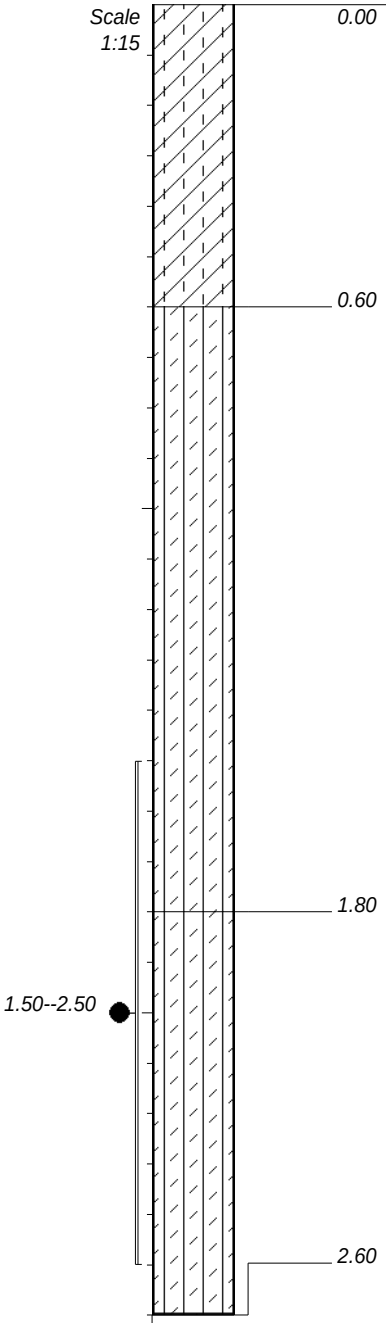
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mb01
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:15



0.00 Slightly moist, brown, very stiff, **open structured and shattered**, silty CLAY, colluvium. Roots

0.60 Slightly moist to moist, maroon streaked and patched black and orange, very stiff, **shattered**, clayey SILT, scattered small boulders, residual shale.

1.80 Slightly moist, maroon streaked black speckled orange, **pinholed structured**, clayey SILT, residual shale.

1.50--2.50

2.60

NOTES

1) Hole stopped.

2) Sample: 1.50--2.50 m.

3) No seepage.

4) Hole stable during investigation.

5) Boulders on surface.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:05
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

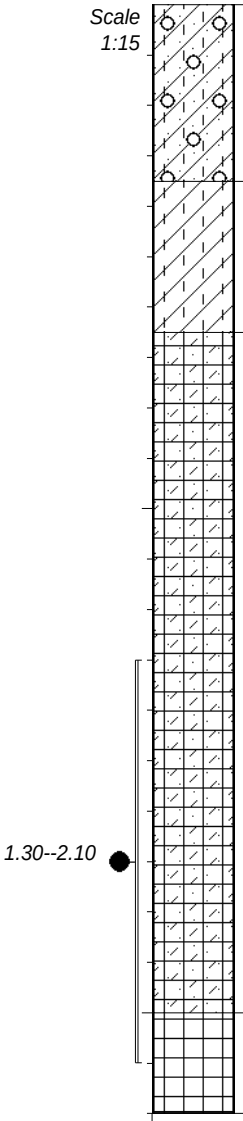
HOLE No: Mb01

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mb02
Sheet 1 of 1

JOB NUMBER: WF14066



0.00 Dry to slightly moist, light grey, stiff, silty sandy fine to gravelly CLAY, colluvium

0.35 Slightly moist, black, very stiff, **desiccation cracks**, silty CLAY, colluvium.

0.65 Slightly moist, cream white yellow streaked black, medium dense, **slightly jointed and layered**, fine sandy clayey SILT, completely weathered shale.

2.00 Slightly moist, mustard yellow streaked black, **layered and jointed**, soft rock highly weathered soft rock shale that excavated to silt and gravel fragments.

2.20

NOTES

1) Progressive Refusal, TLB confined excavation.

2) Sample: 1.30--2.10 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:05
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

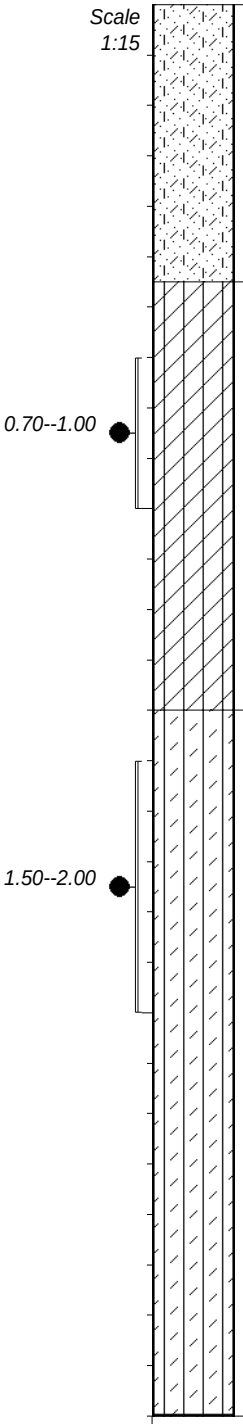
HOLE No: Mb02

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mb03
Sheet 1 of 1

JOB NUMBER: WF14066



0.00 Slightly moist, dark grey brown, medium dense to stiff, **pinholed structured**, silty clayey fine SAND, colluvium.

0.55 Slightly moist to moist, maroon mottled black, very stiff, **intact**, clayey SILT/ silty CLAY, residual shale.

1.40 Slightly moist to moist, speckled maroon yellow orange and black, medium dense, **slightly pinholed**, clayey SILT, residual shale. Large patches of yellow completely weathered shale.

2.80

NOTES

1) Hole stopped.

2) Sample: 0.70--1.00 m and 1.50--2.00 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:05
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

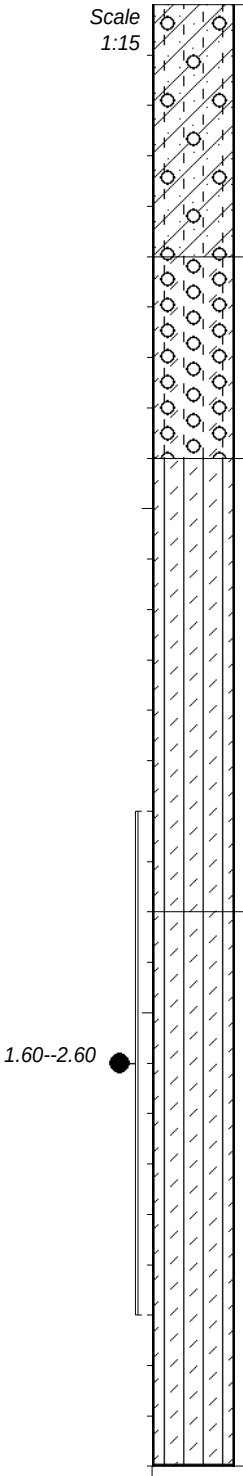
HOLE No: Mb03

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mb04
Sheet 1 of 1

JOB NUMBER: WF14066



0.00 Slightly moist, light grey, stiff, **slightly open**, sandy gravelly silty CLAY, colluvium.

0.50 Slightly moist to moist, grey and black, medium dense, **open**, silty clayey GRAVEL, pebble marker .

0.90 Moist, orange patched black and yellow, medium dense, **pinholed structured**, clayey SILT, residual shale.

1.80 Moist, patched red and grey streaked black, medium dense, **pinholed structured**, clayey SILT, residual shale.

2.90

NOTES

1) Hole stopped.

2) Sample: 1.60--2.60 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:05
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Mb04

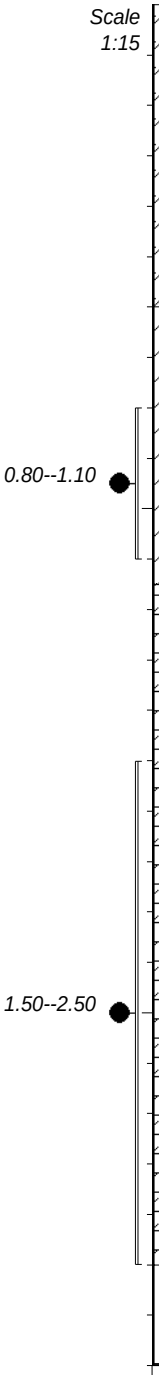
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mb05
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:15



0.00 Slightly moist, light grey, slightly open, stiff, sandy gravelly silty CLAY with abundant fine gravel, colluvium.

0.60 Moist, red mottled black and yellow streaked grey, medium dense to firm, **intact**, clayey SILT/ silty CLAY, residuum.

