



**NKHOPHELE  
HOLDINGS**

*Core to earth's sustainable development*



**GEOTECHNICAL INVESTIGATION**  
Magatle Filling station Development



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**REF NO.:** NK-0108

**DATE:** 15/08/2019

**REPORT DETAILS**

|                        |  |
|------------------------|--|
| <b>Client Name:</b>    | <b>Pollock Chuene</b>  |
| <b>Document Title:</b> | Geotechnical investigation for Magatle Filling station development     |
| <b>File Name:</b>      | NK-0108 Magatle Filling Station Development Geotechnical investigation |

|  |  |
|--|--|
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## Executive Summary

Nkhophela Holdings conducted a geotechnical investigation in June 2019 for the development of a filling station and a shopping centre at Magatle, Zebediela. The site investigation was aimed at evaluating engineering characteristics of near surface soils underlying the site.

Test pitting and laboratory testing were used to conduct the investigation. Nine (9) test pits were excavated which indicated that the surficial soils comprise residual material occurring as gravelly sand.

The investigation findings suggest that the soils encountered on the site may exhibit low potential expansiveness. The investigation findings further suggest that the site be classified as soil site class **2/C** according to NHBRC Loading conditions. Overall the geotechnical investigation indicates that the site is developable albeit with precautionary measures.

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- Appendix A: Test Pit Location
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## 1. INTRODUCTION

Nkhophela Holdings was appointed in June 2019 by Executive Petroleum to conduct a geotechnical investigation for the development of a filling station and a shopping centre. Building plans, layout and structural loads for the proposed structures were not provided. This report presents the findings of a geotechnical investigation carried out on the site.

## 2. TERMS OF REFERENCE AND SCOPE OF WORK

The project entails the development of a filling station and shopping centre at Magatle, Zebediela in Limpopo. The site investigation was carried out in accordance with SAIEG, GFSH-2, TRH14 guidelines, and all NHBRC Home Building Manuals and included the following:

- Trial pitting, in-situ soil profiling and sampling;
- Laboratory testing;
- Site classification according to GFSH-2 Document and;
- Foundation Recommendations

## 3. SITE DESCRIPTION

### 3.1. LOCATION

The site is situated at Magatle, Zebediela, Limpopo, approximately 18 km south west of Lebowakgomo and directly opposite the Magatle Police Station (Figure 1). The site is rectangular in shape and covers an area of approximately 5 Ha. The centre coordinates of the site are 24°27'33.32"S, 29°24'49.65"E. The site is currently undeveloped and occasionally used as a show ground facility. Redundant electrical concrete poles and remnants on old building structures were observed on site.





Figure 1. Site Locality

### 3.2. CLIMATE

The average daily maximum and minimum temperatures of Zebediela are characterised by moderate fluctuations in seasonal temperature, with a high of 30°C in summer and a low of 6°C in winter. Precipitation in the study area occurs mainly in the summer, with the maximum rainfall experienced during November - January. The site is located in an area designated a weinert value less than 5 which suggests that chemical weathering is the dominant form of weathering.

### 3.3. TOPOGRAPHY AND DRAINAGE

The site was relatively flat with the elevation ranging between 903 m amsl (above mean sea level) and 908 m amsl. Erosional features such as dongas, and furrows were not observed on site. No watercourses traverse the site; however, the Nkumpi River is situated 200 m east of the site.

### 3.4. GEOLOGY

According to the 1:250 000 geological map sheet 2428 Nylstroom Geological Map Series (Figure 2), the investigated area is underlain by sedimentary rocks of the Karoo Sequence. The Karoo sequence in the Nylstroom area is made up of the volcanic rocks and sandstones of the Letaba Formation; red sandstone of the Clarens Formation; sandstone, mudstone, siltstone and shale of the Irrigasie Formation and shale, sandstone, conglomerate and coal beds of the Ecca Group. The development site is underlain by the red sandstone of the Clarens Formation.



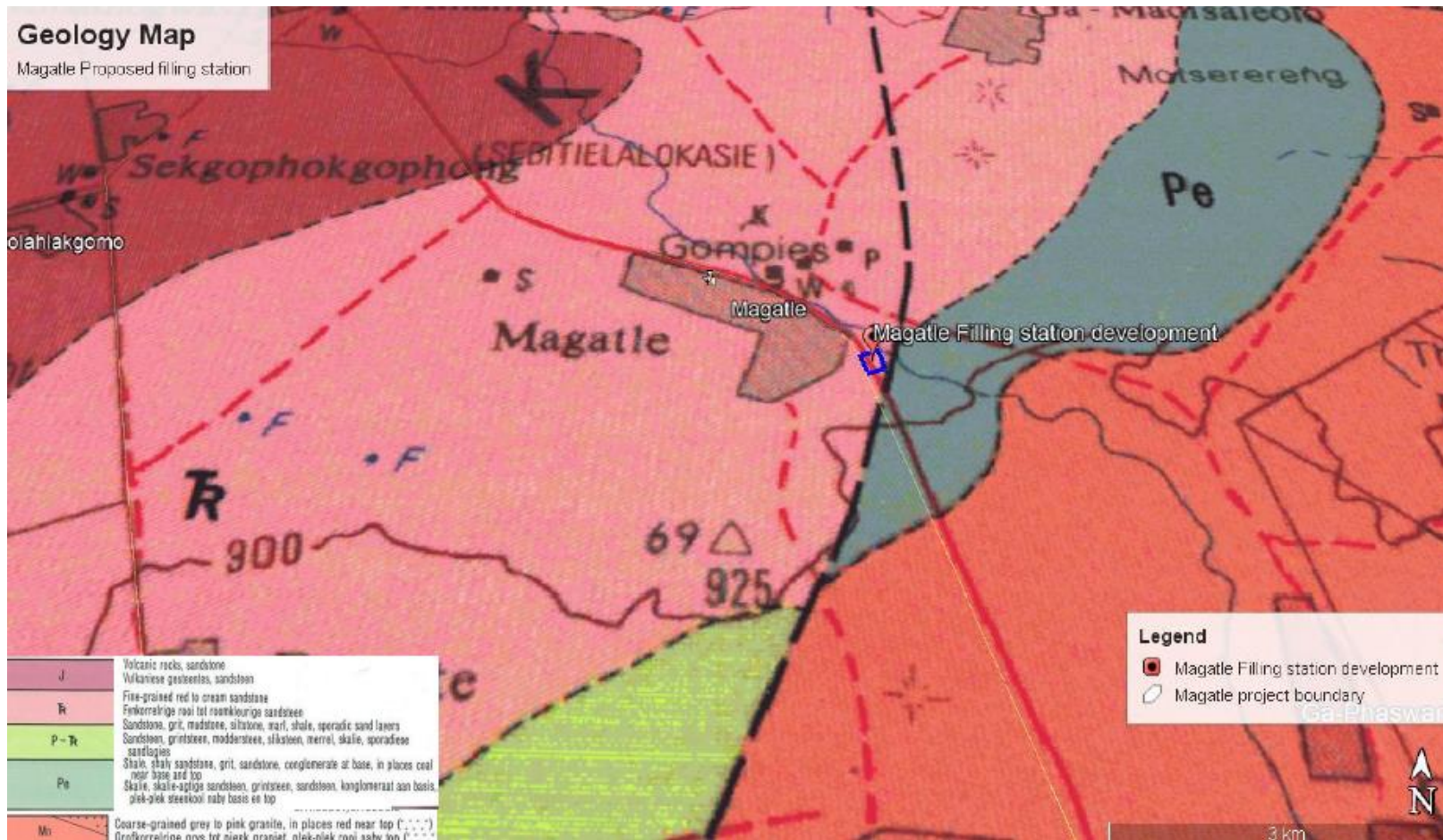


Figure 2. Site Geology

## 4. INVESTIGATION METHODOLOGY

The approach to this geotechnical investigation utilizes of a combination of literature review (Desktop Study) and field investigation. The literature review was conducted to assess the current state of the environment according to available literature resources.

### 4.1. AVAILABLE INFORMATION

- Topographic map of the Director of Surveys at a scale of 1: 50 000: Sheet 2429AD Zebediela (East);
- Geological Map of the GSO: Scale 1: 250 000 Sheet – Geological series 2428 Nylstroom;
- Expansive Roadbed Treatment for Southern Africa: D J Weston (1980) 4th Int. Conf. on Expansive Soils, Vol. 1, Denver pp 339-360
- National Home Builders Registration Council: Home Builders Manual: Parts 1 and 2, Revision 1, February 1999;
- Technical Recommendations for Highways – TRH14 Guidelines for Road Construction Materials by the National Institute for Transport and road research of the Council for Scientific and Industrial Research, (1985);
- SAICE's Guidelines for Urban Engineering Geological Investigations;
- Schwartz, K. (1985). Collapsible soils. The Civil Engineer in South Africa, July, p379-393 and;
- New, M., Lister, D., Hulme, M. and Makin, I., 2002: A high-resolution data set of surface climate over global land areas. Climate Research 21:1-25

### 4.2. FIELD INVESTIGATION

The following methodology was adopted for the field investigation:

Test pitting was conducted using a Tractor-Loader-Backhoe (TLB) and test pits were excavated to the maximum depth of 2.76 m. The test pits were logged by a registered engineering geologist according to MCCSSO method prescribed by Jennings et al. (1973). The trial pits were loosely backfilled after

profiling. The location of the test pits is indicated on the test pit locality plan available in Appendix A. Detailed soil profiles are attached in Appendix B.

## 5. FIELD INVESTIGATION RESULTS

### 5.1. TEST PITTING AND PROFILING

The field investigation was carried out by a Nkhophole holdings engineering geologist on the 27 June 2019. A total of nine (9) test pits were excavated across the site. The test pitting indicates that the site is underlain by a cover of transported colluvial material occurring as sand with sparse to abundant fragments of gravel. The material encountered in the test pits is described below and detailed test pit logs are available in Appendix B.

- **Transported** – The transported horizon was encountered at depths between ground level and 1.02 m. the transported material is comprised of slightly moist, reddish-brown sandy-silt.
- **Pebble Marker**– The transported horizon is underlain by a pebble marker comprising sandy-gravel with round gravel. The pebble marker was encountered at depths between 0.73 m and 1.60 m. The pebble marker is however absent in test pits ZBM 03, ZBM 04, and ZBM 09.
- **Residual Sandstone** – The site is underlain chiefly by Slightly moist, Light brown to reddish-brown gravelly-sand from weathered residual sandstone. The residual sandstone was encountered at depths between 0.88 m and 2.76 m, however at ZBM 09, the sandstone was unweathered when excavated and the trial pit could only be excavated till 0.98 m. Trial pit ZBM 01, ZBM 04 and ZBM05 residual sandstone had cobbles.

### 5.2. LABORATORY TESTING

Representative soil samples were taken at specific positions from material encountered in the test pits. Ten (10) samples were collected and submitted to Civilab Civil Engineering Testing Laboratory for Foundation Indicator and California Bearing (CBR) testing to determine basic engineering characteristics including:

- Atterberg Limits (plastic limit, liquid limit and plasticity index);
- Potential Expansiveness;

- Grading analysis and;
- MOD and CBR.

The laboratory tests were conducted to assist with the classification, description, and delineation of homogenous zones. The results of the foundation indicator, MOD and CBR tests are presented in Appendix C and are summarized in Table 1 and Table 2. The samples were taken from the test pit position denoted in the same manner.

**Foundation Indicator** – A total of six (6) foundation indicator samples were collected. Two (2) from the transported horizon, one (1) from the pebble marker horizon and three (3) from the residual sandstone horizon.