1.15 Moist, grey to light yellow, medium dense to dense, **slightly layered**, clayey SILT, completely weathered shale.

2.50 Moist, grey, dense, **layered**, highly weathered soft rock shale excavates to silt and gravel fragments.

2.70

NOTES

1) Progressive Refusal, TLB confined excavation.

2) Sample: 0.80--1.10 m and 1.50--2.50 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:05
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Mb05

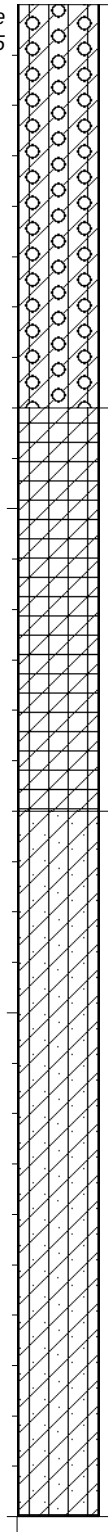
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mc01
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:15



0.00 Slightly moist, grey, very stiff, **open and pinholed structured**, slightly gravel silty CLAY/ clayey SILT, colluvium.

0.80 Moist, orange streaked black and yellow, medium dense, **open and pinholed structured**, clayey SILT with patches of silty clay and patches of completely weathered shale, residuum.

1.60 Slightly moist to moist, orange yellow, medium dense, **slightly pinholed**, fine sandy SILT, residuum with patches of black clay.

3.00

NOTES

1) Hole stopped.

2) No sample.

3) No seepage.

4) Hole stable during investigation.

5) Boulders on surface.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:07
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

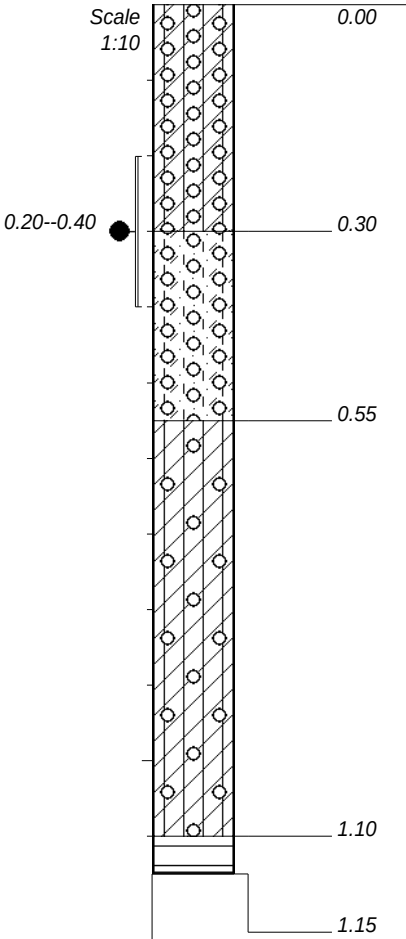
HOLE No: Mc01

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mc02
Sheet 1 of 1

JOB NUMBER: WF14066



0.00 Slightly moist, grey, very stiff, **open and pinholed structured**, slightly gravel silty CLAY/ clayey SILT, colluvium.

0.30 Slightly moist, grey, medium dense, **open structured**, clayey silty sandy GRAVEL, pebble marker.

0.55 Moist, dark grey patched yellow and light grey, medium dense to very stiff, silty open, gravelly clayey SILT/ silty CLAY, residual to completely weathered shale.

1.10 Grey and black stained orange, **fractured and layered**, moderately weathered medium hard rock shale.

1.15

NOTES

1) Refusal, TLB confined excavation.

2) Sample: 0.20--0.40 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:07
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Mc02

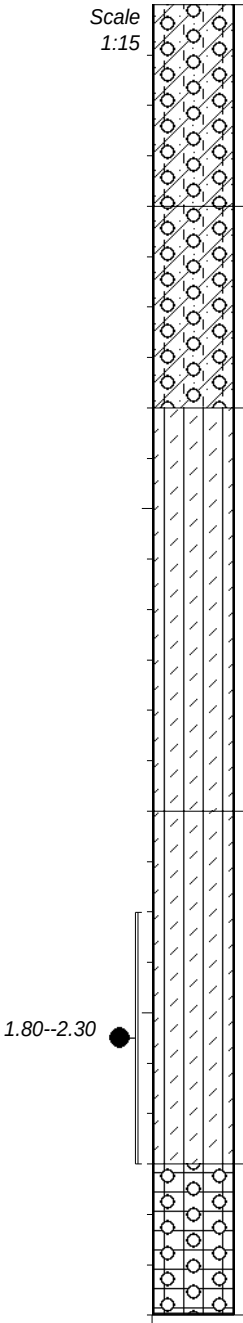
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mc03
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:15



0.00 Slightly moist, light grey, stiff, **slightly open structured**, sandy silty CLAY with abundant fine gravel, colluvium.

0.40 Slightly moist, light grey, stiff, **slightly open structured**, sandy gravelly silty CLAY with abundant fine gravel, colluvium.

0.80 Moist, orange mottled black patched yellow and white streaked black, medium dense to dense to stiff, **open structured**, clayey SILT, residual shale.

1.60 Moist, yellow grey patched yellow grey orange and black, medium dense to dense to stiff, **pinholed and slightly layered**, clayey SILT, residual to completely weathered shale.

2.30 Moist, grey, dense, **layered**, highly weathered soft rock shale excavates to silt and gravel fragments.

2.60

NOTES

1) Progressive Refusal, TLB confined excavation.

2) Sample: 1.80--2.30 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:07
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

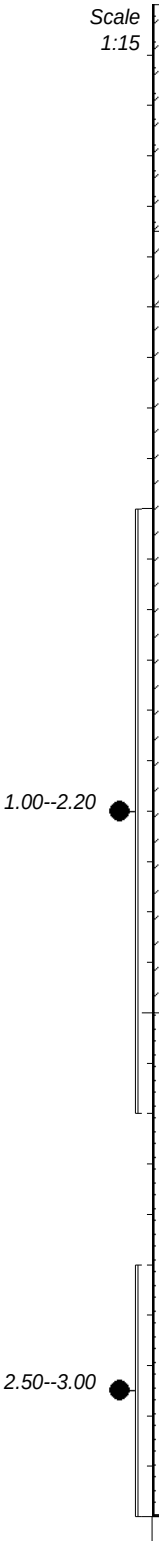
HOLE No: Mc03

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mc04
Sheet 1 of 1

JOB NUMBER: WF14066



0.00 Slightly moist, grey, medium dense, **open structured**, clayey silty sandy GRAVEL, pebble marker.

0.45 Slightly moist, black, very stiff, **desiccation cracks**, silty CLAY, residuum.

0.60 Slightly moist to moist, yellow patched orange mottled black, medium dense to stiff, **slightly open structured**, clayey SILT, residuum.

2.00 Slightly moist, mustard yellow streaked brown, medium dense to dense, slightly open, silty fine SAND/fine sandy SILT, residuum.

3.00

NOTES

1) Hole stopped.

2) Sample: 1.00--2.20 m and 2.50--3.00 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:07
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Mc04

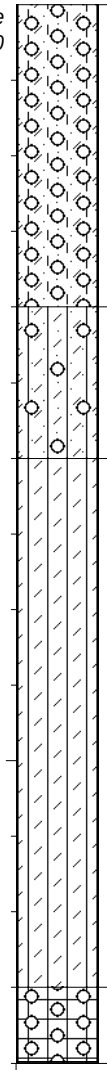
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mc05
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:10



0.00 Slightly moist, light grey, stiff, **open structured**, sandy silty clayey fine GRAVEL, colluvium.

0.40 Slightly moist, grey patched yellow and black, stiff, **open structured**, sandy gravelly clayey SILT, reworked residual shale.

0.60 Slightly moist to moist, yellow patched black and orange, dense, **open and pinholed structured**, clayey SILT, residual shale.

1.30 Slightly moist to moist, grey stained black and orange, very dense, **layered and jointed**, highly weathered soft rock shale that excavates to silt and gravel fragments.

1.40

NOTES

1) Refusal, TLB confined excavation.

2) No sample.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:07
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Mc05

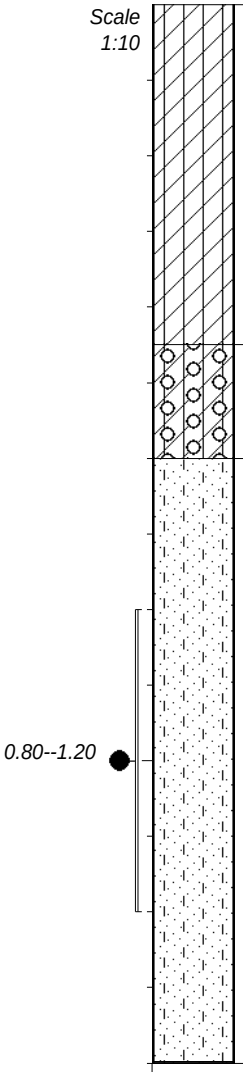
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mc06
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:10



0.00 Dry to slightly moist, light grey, stiff, **open structured**, clayey SILT/ silty CLAY, colluvium.

0.45 Dry to slightly moist, light grey, stiff, **open structured**, clayey SILT/ silty CLAY with abundant gravel, colluvium.

0.60 Slightly moist, light yellow streaked black, very dense, **slightly open structured**, silty fine SAND, scattered cobbles residual shale.

1.40

NOTES

1) Progressive Refusal, TLB confined excavation.

2) Sample: 0.80--1.20 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:07
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Mc06

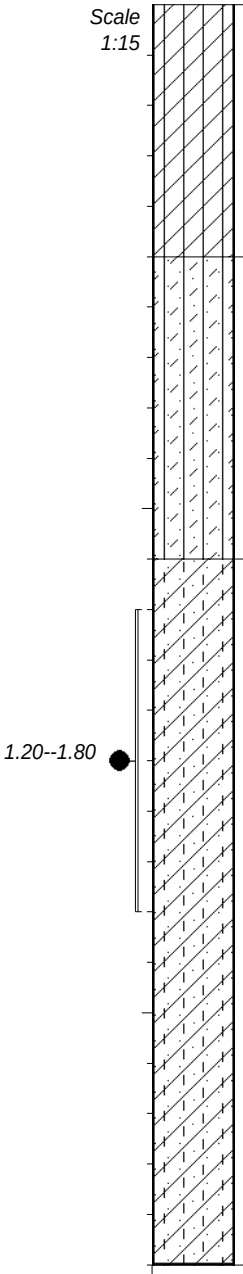
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Mc07
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:15



0.00 Dry to slightly moist, light grey, tiff, **open structured**, clayey SILT/ silty CLAY scattered large cobbles, colluvium.

0.50 Slightly moist to moist, orange brown mottled red and black, medium dense to firm, **open structured**, sandy clayey SILT, scattered boulders and cobbles, residual dolerite

1.10 Slightly moist to moist, mustard yellow speckled and mottled black, medium dense, **open and pinholed structured**, fine to coarse sandy silty CLAY, scattered small to large cobbles, residual dolerite,

2.50

NOTES

1) Progressive Refusal, TLB confined excavation.

2) Sample: 1.20--1.80 m.

3) No seepage.

4) Hole stable during investigation.

5) Outcrop 2m from test pit.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:07
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Mc07

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

LEGEND
Sheet 1 of 1

JOB NUMBER: WF14066

	GRAVEL	{SA02}
	GRAVELLY	{SA03}
	SAND	{SA04}
	SANDY	{SA05}
	SILT	{SA06}
	SILTY	{SA07}
	CLAY	{SA08}
	CLAYEY	{SA09}
	SHALE	{SA12}
Name	DISTURBED SAMPLE	{SA38}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 11/09/14 12:07
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

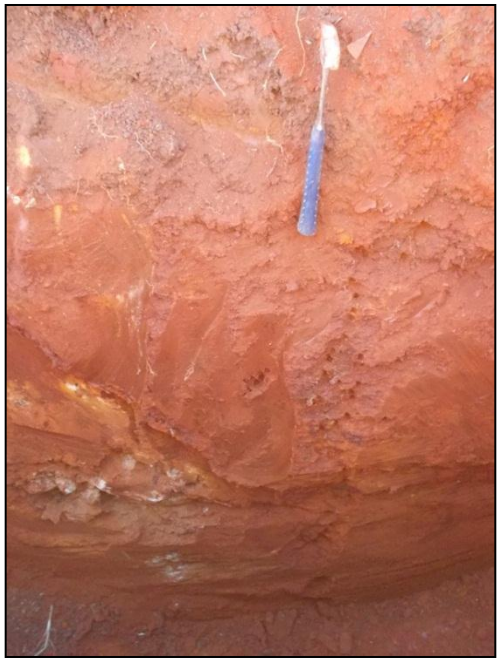
LEGEND
SUMMARY OF SYMBOLS

APPENDIX C

(Soil Profile Photographs)

PROJECT: Housing Project in Eastern Cape (Mbhobeleni) PROJECT no: WF14066

Test Pit number: Mb01



Note: Hole stopped TLB soft excavation.

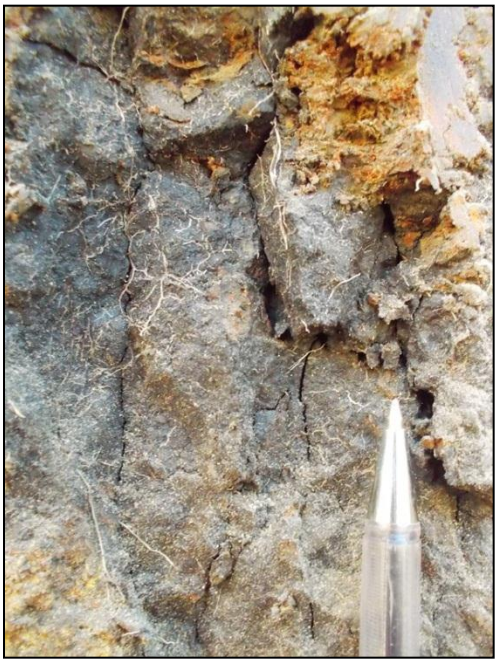
Test Pit number: Mb02

Note: Progressive refusal of TLB.

Test Pit number: Mb02

Note: Layered structure highly weathered shale.

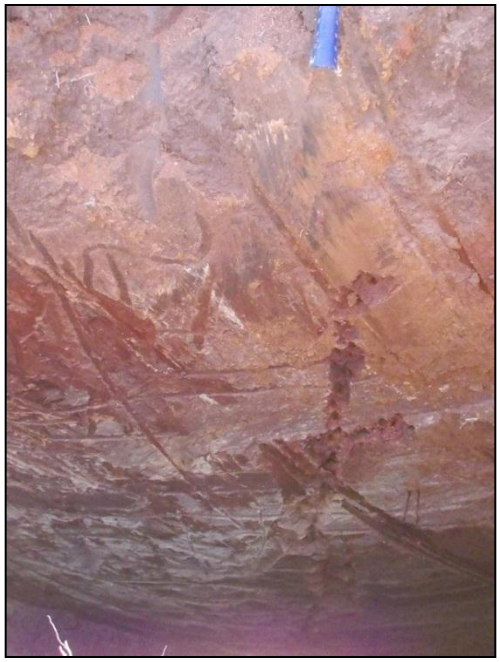
Test Pit number: Mb02



Note: Desiccation cracks in clay horizon.

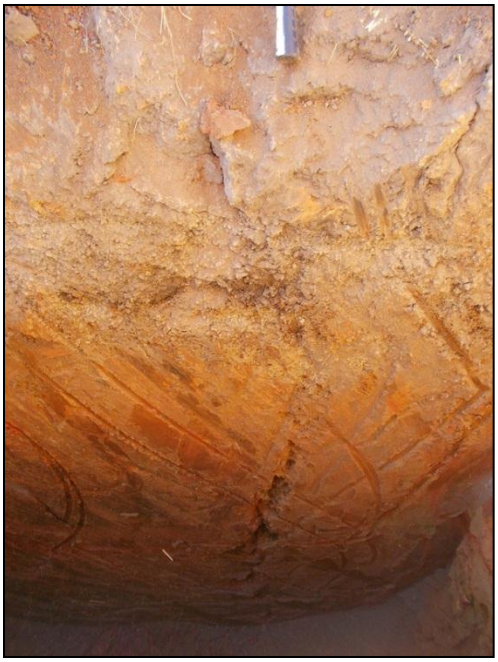
PROJECT: Housing Project in Eastern Cape (Mbhobeleni) PROJECT no: WF14066

Test Pit number: Mb03



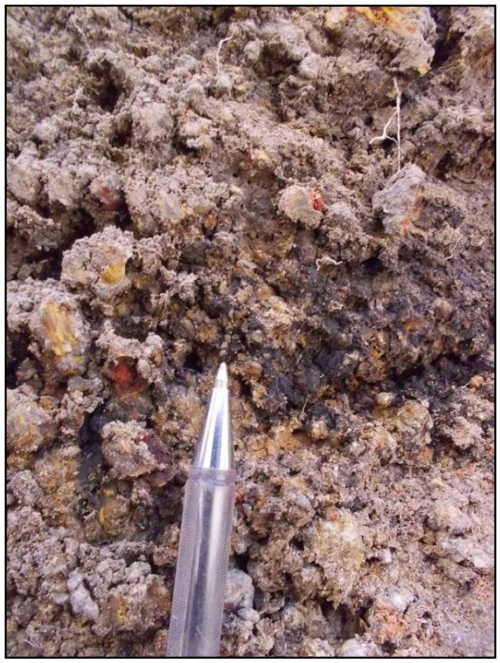
Note: Hole stopped TLB soft excavation.