- **Transported** – The samples collected indicate a Liquid Limit ranging from 21% to 23% with the Linear Shrinkage ranging between 4% and 5.5%. The samples indicate low to medium plasticity with the overall Plasticity Index ranging between 7% and 8%. Based on the clay content and plasticity, the soils underlying the site will exhibit low potential expansiveness.
- **Pebble Marker**– The sample collected indicate a Liquid Limit of 26% with the Linear Shrinkage ranging between 4.5%. The samples indicate low plasticity with the overall Plasticity Index of 4%. Based on the clay content and plasticity, the soils underlying the site will exhibit low potential expansiveness.
- **Residual Sandstone** – The samples collected indicate a Liquid Limit ranging from non-plastic to 31% with the Linear Shrinkage ranging between non-plastic and 5.5%. The samples indicate low to medium plasticity with the overall Plasticity Index ranging between non-plastic and 6%. Based on the clay content and plasticity, the soils underlying the site will exhibit low potential expansiveness.

**Road Indicators and CBR** – Four (4) sample were collected, one (1) transported and three (3) residual sandstone and submitted for California Bearing Ration (CBR) Testing.

- **Transported** – The grading modulus of the sample was 0.9 with a Plasticity Index of 21%. The samples collected indicate a fair CBR with the value of 12% at 95% MOD AASHTO. The sample

indicate a maximum swell of 0.1%. Based on the grading modulus, Atterberg limits and CBR soils underlying the site may be classified as G8.

- **Residual Sandstone** – The grading modulus of the samples ranges between 1.5 and 2.1 with the Plasticity Index ranging between non-plastic and 12%. The samples collected indicate a good CBR with the values ranging between 43% and 82% at 95% MOD AASHTO. The sample indicates a maximum swell ranging between 0.1% and 1.1%. Based on the grading modulus, Atterberg limits and CBR soils underlying the site may be classified as ranging between G5 and G6.



**Table 1: Foundation Indicator Test Results**

| Sample No. | Description        | Depth (m)  | Atterberg Limit |      |              | GM   | Grading analysis (%) |      |      |        | USC | Potential expansiveness |
|------------|--------------------|------------|-----------------|------|--------------|------|----------------------|------|------|--------|-----|-------------------------|
|            |                    |            | LL %            | LS % | Overall PI % |      | Clay                 | Silt | Sand | Gravel |     |                         |
| ZBM01      | Transported        | 0.00-1.73  | 21              | 4    | 7            | 0.89 | 16                   | 16   | 63   | 5      | SC  | Low                     |
| ZBM01      | Residual sandstone | 1.00-1.27  | NP              | NP   | NP           | 1.98 | 3                    | 7    | 44   | 46     | SM  | Low                     |
| ZBM02      | Pebble marker      | 1.02-1.60  | 26              | 4.5  | 4            | 1.63 | 4                    | 15   | 47   | 34     | SC  | Low                     |
| ZBM04      | Residual sandstone | 0.88- 2.50 | 31              | 5.5  | 6            | 1.52 | 6                    | 16   | 52   | 26     | SC  | Low                     |
| ZBM08      | Transported        | 0.00-0.85  | 23              | 5.5  | 8            | 0.99 | 17                   | 14   | 67   | 2      | SC  | Low                     |
| ZBM08      | Residual sandstone | 1.01-2.40  | 30              | 5.5  | 4            | 2.11 | 3                    | 11   | 26   | 60     | GC  | Low                     |

LL :Liquid Limit    PI :Plasticity Index    LS :Linear Shrinkage    GM :Grading Modulus    NP :Non-Plastic    USC :Unified Soil Classification

**Table 2: CBR and MOD Test Results**

| Sample No. | Description        | Depth (m)  | CBR @ |     |     |     |      | GM  | PI (%) | Max. Swell (%) | OMC (%) | Max Dry Density (kg/m <sup>3</sup> ) | TRH14 Classification |
|------------|--------------------|------------|-------|-----|-----|-----|------|-----|--------|----------------|---------|--------------------------------------|----------------------|
|            |                    |            | 90%   | 93% | 95% | 98% | 100% |     |        |                |         |                                      |                      |
| ZBM01      | Transported        | 0.00-1.73  | 11    | 12  | 12  | 13  | 14   | 0.9 | 21     | 0.1            | 9.2     | 2059                                 | G8                   |
| ZBM01      | Residual sandstone | 1.00-1.27  | 38    | 60  | 82  | 131 | 179  | 2.0 | NP     | 0.1            | 9.2     | 2028                                 | G5                   |
| ZBM04      | Residual sandstone | 0.88- 2.50 | 26    | 36  | 45  | 63  | 79   | 1.5 | 12     | 0.4            | 13.2    | 1898                                 | G6                   |
| ZBM08      | Residual sandstone | 1.01-2.40  | 131   | 38  | 43  | 51  | 58   | 2.1 | 12     | 1.1            | 11.4    | 1935                                 | G6                   |

**PI** :Plasticity Index

**GM** :Grading Modulus

**OMC** :Optimum Moisture Content

**CBR** :California Bearing Ratio

**NP**: Non- Plastic

## 6. GEOTECHNICAL EVALUATION

The objective of the investigation was to assess geotechnical properties of the surficial soils. The following geotechnical characteristics relevant to the development were assessed:

- Expansive Potential
- Collapse Potential
- Compressibility
- Groundwater
- Drainage & Erodibility
- Excavatability
- Slope Instability
- Subsidence
- Problematic soils

Table 3 gives the basis of the soil site classification that was applied during the investigation and Table 4 gives the geotechnical classification for urban development.

**Table 3: Soil Site Classification (NHBRC Building Manual)**

| Geotechnical category and site class designation         | Geotechnical characteristics  |
|--|---|
| Active soils (heave/shrink) - (H)<br>H<br>H1<br>H2<br>H3 | Expected range of total movement at surface:<br>< 5 mm<br>5 – 15 mm<br>15 – 30 mm<br>> 30mm |
| Compressible soils (S)<br>S<br>S1<br>S2                  | Expected range of total movement at surface:<br>< 5 mm<br>5 – 15 mm<br>> 15 mm              |
| Collapsible Soils (C)<br>C<br>C1                         | Expected range of total movement at surface:<br>< 5 mm<br>5 – 10 mm                         |

|                                    |   |
|------------------------------------|---|
| C2                                 | > 10 mm   |
| Excavation – (R)<br>r1<br>r2<br>r3 | sub outcrop<br>scattered outcrop and sub-outcrop<br>outcrop, scattered outcrop and sub-outcrop  |
| P – Problem soils                  | Dolomitic Areas, marshy areas, contaminated areas, abandoned borrow areas, land fill, mining subsidence and mine waste fill, shallow undermined areas, exploration pits or adits. |
| Inundation and seepage – (W)       | Wet area, drainage line, seepage zone   |

**Table 4: Geotechnical Classification for Urban Development (GFSH-2 Document)**

| Geotechnical Sub-Area | Definition   |
|-----------------------|--|
| 1                     | Areas recommended or favourable for development                                |
| 2                     | Areas where development can be considered with certain precautionary measures. |
| 3                     | Areas that are not recommended for development                                 |

### 6.1. EXPANSIVE SOILS

Active/expansive soils are defined as fine grained soils (generally with high clay content) that change in volume in response to the change in moisture content. These soils may increase in volume (heave/swell) upon wetting and decrease in volume (shrink) upon drying out. These soils are classified as (H) according to the SAICE site classes. Depending on the severity of the predicted movement, expansive soils can be classified as H, H1, H2 or H3 (Table 3).

The site is mainly underlain by sand and gravelly sand and the laboratory results of all the samples analysed indicate low plasticity. Therefore, problems associated with heaving soils are not anticipated to occur on the site.

## 6.2. COLLAPSIBLE SOILS

Collapsible soils are defined as soils that have a potential for collapse and are commonly open-textured (e.g. honey comb and pinhole) with a high void ratio (Brink, 1985). These soils are typically silty sands, sands, sandy and gravelly soils commonly found in colluvial and aeolian sands. Soils which exhibit potentially collapsible characteristics are classified with the soil site class 'C' according to the SAICE site classification system (Table 3).

The soils encountered on the site typically sand and gravelly sand with no visual open-textured structures such as voids and pinholes, which indicate collapse potential. The laboratory results indicate that the site is underlain by moderate sands with a moderate content of gravelly sands. From the site observations and laboratory testing the site is therefore classified with the soil site class C according to the SAICE site classification system.

## 6.3. COMPRESSIBLE SOILS

Compressible soils are soils in which the bulk volume of the soil may gradually decrease with time when subjected to an applied load. These soils typically comprise fine-grained soils such as clay, clayey sand and clayey silt with low plasticity, gravelly and sandy soil. According to the SAICE soil site class these soils are denoted as class 'S' and may vary (S, S1, S2) depending on the severity of the bulk volume change.

The site is generally underlain by silty and sandy gravel. The laboratory results indicate that the samples comprise low silt and clay content with low plasticity. Therefore, problems associated with compressible soils are not anticipated to occur on the site.

## 6.4. GROUNDWATER

Groundwater may negatively affect structures founded on non-cohesive soil (sands and silt). When non-cohesive soils become saturated, the stiffness, vertical stress and effective confining stress are reduced resulting in lower bearing pressures of the soil. Furthermore, a shallow/perched groundwater table normally presents a problem of rising damp on structures. Therefore, appropriate remedial

measures such as damp proofing needs to be incorporated in the construction of structures in areas where a shallow/ perched water table is anticipated. Various Pedogenic soils (ferricrete/calcrete and signs of ferruginisation/calcification) may indicate fluctuating or seasonally perched water table commonly caused by retarded vertical infiltration and percolation rates.

The fieldwork was conducted during the dry season and no groundwater or groundwater seepage was encountered during the field investigation.

#### **6.5. DRAINAGE AND ERODIBILITY**

The site is relatively flat and may promote the ponding of water and a river is located to the east of the site. Therefore, the site must be shaped to improve stormwater runoff and extensive stormwater management must be considered. All drainage boundaries near wet areas or drainage lines and floodlines must be confirmed by the relevant Competent Person (floodline specialist).

#### **6.6. EXCAVATABILITY**

Excavatability may be defined as the degree of difficulty at which the ground can be excavated. The test pits were excavated to depths ranging between 0.98m and 2.76m with no refusal. Excavatability problems may be anticipated within the vicinity of trial pit ZBM09 where shallow sandstone bedrock was encountered. Excavations for the proposed development are expected to utilise soft to intermediate excavation techniques for the removal of the soils underlying the site.

#### **6.7. SLOPE INSTABILITY**

The site slopes towards the east with a gradient of less than 6%. Therefore, slope related instability is not anticipated on the site.

#### **6.8. SUBSIDENCE**

No subsidence related problems are anticipated on the site

#### **6.9. PROBLEMATIC SOILS**

No problematic soils including dolomite or uncontrolled fill was encountered on the site.

## 7. RECOMMENDATIONS

### 7.1. SOIL SITE CLASSIFICATION

The investigation findings indicate that soils with gravelly sand with low expansive potential underlie the site. Furthermore, based on field observations (geological, hydrogeological, and geomorphological) and laboratory soil testing of soil samples, the site can be classified as: **2/C**

### 7.2. FOUNDATION RECOMMENDATIONS

Founding conditions are favourable for the proposed development and conventional construction methods can be implemented. Depending on the design and loads to be applied, the following foundation recommendations are made:

#### **Strip Footing**

- The width of the strip footings must be at least 600 mm in the case of a foundation to a load-bearing or free-standing masonry wall or to a timber framed wall supporting a roof.
- Where any strip foundation is laid at more than one level, the higher portion of the foundation shall extend over the lower portion for a distance at least equal to the thickness of the foundation.

### 7.3. PRECAUTIONS

The following precautions may be considered during construction on the site:

- The site is relatively flat therefore extensive site drainage and plumbing/service precautions must be considered.
- Structures to have damp proofing.
- The site must be graded to prevent ponding of storm water.
- 1.5 m apron around the structures to prevent water ingress under the immediate area or the foundation.
- Walkways and drive ways must be paved to allow easy access to the property during wet seasons.



- Planting of grass/lawn on the stands may be considered to prevent erosion.
- Roads must be paved or tarred. Specialist advice must be sought for the installation of the roads.
- Care must be taken with foundation designs where foundations straddle different soil mediums such as rock and soil.