Test Pit number: Mb04



Note: Hole stopped TLB soft excavation.

Test Pit number: Mb04

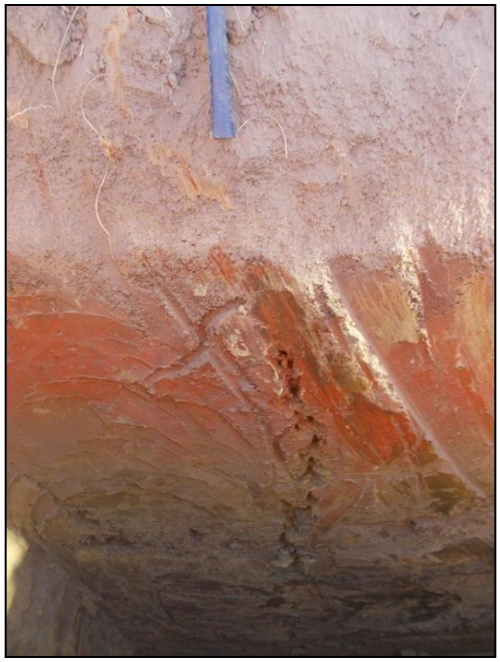


Note: Clayey gravel pebble marker.

Test Pit number: Mb04

Note: Iron and manganese staining on joints.

Test Pit number: Mb05



Note: Progressive refusal.

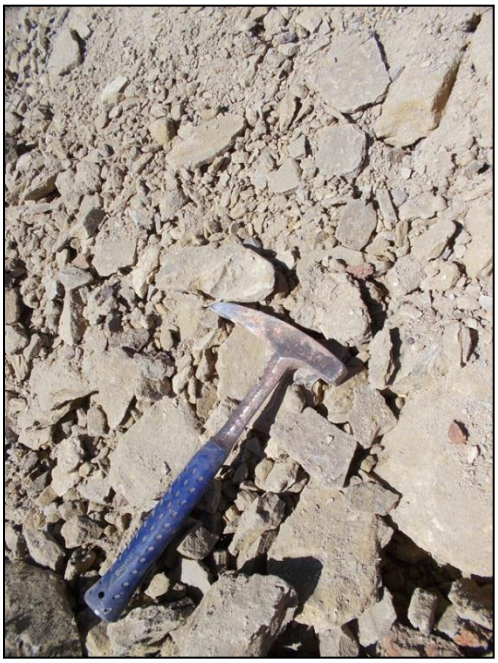
Test Pit number: Mb05

Note: Layered structure in highly weathered shale.

Test Pit number: Mb05

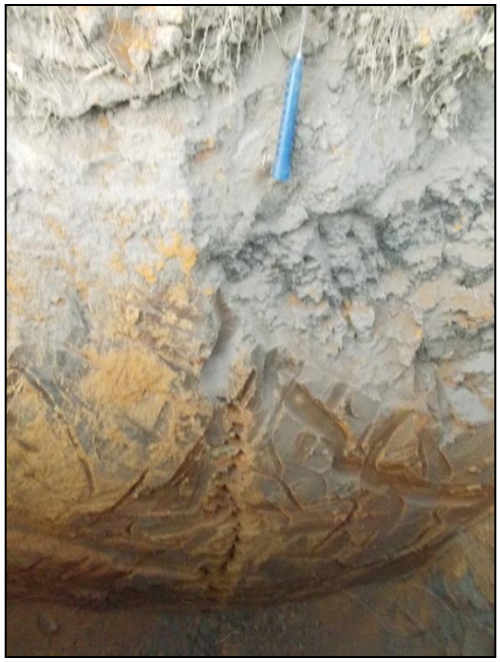
Note: Soft rock shale fragment.

Test Pit number: Mb05



Note: Soft rock shale fragments excavated.

Test Pit number: Mc01



Note: Hole stopped TLB soft excavation.

Test Pit number: Mc01

Note: Silty clay lump excavated.

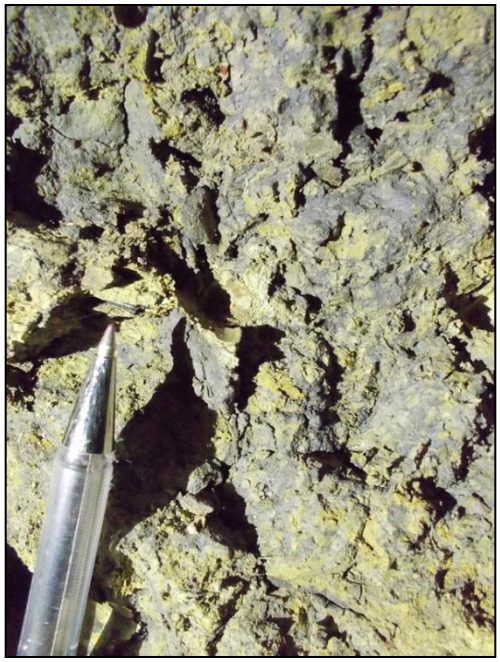
Test Pit number: Mc01

Note: View of slope of village.

Test Pit number: Mc02

Note: Refusal of TLB on medium hard shale.

Test Pit number: Mc02

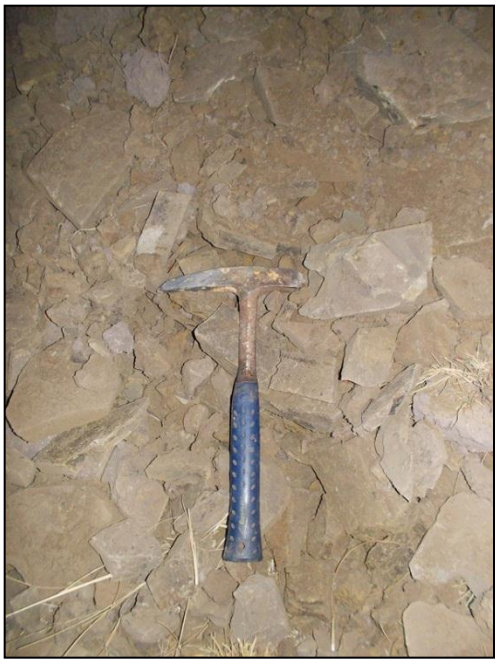


Note: Silty clayey horizon in test pit.

Test Pit number: Mc02

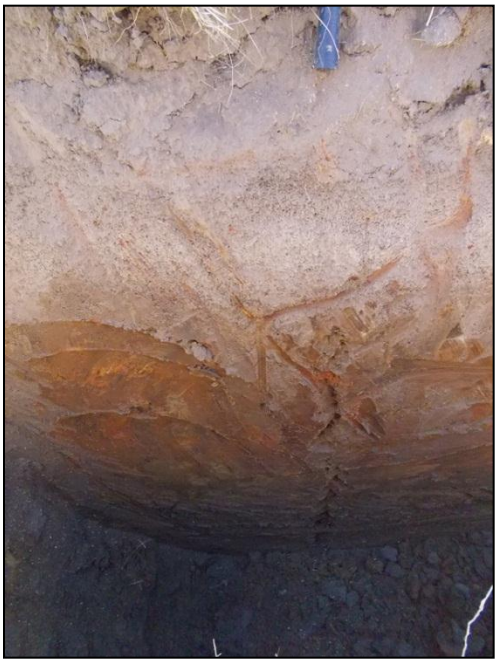
Note: Moderately weathered shale fragment.

Test Pit number: Mc02



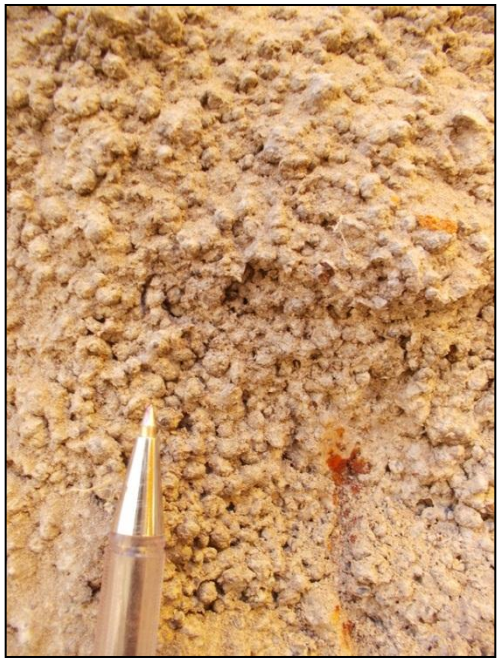
Note: Excavated medium hard shale.