#### 7.4. PAVEMENT LAYERS

The soils underlying the site exhibit good compaction characteristics for road building and pavement construction. According to the TRH14 guidelines, the residual sandstone soils underlying the site are classified as G5 and G6, therefore are suitable for subbase, selected layer and subgrade construction.

### 8. CONCLUSION

This report documents the findings of a near surface geotechnical investigation conducted for the development of Magatle filling station and shopping centre. The investigation was carried out by means of test pitting and laboratory testing of collected samples. Based on the field investigation and laboratory testing the following conclusions can be drawn:

- The site is typically underlain by transported material, pebble marker and residual sandstone. The bedrock encountered on the site is dominantly red sandstone.
- Laboratory testing of the collected samples indicates that the underlying soil exhibits low potential expansiveness.
- The residual sandstone soils underlying the site are classified as G5 and G6, therefore are suitable for subbase, selected layer and subgrade construction.
- Groundwater seepage was not encountered in all of the test pits excavated.
- The investigated site is relatively flat lying which may lead to poor stormwater drainage. The site must be shaped to improve stormwater runoff and extensive management must be considered.

Overall the geotechnical investigation findings suggest that the site is developable albeit with precautionary measures



## Appendix A: Test Pit Location











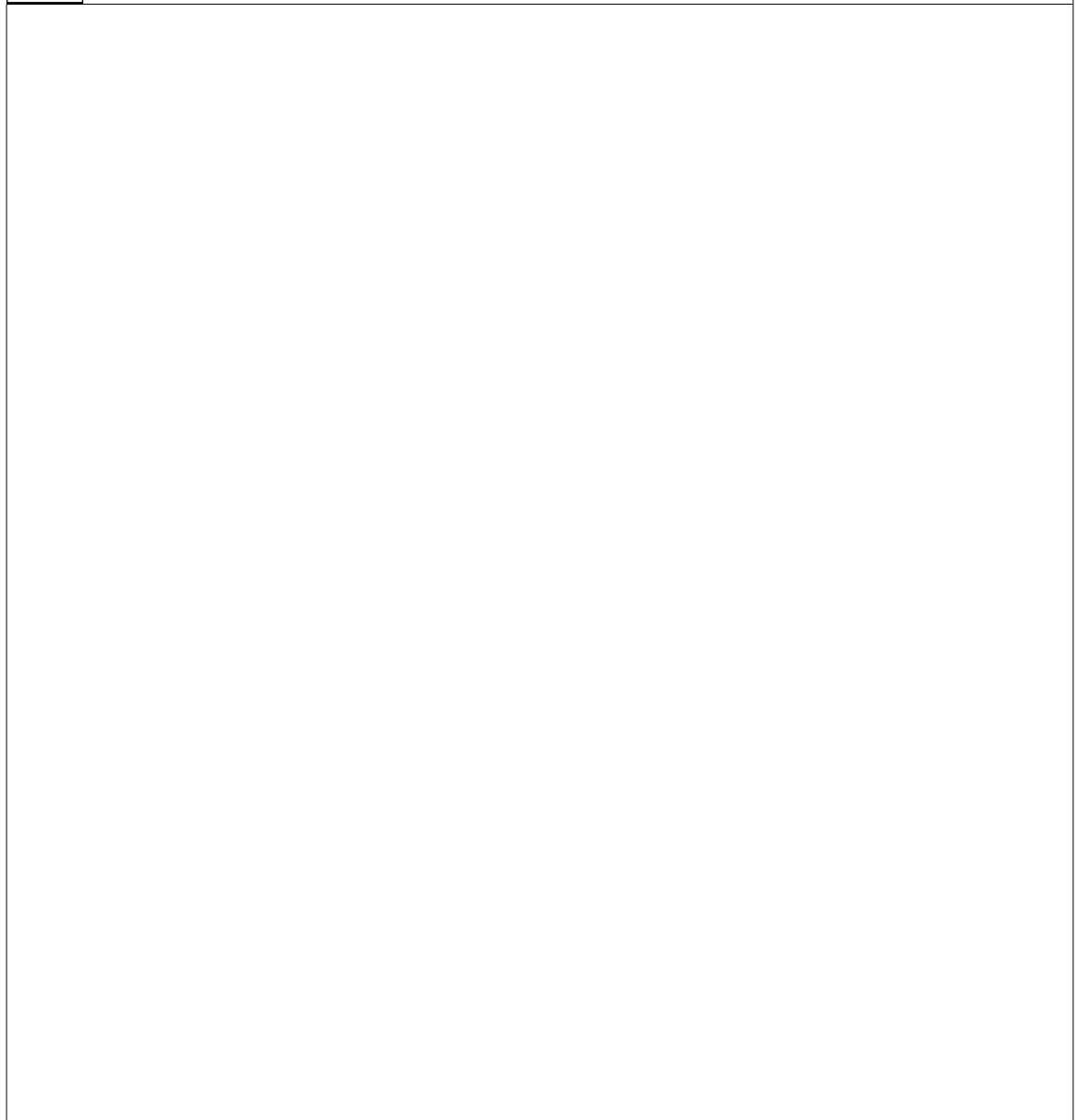


**Appendix B: Soil Logs**



|   |                  |        |
|---|------------------|--------|
|  | GRAVEL           | {SA02} |
|  | SANDY            | {SA05} |
|  | SILT             | {SA06} |
|  | SILTY            | {SA07} |
|  | SANDSTONE        | {SA11} |
|  | DISTURBED SAMPLE | {SA38} |

Name ●



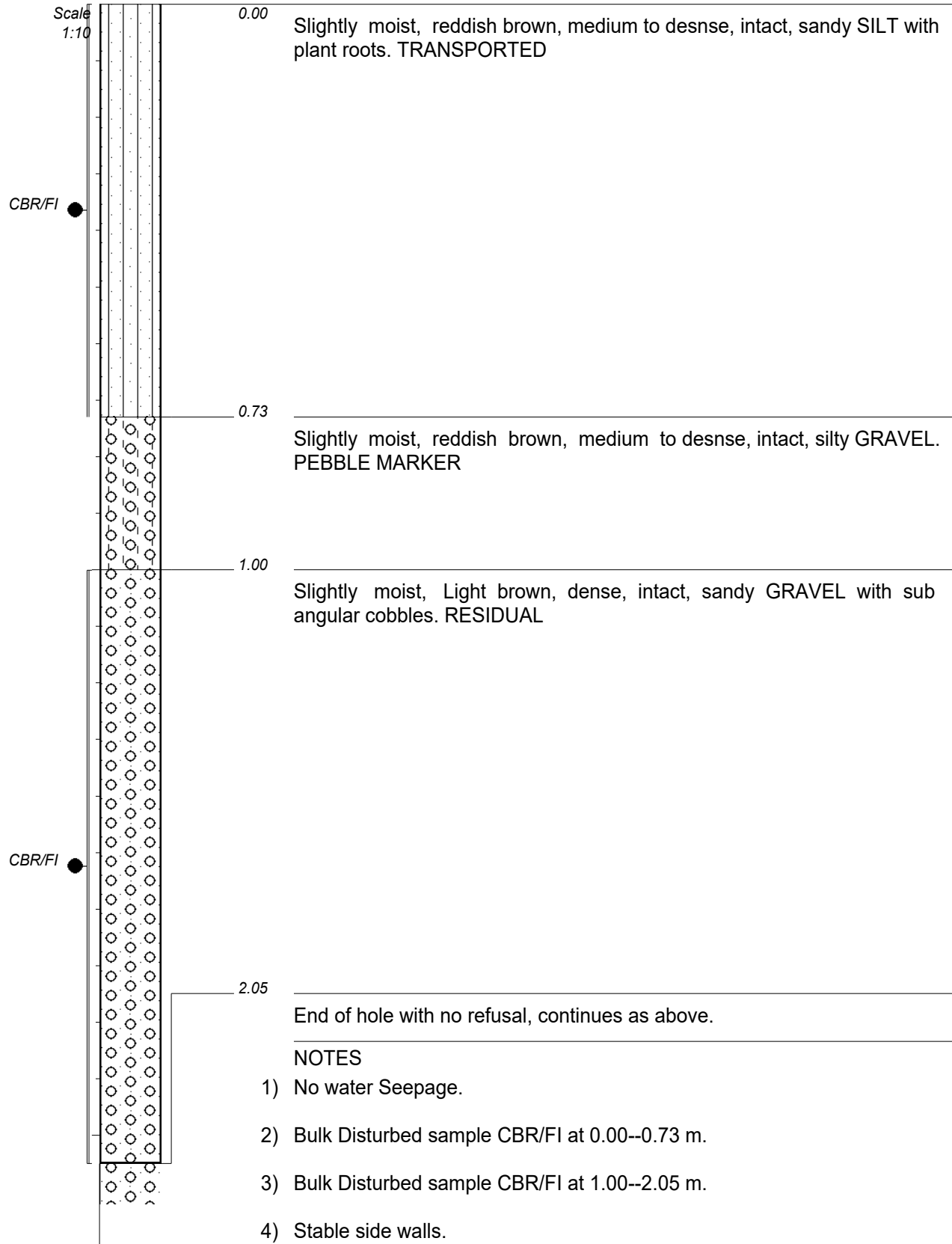
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 MACHINE :  
 DRILLED BY :  
 PROFILED BY :

INCLINATION :  
 DIAM :  
 DATE :  
 DATE :

ELEVATION :  
 X-COORD :  
 Y-COORD :

TYPE SET BY : N. Ratshikhopha  
 SETUP FILE : STANDARD.SET

DATE : 11/07/2019 12:21  
 TEXT : ..ofile\ZBProfilesCopy.txt

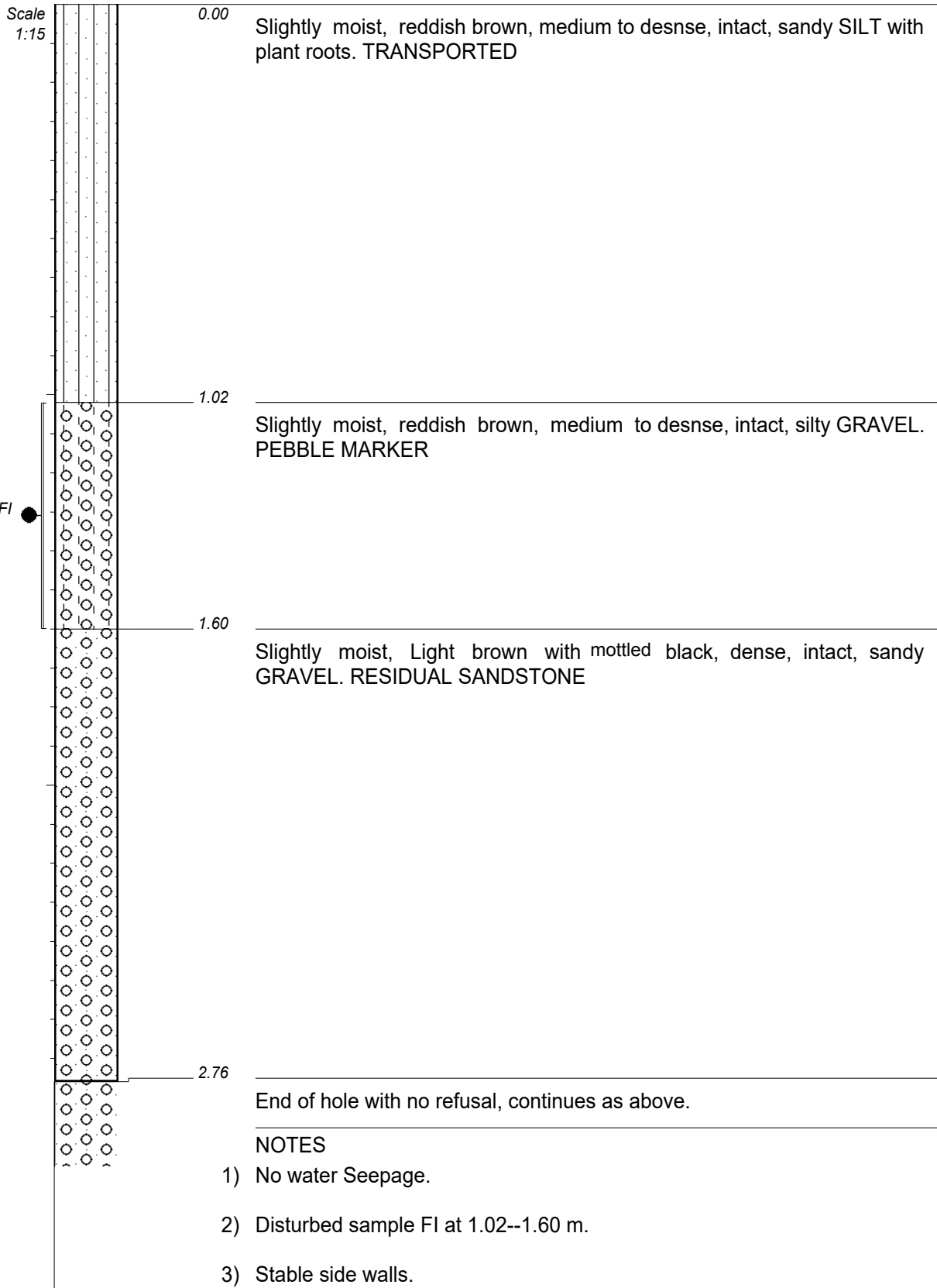


CONTRACTOR :  
MACHINE : TLB  
DRILLED BY :  
PROFILED BY : N. Ratshikhopha  
TYPE SET BY : N. Ratshikhopha  
SETUP FILE : STANDARD.SET

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
TEXT : ..ofile\ZBProfilesCopy.txt

ELEVATION :  
X-COORD : 29,41349  
Y-COORD : -24,46022



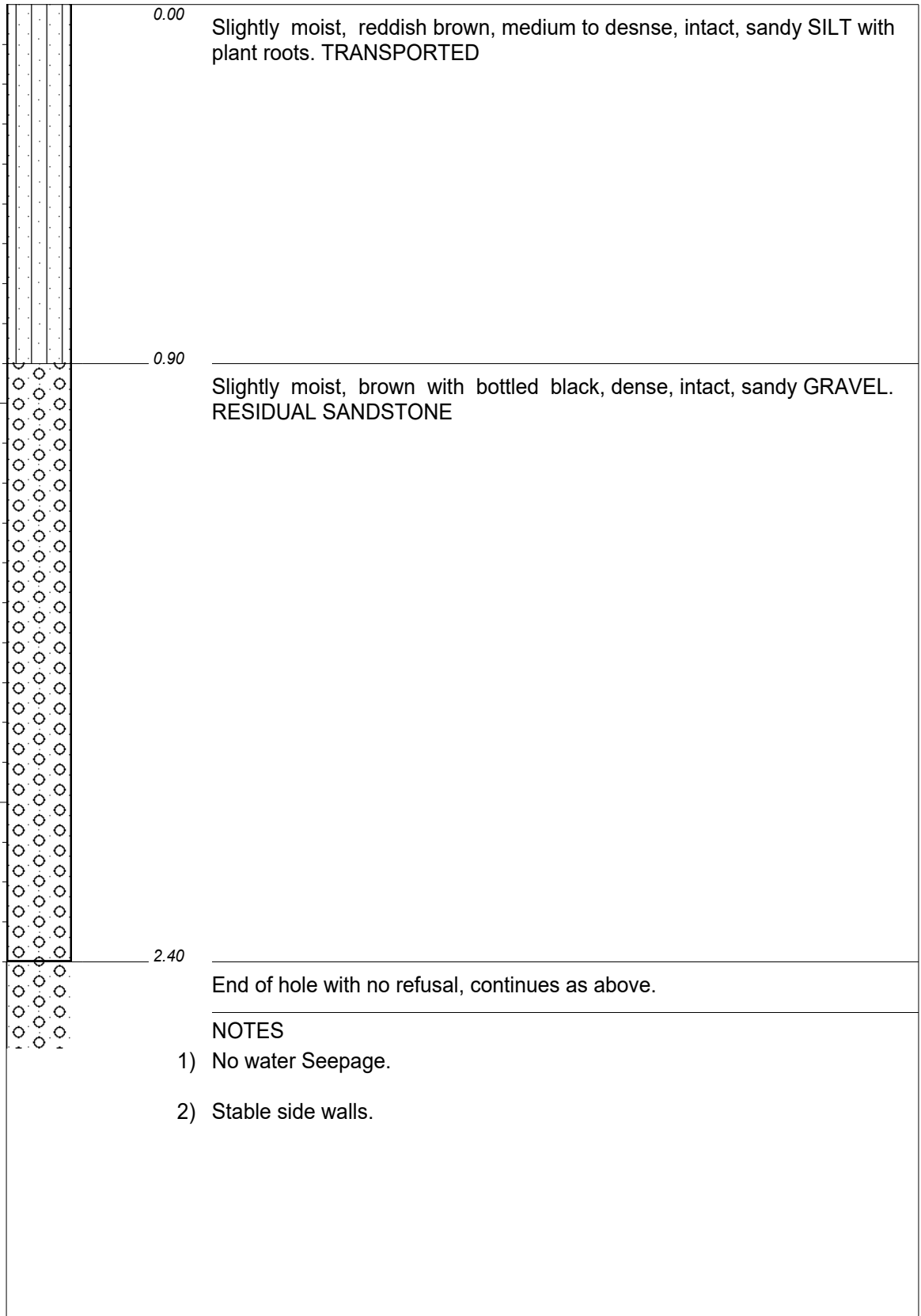


CONTRACTOR :  
MACHINE : TLB  
DRILLED BY :  
PROFILED BY : N. Ratshikhopha  
TYPE SET BY : N. Ratshikhopha  
SETUP FILE : STANDARD.SET

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
TEXT : ..ofile\ZBProfilesCopy.txt

ELEVATION :  
X-COORD : 29,41289  
Y-COORD : -24,459311

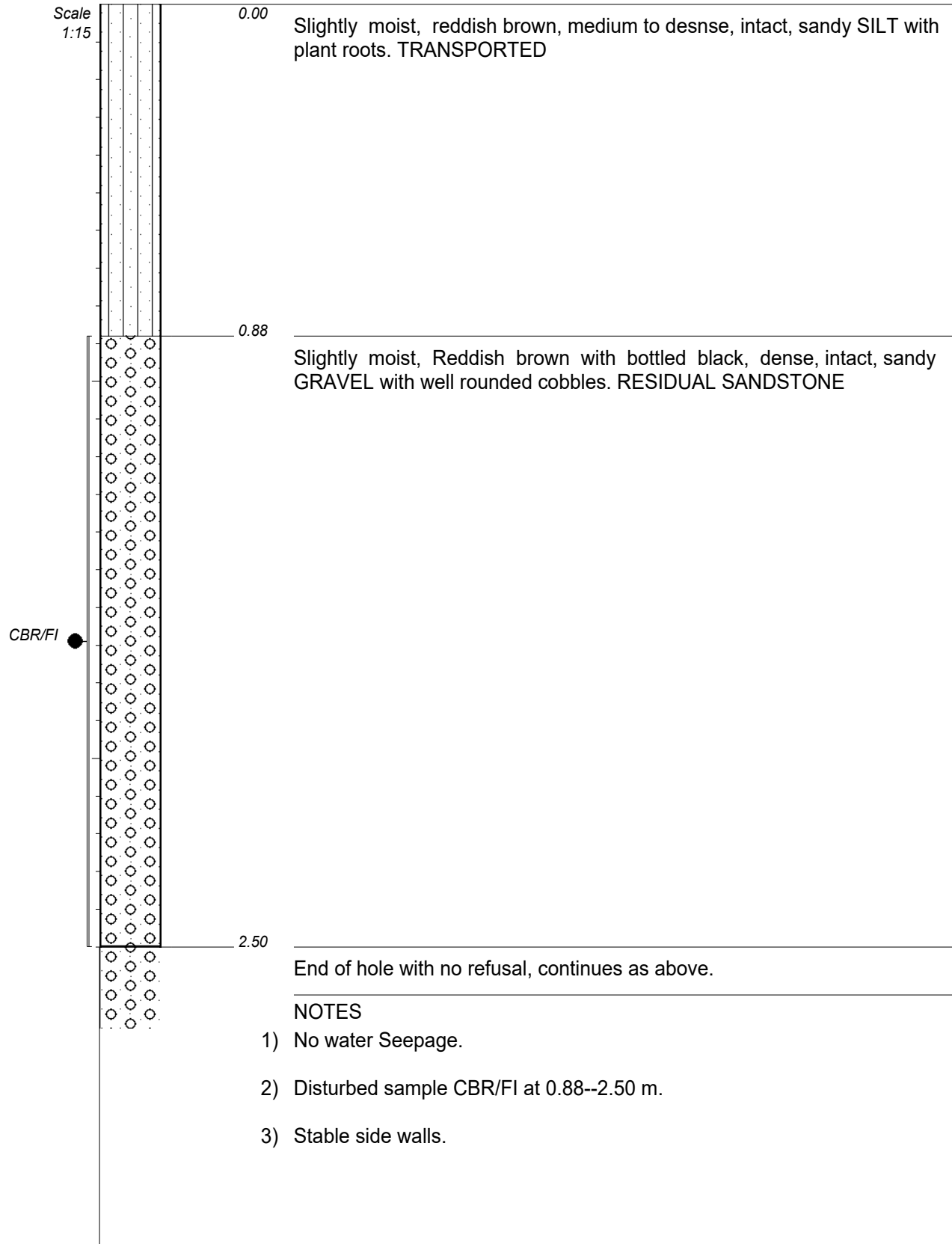
Scale  
1:15



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

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
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ELEVATION :  
X-COORD : 29,41258  
Y-COORD : -24,458442