Test Pit number: Mc03



Note: Progressive refusal of TLB.

Test Pit number: Mc03



Note: Open structure in top horizons.

Test Pit number: Mc04

Note: Hole stopped TLB soft excavation.

Test Pit number: Mc04

Note: Clayey silt material in profile.

Test Pit number: Mc05

Note: Refusal of TLB soft excavation to refusal.

Test Pit number: Mc05

Note: Layered and jointed structure in highly weathered shale.

Test Pit number: Mc05

Note: Soft rock shale fragments excavated.

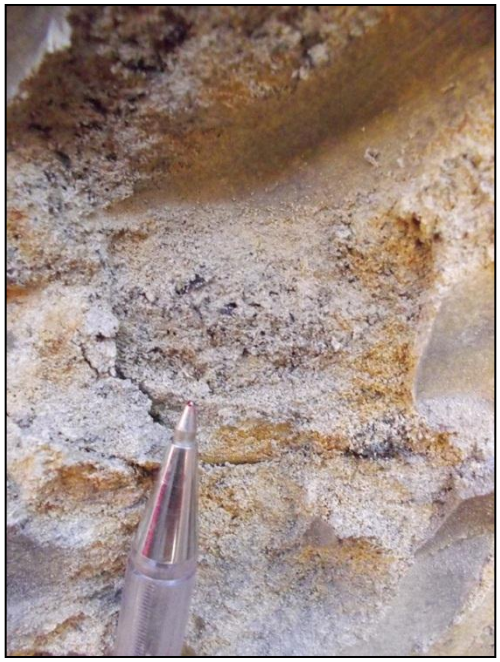
Test Pit number: Mc05

Note: Open structure in gravelly horizon.

Test Pit number: Mc06

Note: Progressive refusal of TLB.

Test Pit number: Mc06



Note: Silty fine sand residual in profile.

Test Pit number: Mc07

Note: Progressive refusal of TLB

Test Pit number: Mc07

Note: Silty clayey residual dolerite in profile.

Test Pit number: Mc07

Note: Dolerite outcrop near test pit.

APPENDIX D

(Laboratory Test Results)

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

2010/006827/07

www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT:	WSM Leshika Consulting (PTY) Ltd	**PROJECT:**	HOUSING PRJCT IN E.C. MBBHOBHELENI VILL
	P.O. Box 39942		
	Moreleta Park		
	PRETORIA 0044	**DATE:**	2014.08.14
ATT :	Mr M. Van Rensburg	**REF:**	MT 24749

O.N. WF14066

FOUNDATION INDICATOR PREDICTION OF HEAVE

SAMPLE NO	3163	3164	3165	3166	3167	3168
POSITION	Mb 01	Mb 02	Mb 03	Mb 03	Mb 04	Mb 05
	MBOBELENI	MBOBELENI	MBOBELENI	MBOBELENI	MBOBELENI	MBOBELENI
DEPTH	1.50 - 2.50	1.30 - 2.10	0.70 - 1.00	1.50 - 2.00	1.60 - 2.60	0.80 - 1.10
DESCRIPTION	lt R cly dec	lt R cly dec	dk Br Sty s	dk Y Br Sty	dk Y Br Sty	R Br Ms
	Dol	Dol		soil	soil	

SIEVE ANALYSIS

% PASSING							
75	mm						
37.5	mm						
19	mm		100			100	
9.5	mm		98	100		98	
4.75	mm	100	96	99	100	95	100
2.36	mm	99	93	98	99	92	96
1.18	mm	96	90	96	97	89	93
0.600	mm	90	87	92	92	87	93
0.425	mm	87	85	88	90	86	93
0.300	mm	85	85	83	87	85	93
0.150	mm	80	80	70	77	82	92
0.075	mm	48.5	40.2	40.9	39.1	40.7	76.4

MECHANICAL ANALYSIS

0.06	mm	41	35	36	34	34	69
0.02	mm	20	17	20	17	14	48
0.006	mm	9	8	8	8	7	35
0.002	mm	6	5	4	4	4	30

SOIL CONSTANTS

LIQUID LIMIT	47	30	40	34	34	36
PLASTICITY INDEX	16	9	12	13	9	17
LINEAR SHRINKAGE	8.0	4.0	6.0	6.0	3.5	9.0

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

MOISTURE CONTENT %						
PI WHOLE SAMPLE	13.9	7.7	10.6	8.1	7.7	15.8
ACTIVITY						
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW	LOW	MED

The above test results are pertinent to the samples received and tested only.
While the tests are carried out according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.
Remarks:

For Controlab:

ConSR19

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 6565, Fax: 043 743 9942, P O Box 345, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT:	WSM Consulting (PTY) Ltd	**PROJECT:**	HOUSING PRJCT IN E.C. MBHOBHELENI VILL
	P.O. Box 39942		
	Moreleta Park		
	PRETORIA 0042	**DATE:**	2014.08.14
ATT :	Mr M. Van Rensburg	**REF:**	MT 24749

O.N. WF 14066

FOUNDATION INDICATOR PREDICTION OF HEAVE

SAMPLE NO	3169					
POSITION	Mb 05					
	MBOBELENI					
DEPTH	1.50 - 2.50					
DESCRIPTION	dk Cl Ms					

SIEVE ANALYSIS

% PASSING 75 mm						
37.5 mm						
19 mm	100					
9.5 mm	93					
4.75 mm	87					
2.36 mm	79					
1.18 mm	72					
0.600 mm	70					
0.425 mm	70					
0.300 mm	69					
0.150 mm	66					
0.075 mm	40.7					

MECHANICAL ANALYSIS

0.06 mm	36					
0.02 mm	20					
0.006 mm	10					
0.002 mm	6					

SOIL CONSTANTS

LIQUID LIMIT	30					
PLASTICITY INDEX	11					
LINEAR SHRINKAGE	4.5					

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

MOISTURE CONTENT %						
PI WHOLE SAMPLE	7.7					
ACTIVITY						
POTENTIAL EXPANSIVENESS	LOW					

Remarks:

For Controlab:

ConSR19

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

2010/006629/07

www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7659, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 6565, Fax: 043 743 9842, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT: WSM Leshika Consulting (PTY) Ltd
P.O. Box 39942
Moreleta Park
PRETORIA, 0044
ATT: Mr. M. van Rensburg

PROJECT: HOUSING PROJECT IN E.C.
DATE RECEIVED: 2014.07.18
DATE TESTED: 2014.08.04
DATE REPORTED: 2014.08.19
TEST REPORT NO.: MT 24749

O.N. WF14066

MATERIALS TEST REPORT

SAMPLE NO:	3163	3164	3167	3169		
POSITION	Mb 01	Mb 02	Mb 04	Mb 05		
VILLAGE NAME	MBHOBHELENI VILLAGE					
DEPTH mm	1.50 - 2.50	1.30 - 2.10	1.60 - 2.60	1.50 - 2.50		
DESCRIPTION	lt R cly dec	lt R cly dec	dk Y Br sty	dk Ol Ms		
	Dol	Dol	soil			
CLASSIFICATION (TRH 14)	G 10	G 10	G 10	G 10		

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING							
	75	mm					
	63	mm					
	53	mm					
	37.5	mm					
	26.5	mm					
	19	mm		100	100	100	
	13.2	mm		99	99	96	
	4.75	mm	100	96	95	87	
	2.00	mm	98	92	91	77	
	0.425	mm	87	85	86	70	
	0.075	mm	48.5	40.2	40.7	40.7	

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	11	8	5	9		
FINE SAND (%)	39	49	50	38		
SILT / CLAY (%)	49	44	45	53		
GRADING MODULUS	0.67	0.83	0.82	1.12		

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	47	30	34	30		
PLASTICITY INDEX (%)	16	9	9	11		
LINEAR SHRINKAGE (%)	8.0	4	3.5	4.5		

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	1435	1783	1671	1855		
Optimum Moisture Content (%)	29.0	14.2	20.5	12.8		
C.B.R. @ 100% COMPACTION	12	5	4	13		
C.B.R. @ 98 % COMPACTION	8	4	3	10		
C.B.R. @ 95 % COMPACTION	5	4	2	8		
C.B.R. @ 93 % COMPACTION	4	4	2	6		
C.B.R. @ 90 % COMPACTION	2	3	1	5		
SWELL @ 100% COMP. (%)	3.18	2.48	1.74	2.20		

Lab Manager:

Remarks:
Sample Delivered by Customer [X]
Sampled by Controlab [ ]

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT: WSM Leshika Consulting (PTY) Ltd
P.O. Box 39942
Moreleta Park
PRETORIA 0044

ATT : Mr M. Van Rensburg

PROJECT: HOUSING PROJECT IN E.C MCWILI VILLAGE

DATE: 2014.08.13

REF: MT 24747

O.N. WF 14086

FOUNDATION INDICATOR DESIGN

SAMPLE NO	3140	3141	3142	3143	3144	3145
POSITION	Mc 02	Mc 03	Mc 04	Mc 04	Mc 06	Mc 07
	MCWILI VILL	MCWILI VILL	MCWILI VILL	MCWILI VILL	MCWILI VILL	MCWILI VILL
DEPTH	0.20 - 0.40	1.80 - 2.30	1.00 - 2.20	2.50 - 3.00	0.80 - 1.20	1.20 - 1.80
DESCRIPTION	dk G Br Sty cl	lt Y Ms	lt Y Sty s	lt Br s	lt Br Ss Mottl	dk Br Ss Mottl
	lt Y Br Ms				Sty s	Sty s

SIEVE ANALYSIS

% PASSING							
75	mm						
37.5	mm	100					100
19	mm	98	100				93
9.5	mm	97	90	100	100		84
4.75	mm	84	84	99	99	100	80
2.36	mm	53	79	98	99	99	72
1.18	mm	34	75	96	98	99	63
0.600	mm	33	72	93	92	97	57
0.425	mm	33	70	90	83	94	55
0.300	mm	33	70	85	73	84	52
0.150	mm	30	69	68	54	53	44
0.075	mm	19.4	44.5	33.3	31.4	29.6	24.1

MECHANICAL ANALYSIS

0.06	mm	17	38	28	27	27	21
0.02	mm	9	19	13	15	17	10
0.006	mm	5	10	6	7	11	5
0.002	mm	4	7	4	4	7	4

SOIL CONSTANTS

LIQUID LIMIT	25	34	26	24	40	23
PLASTICITY INDEX	6	13	9	8	12	7
LINEAR SHRINKAGE	3.0	5.5	4.0	3.0	6.0	3.0

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

MOISTURE CONTENT %						
PI WHOLE SAMPLE	2.6	9.1	7.8	6.6	11.3	3.9
ACTIVITY						
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW	LOW	LOW

The above test results are pertinent to the samples received and tested only.
While the tests are carried out according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.
Remarks:

For Controlab:

ConSR19

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

2010/009822/07

www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT:	WSM Leshika Consulting (PTY) Ltd	**PROJECT:**	HOUSING PROJECT IN E.C.
	P.O. Box 39942	**DATE RECEIVED:**	2014.07.18
	Moreleta Park	**DATE TESTED:**	2014.08.04
	PRETORIA, 0044	**DATE REPORTED:**	2014.08.19
ATT:	Mr. M. van Rensburg	**TEST REPORT NO.:**	MT 24751

O.N. WF14066

MATERIALS TEST REPORT

SAMPLE NO:		3142					
POSITION		Mc 04					
VILLAGE NAME		MCWILI VILLAGE					
DEPTH mm		1.00 - 2.20					
DESCRIPTION		lt Y sty s					
CLASSIFICATION (TRH 14)		G 10					

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING	75 mm						
	63 mm						
	53 mm						
	37.5 mm						
	26.5 mm						
	19 mm						
	13.2 mm	100					
	4.75 mm	99					
	2.00 mm	98					
	0.425 mm	90					
	0.075 mm	33.3					

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	8					
FINE SAND (%)	58					
SILT / CLAY (%)	34					
GRADING MODULUS	0.79					

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	26					
PLASTICITY INDEX (%)	9					
LINEAR SHRINKAGE (%)	4.0					

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	1815					
Optimum Moisture Content (%)	12.5					
C.B.R. @ 100% COMPACTION	5					
C.B.R. @ 98 % COMPACTION	4					
C.B.R. @ 95 % COMPACTION	3					
C.B.R. @ 93 % COMPACTION	2					
C.B.R. @ 90 % COMPACTION	2					
SWELL @ 100% COMP. (%)	0.98					

Lab Manager:

Remarks:
Sample Delivered by Customer [X]
Sampled by Controlab [ ]

APPENDIX E

(Typical Material Properties)

TABLE E1: Typical material properties (Unified Soil Classification System)

Class:	Material description	Subgrade	Subbase	Base	Drainage when compacted	Compaction characteristics	Embankment material	Compressibility when compacted
GW	Well-graded gravel	Good to Excellent	Good	Fair to good	Excellent	Good	Reasonably stable	Low
GP	Poorly grade gravel (<5% fines)	Good to Excellent	Good	Fair to good	Excellent	Good	Reasonably stable	Low
GC	Clayey gravel (>12% fines)	Good	Fair	Poor to not suitable	Poor to practically impervious	Good to fair	Reasonably stable	Low
SP	Poorly graded sand (<5% fines)	Fair to good	Fair	Poor to not suitable	Excellent	Good	Reasonably stable	Low
SM	Silty sand (sand with fines PI<4)	Fair to good	Fair to good	Poor to not suitable	Fair to practically impervious to impervious	Good	Reasonably stable	Low
SC	Clayey sand (>12% fines PI>7)	Fair	Poor	Not suitable	Poor, impervious when compacted	Good to fair	Reasonably stable	Low
CL	Silts and clays (LL<50 & PI>7)	Fair to poor	Not suitable	Not suitable	Practically impervious	Good to fair	Good stability	Medium
ML	Silts and clays (LL<50 & PI<4)	Fair to poor	Not suitable	Not suitable	Semi-pervious to impervious	Good to poor	Poor stability	Medium
CH	Silts and clays (LL>50)	Poor to fair	Not suitable	Not suitable	Practically impervious	Fair to poor	Fair stability	Medium to high
MH	Silts and clays (LL>50)	Poor	Not suitable	Not suitable	Fair to poor, semi-pervious to pervious	Fair to poor	Poor stability	Medium to high

TABLE E2: Material properties after NAVFAC DM7 (1971)

Group symbol	Soil type	Max yd	Optimum moisture (%)	Typical strength characteristics			
				Cu (kPa)	C` (kPa)	ϕ` (deg.)	tan ϕ`
GW	Well-graded clean gravels, gravel-sand mixtures	19.7-21.2	11-8	0	0	>38	>0.78
GC	Clayey gravels, poorly graded gravel-sand-clay	18.1-20.5	14-9	0	0	>31	>0.60
SM	Silty sands, poorly graded sand-silt mixtures	17.3-19.7	16-11	50	5	34	0.67
SC	Clayey sands poorly graded sand-clays	16.5-19.7	19-11	75	10	31	0.60
CL	Inorganic clays of low to medium plasticity	15.0-18.9	24-12	85	12	28	0.54
ML	Inorganic silts and clayey silts	15.0-18.9	24-12	65	10	32	0.62
CH	Inorganic clays of high plasticity	11.8-16.5	36-19	100	12	19	0.35

yd – Dry density; Cu – Undrained cohesion; C` - Drained cohesion; ϕ`(deg.) – Shearing resistance

APPENDIX F

(Classification Tables)

TABLE C1. GEOTECHNICAL CLASSIFICATION FOR URBAN DEVELOPMENT (after Partridge, Wood and Brink 1993)

CONSTRAINT		Most favourable (1)	Intermediate (2)	Least favourable (3)
A	Collapsible Soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750 mm in thickness.*	Any collapsible horizon or consecutive horizons with a depth of more than 750 mm in thickness.	A least favourable situation for this constraint does not occur.
B	Seepage	Permanent or perched water table more than 1,5 m below ground surface.	Permanent or perched water table less than 1,5 m below ground surface	Swamps and marshes.
C	Active soil	Low soil-heave potential predicted. *	Moderate soil heave potential predicted.	High soil-heave potential predicted.
D	Highly compressible soil	Low soil compressibility expected.*	Moderate soil compressibility expected.	High soil compressibility expected.
E	Erodability of soil	Low.	Intermediate.	High.
F	Difficulty of excavation to 1,5 m depth	Scattered or occasional boulders less than 10% of the total volume.	Rock or hardpan pedocretes between 10 and 40 % of the total volume.	Rock or hardpan pedocretes more than 40 % of the total volume.
G	Undermined ground	Undermining at a depth greater than 100 m below surface (except where total extraction mining has not occurred.)	Old undermined areas to a depth of 100m below surface where stope closure has ceased.	Mining within less than 100 m of surface or where total extraction mining has taken place.
H	Instability in areas of soluble rock	Possibly unstable.	Probably unstable.	Known sinkholes and dolines
I	Steep slopes	Between 2 and 6 degrees (all regions).	Slopes between 6 and 18 degrees and less than 2 degrees (Natal and Western Cape). Slopes between 6 and 12 degrees and less than 12 degrees (all other regions).	More than 18 degrees (Natal and Western Cape). More than 12 degrees (all other regions).
J	Areas of unstable natural slopes	Low risk.	Intermediate risk.	High risk (especially in areas subject to seismic activity).
K	Areas subject to seismic activity	10% probability of an event less than 100 cm/s^2 within 50 years	Mining-induced seismic activity more 100 cm/s^2.	Natural seismic activity more than 100 cm/s^2.
L	Areas subject to flooding	A “most favourable” situation for this constraint does not occur.	Areas adjacent to a known drainage channel or floodplain with slope less than 1%.	Areas within a known drainage channel or floodplain.