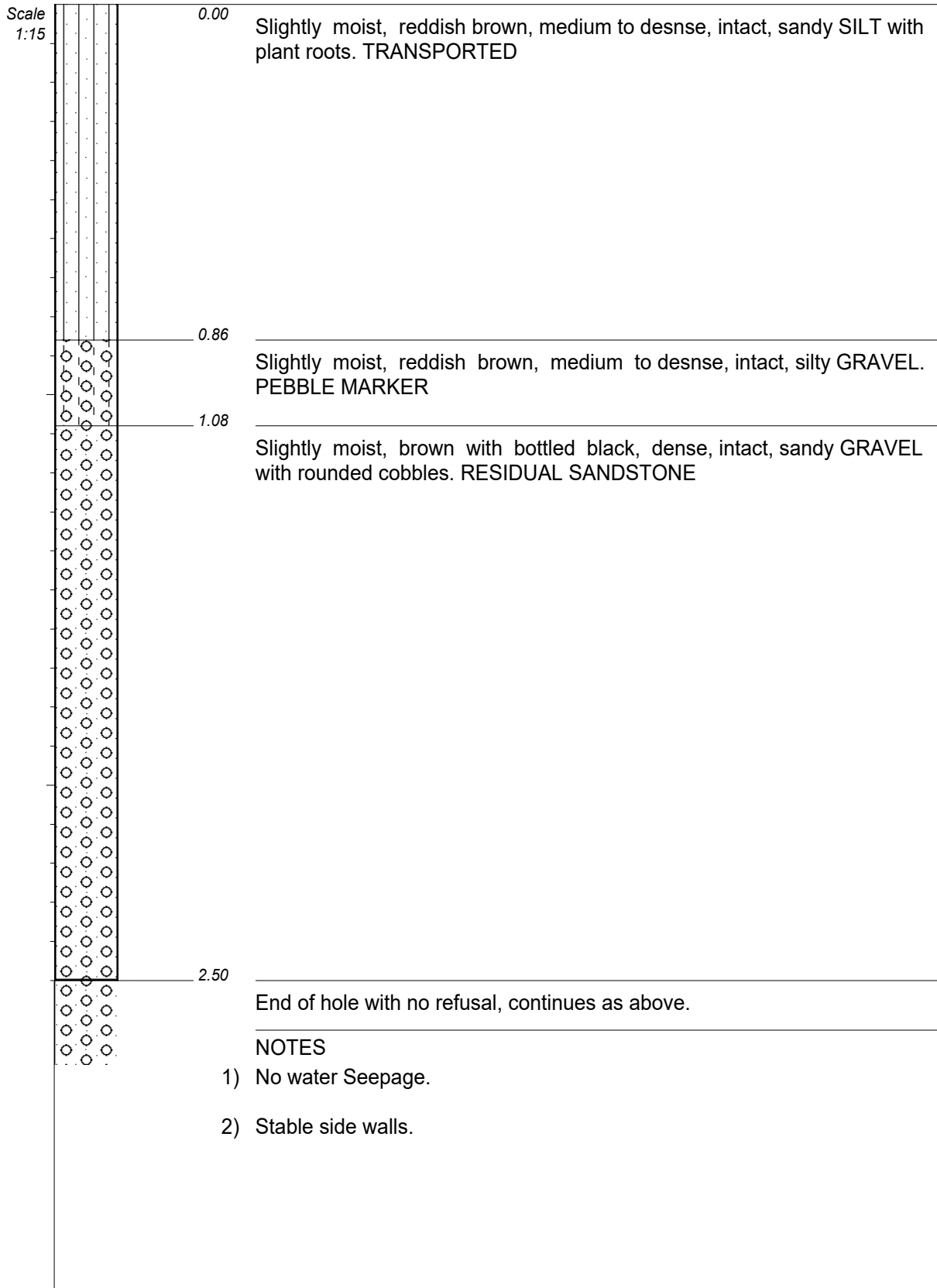


CONTRACTOR :  
MACHINE : TLB  
DRILLED BY :  
PROFILED BY : N. Ratshikhopha  
TYPE SET BY : N. Ratshikhopha  
SETUP FILE : STANDARD.SET

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
TEXT : ..ofile\ZBProfilesCopy.txt

ELEVATION :  
X-COORD : 29,4132472  
Y-COORD : -24,458164

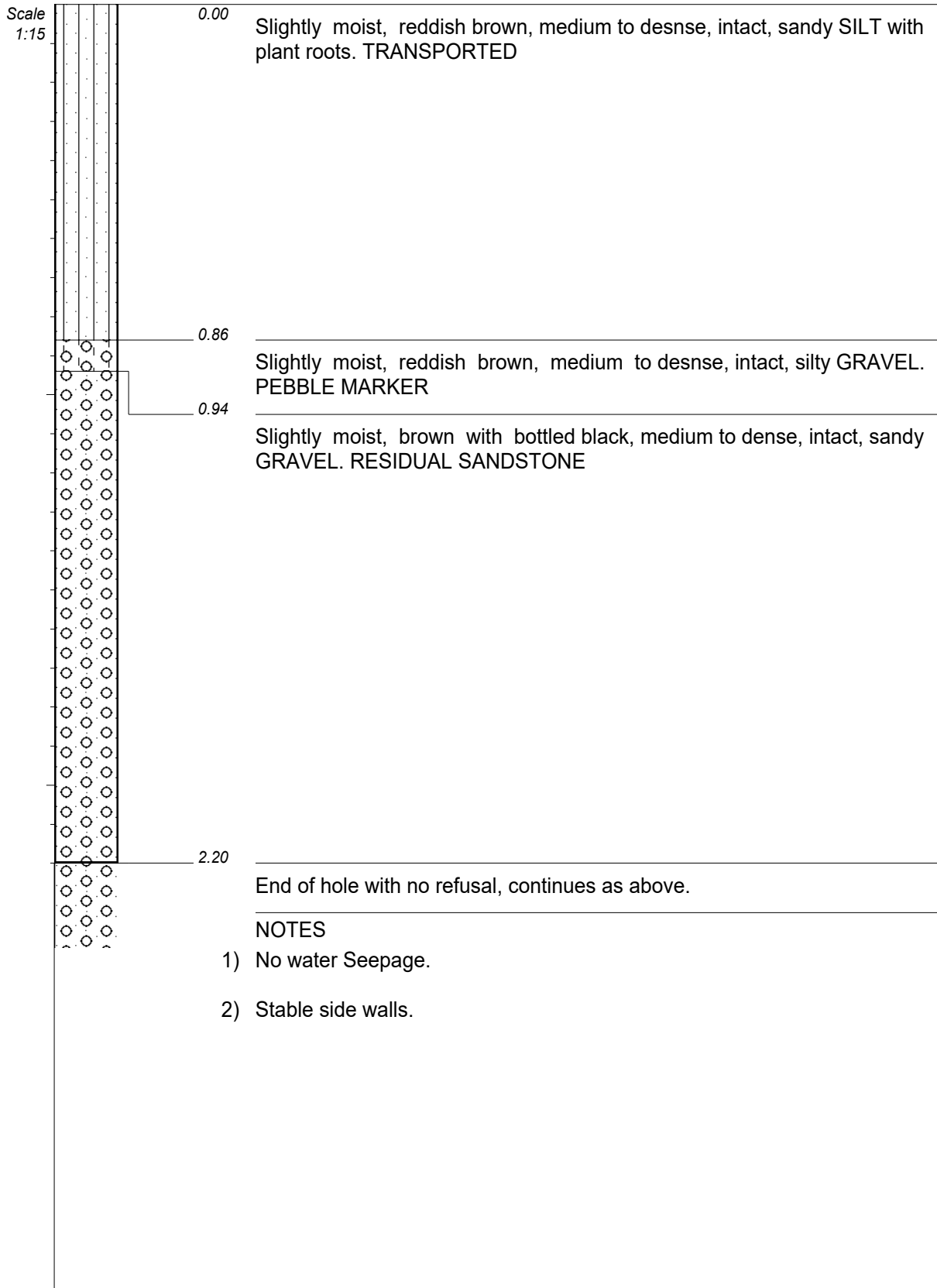
HOLE No: ZBM04



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

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
TEXT : ..ofile\ZBProfilesCopy.txt

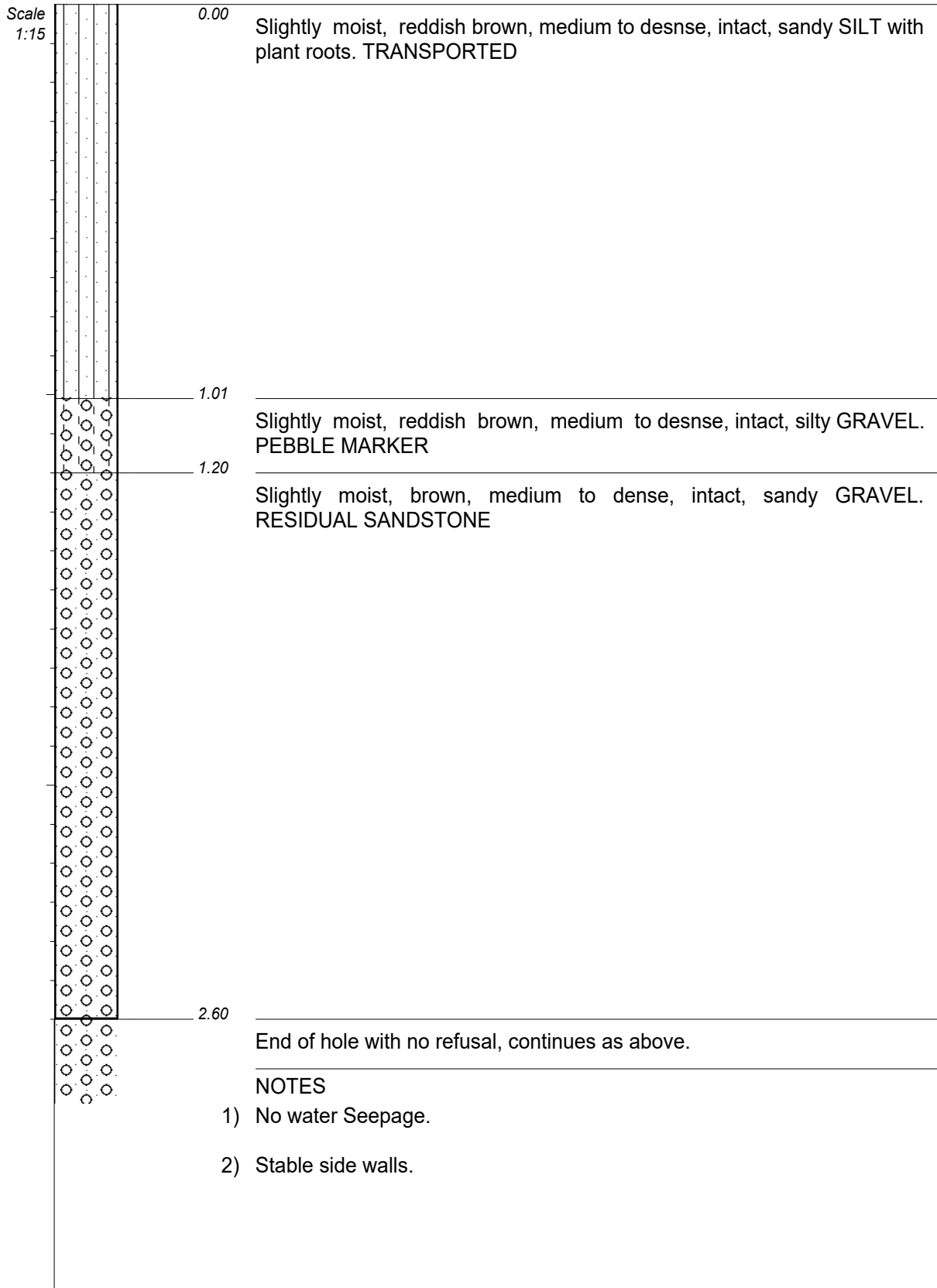
ELEVATION :  
X-COORD : 29,4136301  
Y-COORD : -24,4592438



CONTRACTOR :  
MACHINE : TLB  
DRILLED BY :  
PROFIED BY : N. Ratshikhopha  
TYPE SET BY : N. Ratshikhopha  
SETUP FILE : STANDARD.SET

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
TEXT : ..ofile\ZBProfilesCopy.txt