* These areas are designated as 1A, 1C, 1D, or 1F where localised occurrences of the constraint may arise.

TABLE C2: RESIDENTIAL SITE CLASS DESIGNATIONS (SAICE, 1995)

TYPICAL FOUNDATION MATERIAL	CHARACTER OF FOUNDING MATERIAL	EXPECTED RANGE OF TOTAL SOIL MOVEMENTS (mm)	ASSUMED DIFFERENTIAL MOVEMENT (% OF TOTAL)	SITE CLASS
Rock (excluding mud rocks which exhibit swelling to some depth)	STABLE	NEGLIGIBLE	-	R
Fine-grained soils with moderate to very high plasticity (clays, silty clays, clayey silts and sandy clays)	EXPANSIVE SOILS	< 7,5 7,5 – 15 15 – 30 > 30	50% 50% 50% 50%	H H1 H2 H3
Silty sands, sands, sandy and gravelly soils	COMPRESSIBLE AND POTENTIALLY COLLAPSIBLE SOILS	< 5,0 5,0 – 10 > 10	75% 75% 75%	C C1 C2
Fine-grained soils (clayey silts and clayey sands of low plasticity), sands, sandy and gravelly soils	COMPRESSIBLE SOIL	< 10 10 – 20 > 20	50% 50% 50%	S S1 S2
Contaminated soils Controlled fill Dolomitic areas Land fill Marshy areas Mine waste fill Mining subsidence Reclaimed areas Very soft silt/silty clays Uncontrolled fill	VARIABLE	VARIABLE		P

NOTES:

1. The classifications C, H, R and S are not intended for dolomitic area sites unless specific investigations are carried out to assess the stability (risk of sinkholes and doline formation) of the dolomites. Where this risk is found to be acceptable, the site shall be designated as Class P (dolomitic areas).
2. Site classes are based on the assumption that differential movements, experienced by single-storey residential buildings, expressed as a percentage of the total movements are equal to about 50% for soils that exhibit expansive or compressive characteristics and 75% for soils that exhibit both compressible and collapse characteristics. Where this assumption is incorrect or inappropriate, the total soil movements must be adjusted so that the resultant different movements implied by the table are equal to that which is expected in the field.
3. In some instances, it may be more appropriate to use a composite description to describe a site mote fully e.g. C1/H2 or S1 and/or H2. Composite Site Classes may lead to higher differential movements and result in design solutions appropriate to a higher range of differential movement e.g. a Class R/C1 site. Alternatively, a further site investigation may be necessary since the final design solution may depend on the location of the building on a particular site.
4. Where it is not possible to provide a single site designation and a composite description is inappropriate, sites may be given multiple descriptions to indicate the range of possible conditions e.g. H-H1-H2 or C1-C2.
5. Soft silts and clays usually exhibit high consolidation and low bearing characteristics. Structures founded on these horizons may experience high settlements and such sites should be designated as being Class S1 or S2 as relevant and appropriate.
6. Sites containing contaminated soils include those associated with reclaimed mine land, land down-slope of mine tailings and old land fills.
7. Where a site is designated as Class P, full particulars relating to the founding conditions on the site must be provided.
8. Where sites are designated as being Class P, the reason for such classification shall be placed in brackets immediately after the suffix – i.e. P(contaminated soils). Under certain circumstances, composite description may be more appropriate – e.g. P(dolomite areas)-C1.
9. Certain fills may contain contaminates which present a health risk. The nature of such fill should be evaluated and should be clearly demarcated as such.

TABLE C3: FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES FOR SINGLE-STOREY RESIDENTIAL BUILDINGS FOUNDED ON HORIZONS SUBJECT TO CONSOLIDATION SETTLEMENT (SAICE, 1995)

SITE CLASS	ESTIMATED TOTAL SETTLEMENT (mm)	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES
S	**<10**	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage
S1	**10-20**	Modified normal	- Reinforced strip footings - Articulation joints at some internal and all external doors - Light reinforcement in masonry - Site drainage and service/plumbing precautions - Foundation pressure not to exceed 50 kPa
		Compaction of in situ soils below individual footings	- Remove in situ material below foundations to a depth and width of 1,5 times the foundation width or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip foundations and light reinforcement in masonry.
		Deep strip foundations	- Normal construction with drainage requirements. - Founding on a competent horizon below the problem horizon
		Soil raft	- Remove in situ material to 1,0m beyond perimeter of building to a depth and width of 1,5 times the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip footings and light reinforcement in masonry.
S2	**>20**	Stiffened strip footings, stiffened or cellular raft	- Stiffened strip footing or stiffened or cellular raft with articulation joints or solid lightly reinforced masonry. - Bearing pressure not to exceed 50kPa. - Fabric reinforcement in floor slabs. - Site drainage and service/plumbing precautions.
		Deep strip foundations	- As for S1 but with fabric reinforcement in floor slabs
		Compaction of in-situ soils below individual footings	- As for S1.
		Piled or pier foundations	- Reinforced concrete ground beams or solid slabs on piled or pier foundations. - Ground slabs with fabric reinforcement. - Good site drainage.
		Soil raft	- As for S1.

NOTES:

1. Differential settlement assumed to equal 50% of total settlement.
2. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage.
3. Account must be taken on sloping site since differential fill heights may lead to greater differential settlements.
4. Settlements induced by loads imposed by deep filling beneath surface beds may necessitate the adoption of a construction type appropriate to a more severe site class.

TABLE C4: FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES FOR SINGLE-STOREY RESIDENTIAL BUILDINGS FOUNDED ON HORIZONS SUBJECT TO BOTH CONSOLIDATION AND COLLAPSE SETTLEMENT
(SAICE, 1995)

SITE CLASS	ESTIMATED TOTAL SETTLEMENT (mm)	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES
C	**<5**	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage
C1	**5 – 10**	Modified normal	- Reinforced strip footings - Articulation joints at some internal and all external doors - Light reinforcement in masonry - Site drainage and service/plumbing precautions - Foundation pressure not to exceed 50 kPa
		Compaction of in situ soils below individual footings	- Remove in situ material below foundations to a depth and width of 1,5 times the foundation width or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip foundations and light reinforcement in masonry.
		Deep strip foundations	- Normal construction with drainage requirements. - Founding on a competent horizon below the problem horizon
		Soil raft	- Remove in situ material to 1,0m beyond perimeter of building to a depth and width of 1,5 times the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip footings and light reinforcement in masonry.
C2	**>10**	Stiffened strip footings, stiffened or cellular raft	- Stiffened strip footing or stiffened or cellular raft with articulation joints or solid lightly reinforced masonry. - Bearing pressure not to exceed 50kPa. - Fabric reinforcement in floor slabs. - Site drainage and service/plumbing precautions.
		Deep strip foundations	- As for C1 but with fabric reinforcement in floor slabs
		Compaction of in situ soils below individual footings	- As for C1.
		Piled or pier foundations	- Reinforced concrete ground beams or solid slabs on piled or pier foundations. - Ground slabs with fabric reinforcement. - Good site drainage.
		Soil raft	- As for C1.

NOTES:
1. Differential settlement assumed to equal 75% of total settlement
2. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage.

TABLE C5: FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES FOR SINGLE-STOREY RESIDENTIAL BUILDINGS FOUNDED ON HORIZONS SUBJECT TO HEAVE (SAICE, 1995)

SITE CLASS	ESTIMATED TOTAL EXPANSION (mm)	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES
H	**<7,5**	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage and service/plumbing precautions recommended.
H1	**7,5 – 15**	Modified normal	- Lightly reinforced strip footings - Articulation joints at all internal/external doors - Light reinforcement in masonry - Site drainage and service/plumbing precautions
		Soil raft	- Remove in situ material to 1,0m beyond perimeter of the structure and replace with inert backfill, compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip footings and light reinforcement in masonry if residual movements are <7,5mm, or construction type appropriate to residual movements. - Site drainage and plumbing/service precautions.
H2	**15-30**	Stiffened or cellular raft	- Stiffened or cellular raft with articulation joints or lightly reinforced masonry. - Site drainage and plumbing/service precautions.
		Piled construction	- Piled foundations with suspended floor slabs with or without ground beams. - Site drainage and plumbing/service precautions.
		Split construction	- Combination of reinforced brickwork/block work and full movement joints. - Suspended floors of fabric-reinforced ground slabs acting independently from the structure. - Site drainage and plumbing/service precautions.
		Soil raft	- As for H1.
H3	**>30**	Stiffened or cellular raft	- As for H2.
		Piled construction	- As for H2.
		Soil raft	- As for H1.

NOTES:

1. Differential settlement assumed to equal 50% of total settlement
2. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage.

CHART C1: USCS MATERIAL DESIGNATION CHART

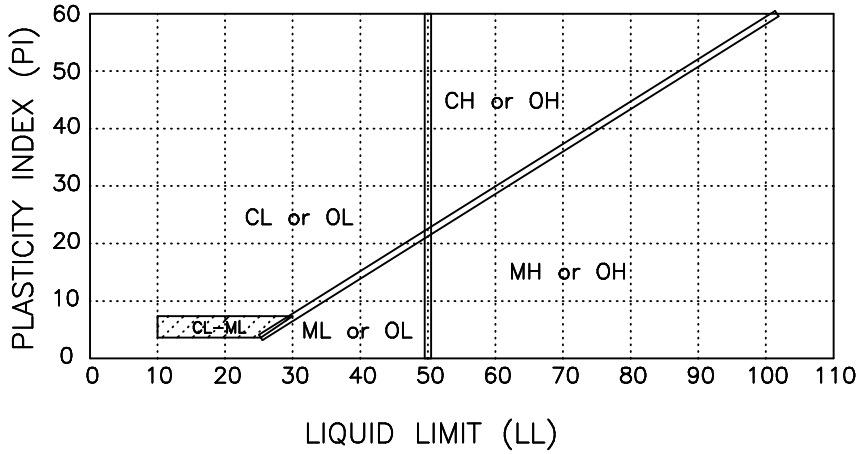
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the United Soil Classification System (USCS) on the boring logs presented in this report. Grain size analysis and Atterberg limits tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corps of Engineers, US Army Technical Memorandum No. 3–357 (Revised April 1960) or ASTM Designation: D2487–66T.

MAJOR DIVISIONS				GROUP SYMBOL	TYPICAL NAMES
COARSE – GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		GW	Well graded gravels, gravel–sand mixtures, or sand–gravel–cobble mixtures.
				GP	Poorly graded gravels, gravel–sand mixtures, or sand–gravel–cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below the "A" line & hatched zone on plasticity chart	GM	Silty gravels, gravel–sand–silt mixtures.
			Limits plot above the "A" line & hatched zone on plasticity chart	GC	Clayey gravels, gravel–sand–clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)		SW	Well graded sands, gravelly sands.
				SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below the "A" line & hatched zone on plasticity chart	SM	Silty sands, sand–silt mixtures.
			Limits plot above the "A" line & hatched zone on plasticity chart	SC	Clayey sands, sand–clay mixtures.
FINE – GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (Limits Plot Below "A" Line & hatched Zone on Plasticity Chart)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)		ML	Inorganic silts, non–plastic or slightly plastic.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)		MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS (Limits Plot Above "A" Line & hatched Zone on Plasticity Chart)	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)		CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE:
Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with Atterberg limits plotting in the hatched zone on the plasticity chart shall have dual symbol. In Arizona, local streams contain sand, gravel & cobble type material, which are locally known as SGC or riverrun material. The USCS is not used to divide and symbolize this material.

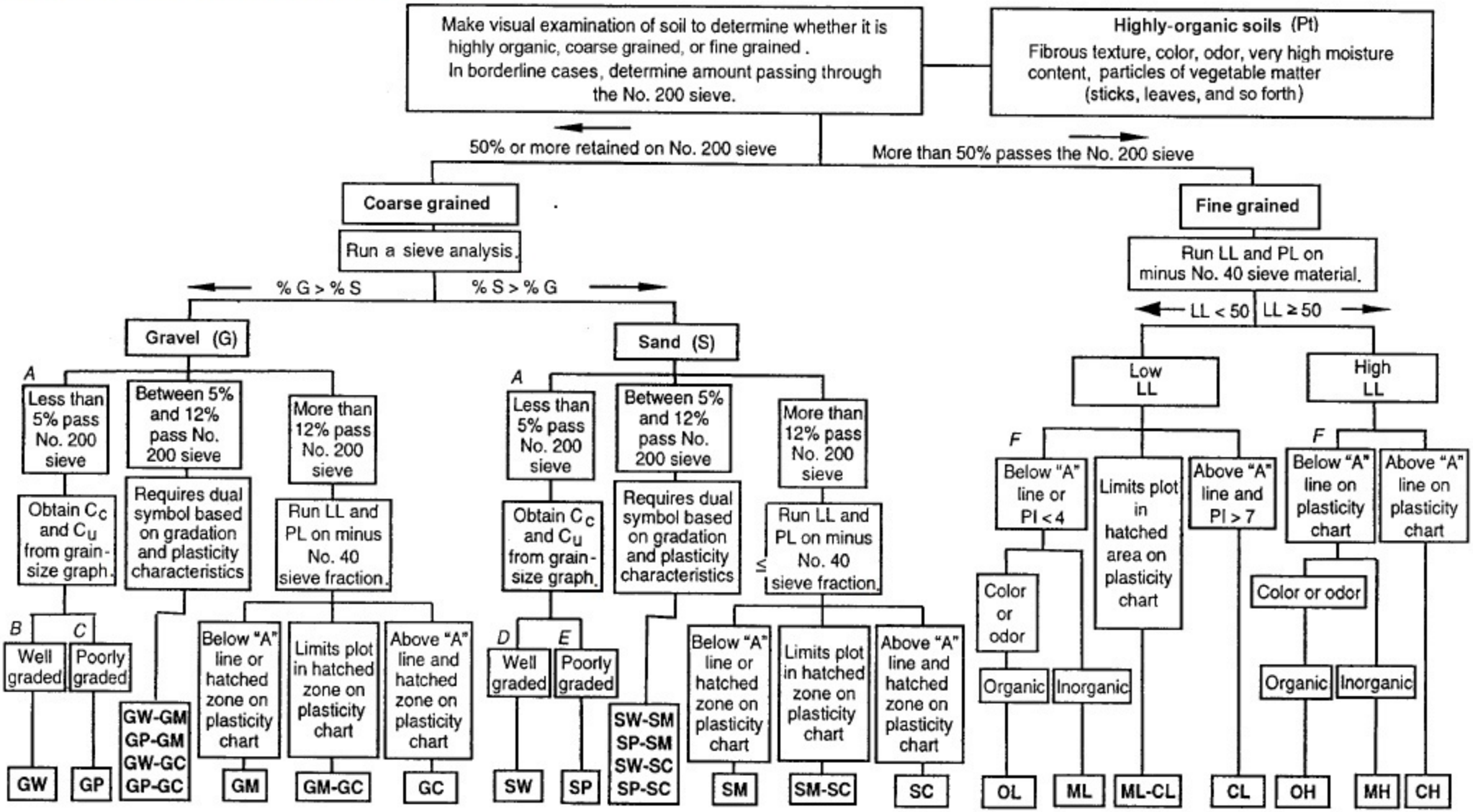
PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt & clay)	Below No. 200 sieve
Clay	Smaller than 2 microns
Colloid	Smaller than 5 microns

CHART C2: USCS DESIGNATION FLOW CHART



A If fines interfere with free-draining properties, use a double symbol such as GW-GM.

B For well-graded gravel, the C_U must be > 4 and the C_C must be ≥ 1 and ≤ 3.

C For poorly graded gravel, the C_U must be ≤ 4 and/or the C_C is < 1 or > 3.

D For well graded sand, the C_U must be > 6 and the C_C must be ≥ 1 and ≤ 3.

E For poorly graded sand, the C_U must be ≤ 6 and/or the C_C is < 1 or > 3.

F In cases where organic material can't be determined by color or odor, a LL and PL test must be conducted on a sample of natural moisture content and a sample that has been oven-dried. Organic soils will show a radical drop in plasticity for the oven-dried sample compared to the retained-moisture sample. Inorganic soils generally fall within ± 1 or 2 percent of each other.