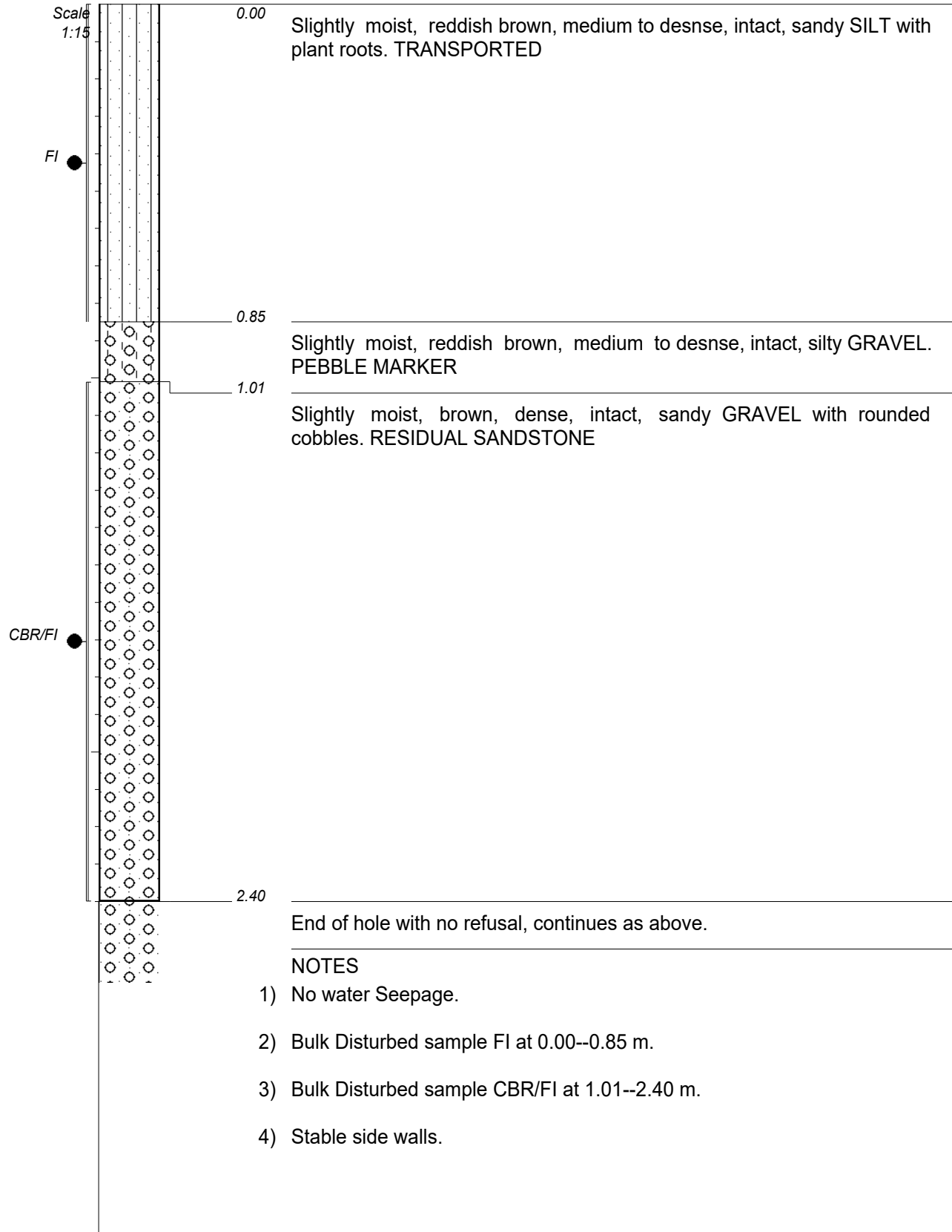
ELEVATION :  
X-COORD : 29,414081  
Y-COORD : -24,460023



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

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
TEXT : ..ofile\ZBProfilesCopy.txt

ELEVATION :  
X-COORD : 29,414565  
Y-COORD : -24,459817

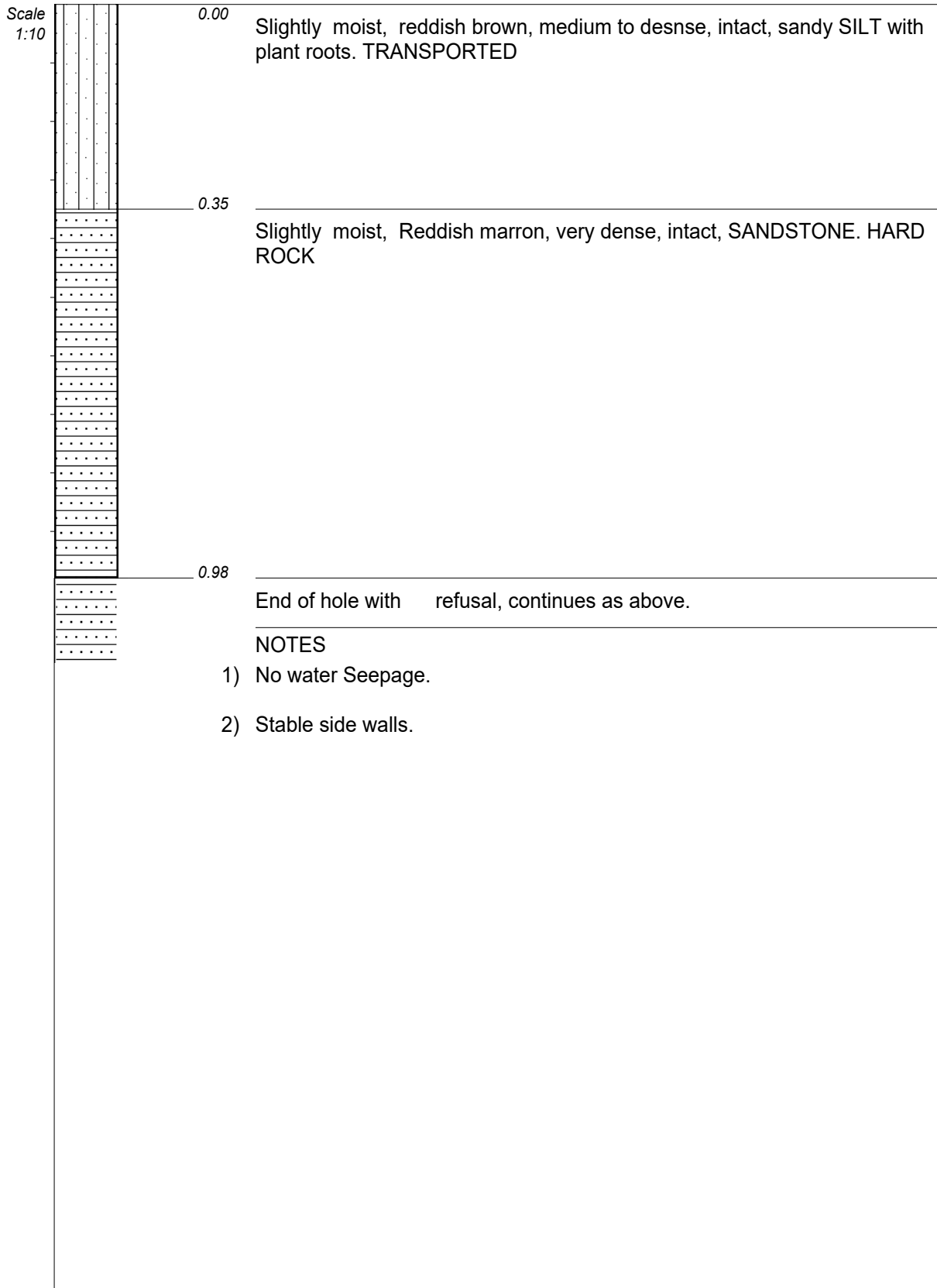


CONTRACTOR :  
MACHINE : TLB  
DRILLED BY :  
PROFILED BY : N. Ratshikhopha  
TYPE SET BY : N. Ratshikhopha  
SETUP FILE : STANDARD.SET

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
TEXT : ..ofile\ZBProfilesCopy.txt

ELEVATION :  
X-COORD : 29,4136301  
Y-COORD : -24,4592438





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

INCLINATION :  
DIAM : 0,7m trench  
DATE :  
DATE : 27/06/2019  
DATE : 11/07/2019 12:21  
TEXT : ..ofile\ZBProfilesCopy.txt

ELEVATION :  
X-COORD : 29,4132472  
Y-COORD : -24,458164

**Appendix C: Laboratory Test Results**



|                      |                            |                           |                         |
|----------------------|----------------------------|---------------------------|-------------------------|
| <b>Client</b> :      | NKHOPHELE HOLDINGS (COO)   | <b>Client Reference</b> : |                         |
| <b>Address</b> :     | UNIT 3, OXFORD OFFICE PARK | <b>Order No.</b> :        | Ndivhuwo                |
|                      | 3 BAUHINIA STREET          |                           |                         |
|                      | HIGHVELD TECHNO PARK       |                           |                         |
| <b>Attention</b> :   |                            | <b>Date Received</b> :    | 01/07/2019              |
| <b>Facsimile</b> :   | 086 565 5359               | <b>Date Tested</b> :      | 01/07/2019 - 22/07/2019 |
| <b>E-mail</b> :      | ndivhuwo@nkhopheleh.co.za  | <b>Date Reported</b> :    | 01/08/2019              |
| <b>Project</b> :     | Zebedial Geotech           | <b>Report Status</b> :    | Final                   |
| <b>Project No.</b> : | 2019-B-968                 | <b>Page</b> :             | 1 of 10                 |

Herewith please find the test report(s) pertaining to the above project. All tests were conducted in accordance with prescribed test method(s). Information herein consists of the following:

| Test(s) conducted / Item(s) measured | Qty.  | Test Method(s) | Authorized By**     | Page(s)   |
|--------------------------------------|-------|----------------|---------------------|-----------|
| Moisture Density Relationship        | 4.000 | SANS 3001 GR30 | S Pullen            | 5-8       |
| Atterberg Limits <0.425mm            | 6.000 | SANS 3001 GR10 | S Pullen/C Petersen | 2-4, 9-10 |
| Sieve Analysis 0.075mm               | 6.000 | SANS 3001 GR1  | S Pullen/B Mvubu    | 2-4, 9-10 |
| California Bearing Ratio (CBR)       | 4.000 | SANS 3001 GR40 | S Pullen            | 9-10      |
| Hydrometer Analysis                  | 6.000 | SANS 3001 GR3  | S Pullen/B Mvubu    | 2-4       |

Any test results contained in this report and marked with \* in the table above are "not SANAS accredited" and are not included in the schedule of accreditation for this laboratory.

Any information contained in this test report pertain only to the areas and/or samples tested. Documents may only be reproduced or published in their full context.

While every care is taken to ensure that all tests are carried out in accordance with recognised standards, neither Civilab (Proprietary) Limited nor its employess shall be liable in any way whatsoever for any error made in the execution or reporting of tests or any erroneous conclusions drawn therefrom or for any consequences thereof.

All interpretations, Interpolations, Opinions and/or Classifications contained in this report falls outside our scope of accreditation.



The following parameters, where applicable, were excluded from the classification procedure: Chemical modifications, Additional fines, Fractured Faces, Soluble Salts, pH, Conductivity, Coarse Sand Ratio, Durability (COLTO: G4-G9).

The following parameters, where applicable, were assumed: Rock types were assumed to be of an Arenaceous nature with Siliceous cementing material.

Unless otherwise requested or stated, all samples will be discarded after a period of 3 months.

This report is completely confidential between the parties (Civilab and Civilab's client) and shall not be disclosed to anybody else, unless agreed upon in writing or made publicly available by the client or required to make available by law.

Deviations in Test Methods:

|                      |   |
|----------------------|---|
| Technical Signatory: |  |
| Signature:           |  |

\*\*All results are authorized electronically by approved managers and/or technical signatories.

**Client** : NKHOPHELE HOLDINGS (COO)  
**Address** : UNIT 3, OXFORD OFFICE PARK  
 : 3 BAUHINIA STREET  
 : HIGHVELD TECHNO PARK

**Client Reference** :  
**Order No.** : Ndivhuwo

**Attention** :  
**Facsimile** : 086 565 5359  
**E-mail** : ndivhuwo@nkhopheleh.co.za

**Date Received** : 01/07/2019  
**Date Tested** : 01/07/2019 - 22/07/2019  
**Date Reported** : 01/08/2019

**Project** : Zebedial Geotech  
**Project No.** : 2019-B-968

**Report Status** : Final  
**Page** : 1 of 10

Herewith please find the test report(s) pertaining to the above project. All tests were conducted in accordance with prescribed test method(s). Information herein consists of the following:

| Test(s) conducted / Item(s) measured | Qty.  | Test Method(s) | Authorized By**     | Page(s)   |
|--------------------------------------|-------|----------------|---------------------|-----------|
| Moisture Density Relationship        | 4.000 | SANS 3001 GR30 | S Pullen            | 5-8       |
| Atterberg Limits <0.425mm            | 6.000 | SANS 3001 GR10 | S Pullen/C Petersen | 2-4, 9-10 |
| Sieve Analysis 0.075mm               | 6.000 | SANS 3001 GR1  | S Pullen/B Mvubu    | 2-4, 9-10 |
| California Bearing Ratio (CBR)       | 4.000 | SANS 3001 GR40 | S Pullen            | 9-10      |
| Hydrometer Analysis                  | 6.000 | SANS 3001 GR3  | S Pullen/B Mvubu    | 2-4       |
|                                      |       |                |                     |           |
|                                      |       |                |                     |           |
|                                      |       |                |                     |           |
|                                      |       |                |                     |           |

Any test results contained in this report and marked with \* in the table above are "not SANAS accredited" and are not included in the schedule of accreditation for this laboratory.

Any information contained in this test report pertain only to the areas and/or samples tested. Documents may only be reproduced or published in their full context.

While every care is taken to ensure that all tests are carried out in accordance with recognised standards, neither Civilab (Proprietary) Limited nor its employess shall be liable in any way whatsoever for any error made in the execution or reporting of tests or any erroneous conclusions drawn therefrom or for any consequences thereof.

All interpretations, Interpolations, Opinions and/or Classifications contained in this report falls outside our scope of accreditation.

The following parameters, where applicable, were excluded from the classification procedure: Chemical modifications, Additional fines, Fractured Faces, Soluble Salts, pH, Conductivity, Coarse Sand Ratio, Durability (COLTO: G4-G9).

The following parameters, where applicable, were assumed: Rock types were assumed to be of an Arenaceous nature with Siliceous cementing material.

Unless otherwise requested or stated, all samples will be discarded after a period of 3 months.

This report is completely confidential between the parties (Civilab and Civilab's client) and shall not be disclosed to anybody else, unless agreed upon in writing or made publicly available by the client or required to make available by law.

Deviations in Test Methods:

|                      |  |
|----------------------|--|
| Technical Signatory: |  |
| Signature:           |  |

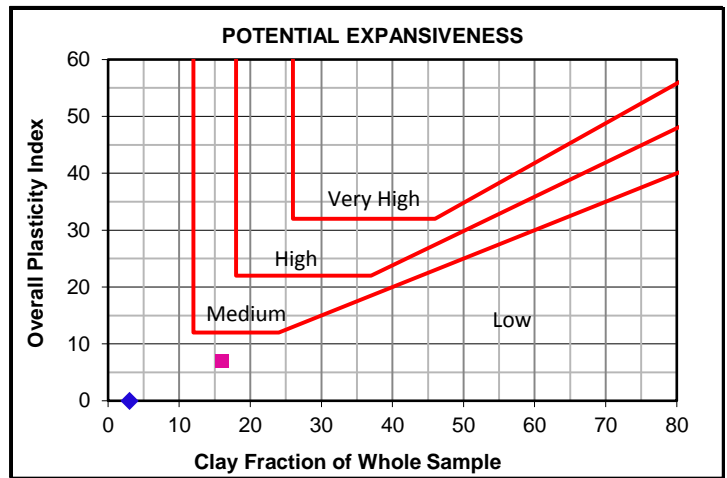
\*\*All results are authorized electronically by approved managers and/or technical signatories.

Client : NKHOPHELE HOLDINGS (COO)  
 Project : Zebedial Geotech  
 Project No : 2019-B-968

Date Received: 01/07/2019  
 Date Reported: 01/08/2019  
 Page No. : 2 of 10

## FOUNDATION INDICATOR

|                                      |                                     |  |
|--------------------------------------|-------------------------------------|--|
| Laboratory Number                    | 1 <span style="color:blue">◆</span> | 2 <span style="color:magenta">■</span> |
| Field Number                         | ZBM01                               | ZBM01                                  |
| Client Reference                     |                                     |  |
| Depth (m)                            | 1.0-1.27                            | 0.00-1.73                              |
| Position                             |                                     |  |
| Coordinates                          | X                                   |  |
|                                      | Y                                   |  |
| Description                          |                                     |  |
| Additional Information               |                                     |  |
| Calcrete / Crushed Stabilizing Agent |                                     |  |

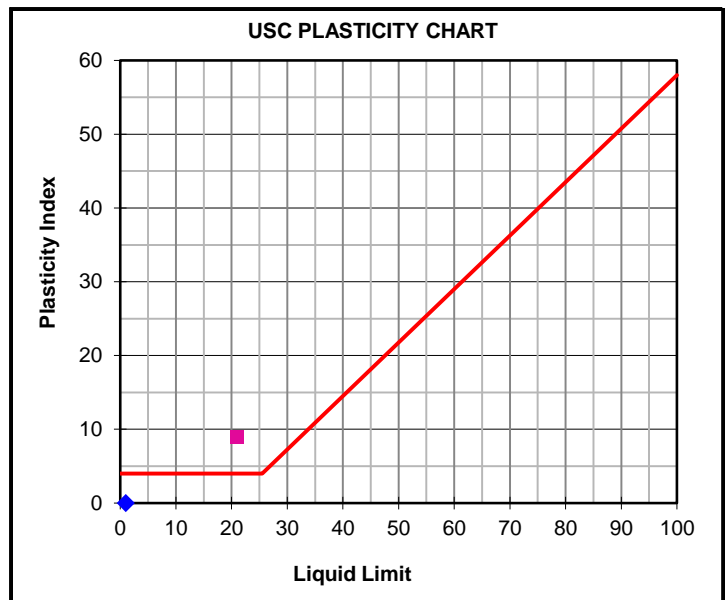


**Moisture Content & Relative Density SANS 3001 GR30**

|                         |  |  |
|-------------------------|--|--|
| Moisture Content (%)    |  |  |
| Relative Density (S.G.) |  |  |

**Sieve Analysis (Wet Prep) SANS 3001 GR1**

| Percentage Passing | 100 mm | 75 mm | 63 mm | 50 mm | 37.5 mm | 28 mm | 20 mm | 14 mm | 5 mm | 2 mm | 1 mm | 0.425 mm | 0.250 mm | 0.150 mm | 0.075 mm | Grading Modulus |
|--------------------|--------|-------|-------|-------|---------|-------|-------|-------|------|------|------|----------|----------|----------|----------|-----------------|
|                    | 100    | 100   | 100   | 100   | 94      | 89    | 81    | 71    | 61   | 54   | 46   | 34       | 30       | 23       | 14       | 1.98            |
|                    | 100    | 100   | 100   | 100   | 100     | 100   | 100   | 100   | 99   | 95   | 90   | 82       | 74       | 54       | 34       | 0.89            |



**Hydrometer Analysis SANS 3001 GR3**

| Percentage Passing | 0.060 mm | 0.040 mm | 0.020 mm | 0.006 mm | 0.002 mm | Gravel | Sand | Silt | Clay |
|--------------------|----------|----------|----------|----------|----------|--------|------|------|------|
|                    | 10       | 7        | 6        | 4        | 3        | 46     | 44   | 7    | 3    |
|                    | 32       | 28       | 24       | 20       | 16       | 5      | 63   | 16   | 16   |

**Laboratory Number 1 ◆ 2 ■**

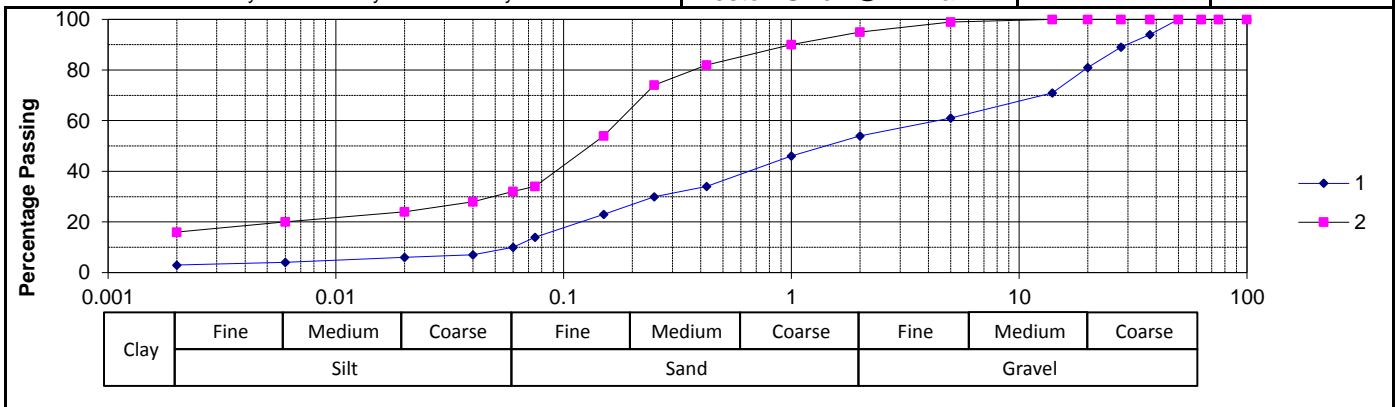
**Atterberg Limits -425µ SANS 3001 GR10**

|                  |   |    |     |
|------------------|---|----|-----|
| Liquid Limit     | % |    | 21  |
| Plasticity Index | % | NP | 9   |
| Linear Shrinkage | % |    | 4.0 |
| Overall PI       | % |    | 7   |

**Classifications**

|                      |          |          |
|----------------------|----------|----------|
| HRB (AASHTO)         | A-1-b(0) | A-2-4(0) |
| Unified (ASTM D2487) | SM       | SC       |
| Weston Swell @ 1 kPa |          |          |

Note: An assumed S.G. may be used in Hydrometer Analysis calculations

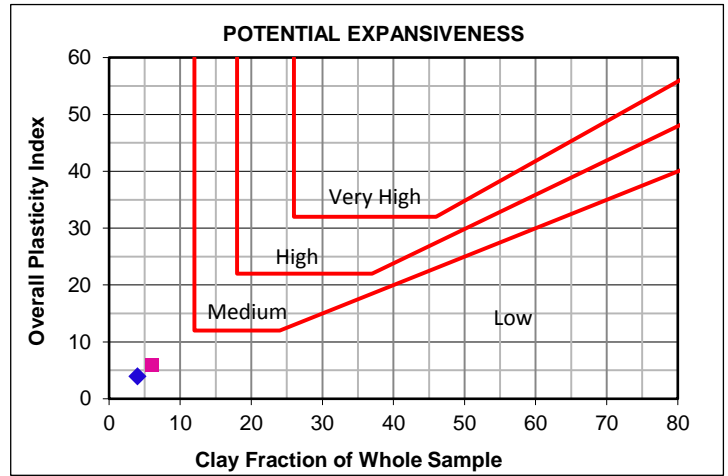


Client : NKHOPHELE HOLDINGS (COO)  
 Project : Zebedial Geotech  
 Project No : 2019-B-968

Date Received: 01/07/2019  
 Date Reported: 01/08/2019  
 Page No. : 3 of 10

## FOUNDATION INDICATOR

|                                      |           |           |
|--------------------------------------|-----------|-----------|
| Laboratory Number                    | 3         | 4         |
| Field Number                         | ZBM02     | ZBM04     |
| Client Reference                     |           |           |
| Depth (m)                            | 1.02-1.60 | 0.88-2.50 |
| Position                             |           |           |
| Coordinates                          | X<br>Y    |           |
| Description                          |           |           |
| Additional Information               |           |           |
| Calcrete / Crushed Stabilizing Agent |           |           |

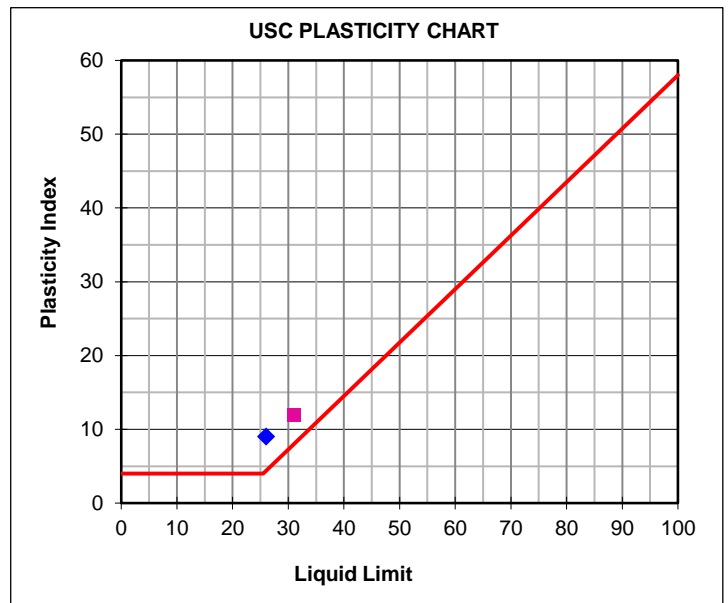


### Moisture Content & Relative Density

|                         |  |  |
|-------------------------|--|--|
| Moisture Content (%)    |  |  |
| Relative Density (S.G.) |  |  |

### Sieve Analysis (Wet Prep) SANS 3001 GR1

|                    |          |      |     |
|--------------------|----------|------|-----|
| Percentage Passing | 100 mm   | 100  | 100 |
|                    | 75 mm    | 100  | 100 |
|                    | 63 mm    | 100  | 100 |
|                    | 50 mm    | 100  | 100 |
|                    | 37.5 mm  | 100  | 100 |
|                    | 28 mm    | 100  | 100 |
|                    | 20 mm    | 100  | 100 |
|                    | 14 mm    | 95   | 96  |
|                    | 5 mm     | 81   | 86  |
|                    | 2 mm     | 66   | 74  |
|                    | 1 mm     | 57   | 64  |
|                    | 0.425 mm | 48   | 52  |
|                    | 0.250 mm | 43   | 45  |
|                    | 0.150 mm | 34   | 34  |
| 0.075 mm           | 23       | 22   |     |
| Grading Modulus    | 1.63     | 1.52 |     |



### Hydrometer Analysis SANS 3001 GR3

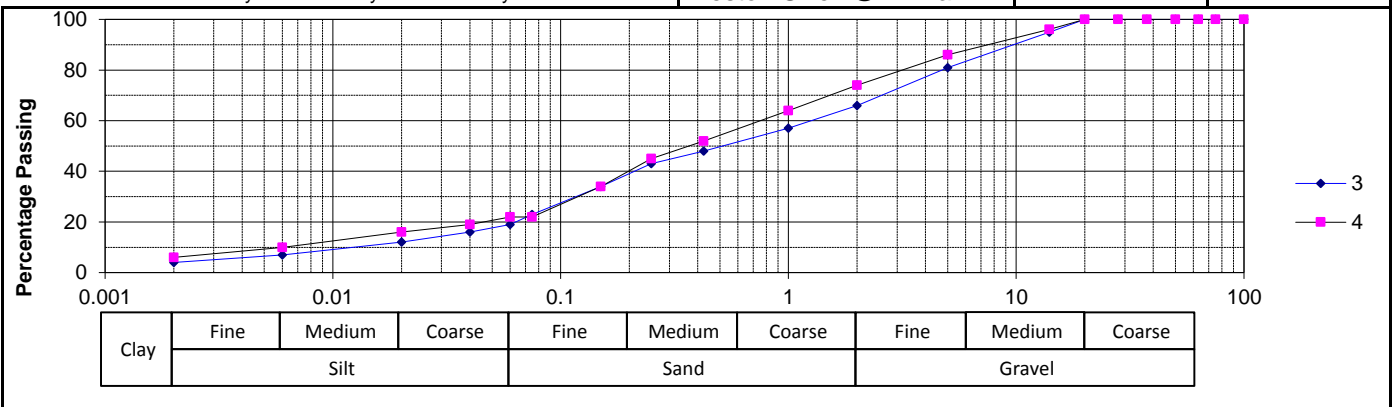
|                    |          |    |    |
|--------------------|----------|----|----|
| Percentage Passing | 0.060 mm | 19 | 22 |
|                    | 0.040 mm | 16 | 19 |
|                    | 0.020 mm | 12 | 16 |
|                    | 0.006 mm | 7  | 10 |
|                    | 0.002 mm | 4  | 6  |
| Gravel             | %        | 34 | 26 |
| Sand               | %        | 47 | 52 |
| Silt               | %        | 15 | 16 |
| Clay               | %        | 4  | 6  |

|                                       |   |     |     |
|---------------------------------------|---|-----|-----|
| Laboratory Number                     | 3 | 4   |     |
| Atterberg Limits -425µ SANS 3001 GR10 |   |     |     |
| Liquid Limit                          | % | 26  | 31  |
| Plasticity Index                      | % | 9   | 12  |
| Linear Shrinkage                      | % | 4.5 | 5.5 |
| Overall PI                            | % | 4   | 6   |

### Classifications

|                      |          |          |
|----------------------|----------|----------|
| HRB (AASHTO)         | A-2-4(0) | A-2-6(0) |
| Unified (ASTM D2487) | SC       | SC       |
| Weston Swell @ 1 kPa |          |          |

Note: An assumed S.G. may be used in Hydrometer Analysis calculations

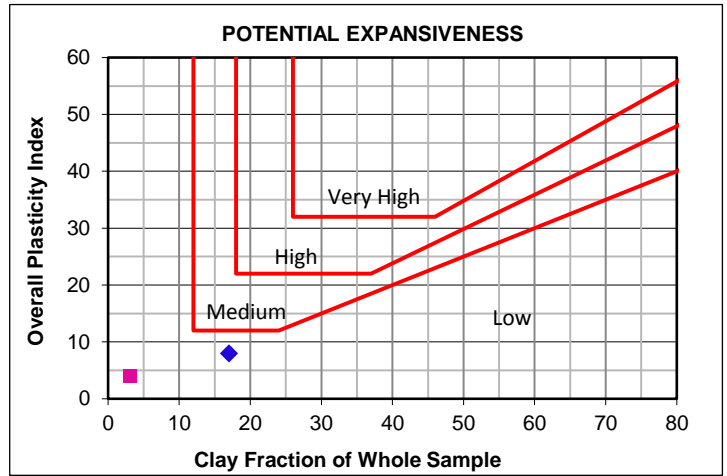


Client : NKHOPHELE HOLDINGS (COO)  
 Project : Zebedial Geotech  
 Project No : 2019-B-968

Date Received: 01/07/2019  
 Date Reported: 01/08/2019  
 Page No. : 4 of 10

## FOUNDATION INDICATOR

|                                      |                                     |  |
|--------------------------------------|-------------------------------------|--|
| Laboratory Number                    | 5 <span style="color:blue">◆</span> | 6 <span style="color:magenta">■</span> |
| Field Number                         | ZBM08                               | ZBM08                                  |
| Client Reference                     |                                     |  |
| Depth (m)                            | 0.00-0.85                           | 1.01-2.40                              |
| Position                             |                                     |  |
| Coordinates                          | X                                   |  |
|                                      | Y                                   |  |
| Description                          |                                     |  |
| Additional Information               |                                     |  |
| Calcrete / Crushed Stabilizing Agent |                                     |  |

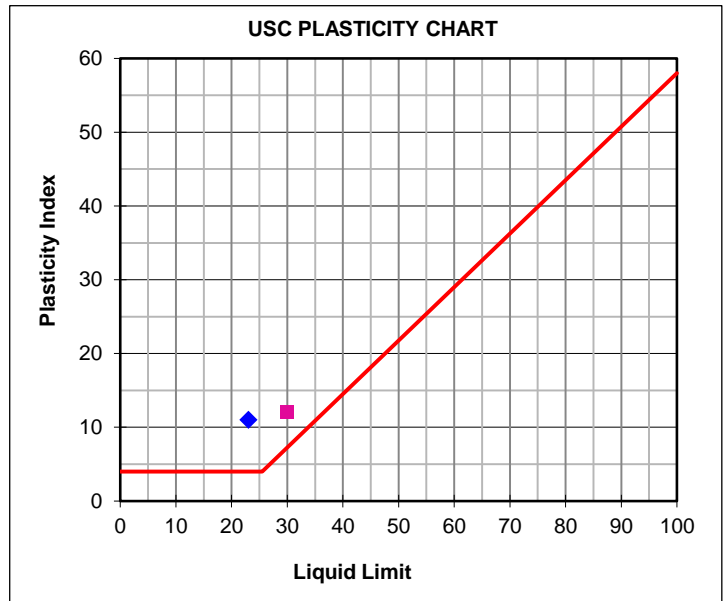


### Moisture Content & Relative Density

|                         |  |  |
|-------------------------|--|--|
| Moisture Content (%)    |  |  |
| Relative Density (S.G.) |  |  |

### Sieve Analysis (Wet Prep) SANS 3001 GR1

| Percentage Passing | 100 mm | 75 mm | 63 mm | 50 mm | 37.5 mm | 28 mm | 20 mm | 14 mm | 5 mm | 2 mm | 1 mm | 0.425 mm | 0.250 mm | 0.150 mm | 0.075 mm | Grading Modulus |
|--------------------|--------|-------|-------|-------|---------|-------|-------|-------|------|------|------|----------|----------|----------|----------|-----------------|
|                    | 100    | 100   | 100   | 100   | 100     | 100   | 100   | 100   | 100  | 98   | 88   | 72       | 62       | 45       | 31       | 0.99            |
|                    | 100    | 100   | 100   | 100   | 91      | 88    | 79    | 70    | 49   | 40   | 37   | 34       | 30       | 24       | 15       | 2.11            |



### Hydrometer Analysis SANS 3001 GR3

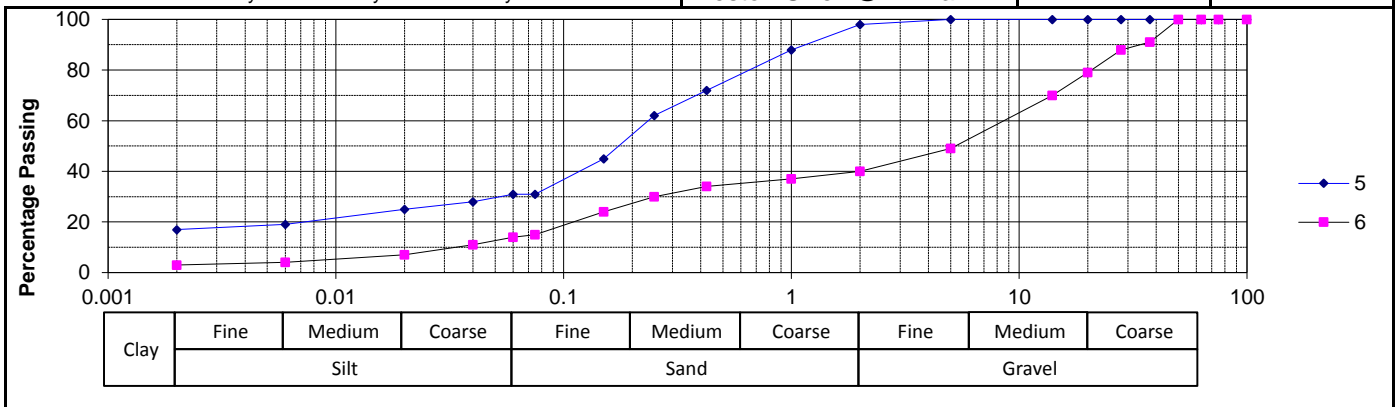
| Percentage Passing | 0.060 mm | 0.040 mm | 0.020 mm | 0.006 mm | 0.002 mm | Gravel | Sand | Silt | Clay |
|--------------------|----------|----------|----------|----------|----------|--------|------|------|------|
|                    | 31       | 28       | 25       | 19       | 17       | 2      | 67   | 14   | 17   |
|                    | 14       | 11       | 7        | 4        | 3        | 60     | 26   | 11   | 3    |

|  |                                     |  |     |
|--|-------------------------------------|--|-----|
| Laboratory Number                            | 5 <span style="color:blue">◆</span> | 6 <span style="color:magenta">■</span> |     |
| <b>Atterberg Limits -425µ SANS 3001 GR10</b> |                                     |  |     |
| Liquid Limit                                 | %                                   | 23                                     | 30  |
| Plasticity Index                             | %                                   | 11                                     | 12  |
| Linear Shrinkage                             | %                                   | 5.5                                    | 5.5 |
| Overall PI                                   | %                                   | 8                                      | 4   |

### Classifications

|                      |          |          |
|----------------------|----------|----------|
| HRB (AASHTO)         | A-2-6(0) | A-2-6(0) |
| Unified (ASTM D2487) | SC       | GC       |
| Weston Swell @ 1 kPa |          |          |

Note: An assumed S.G. may be used in Hydrometer Analysis calculations





## MOISTURE DENSITY RELATIONSHIP

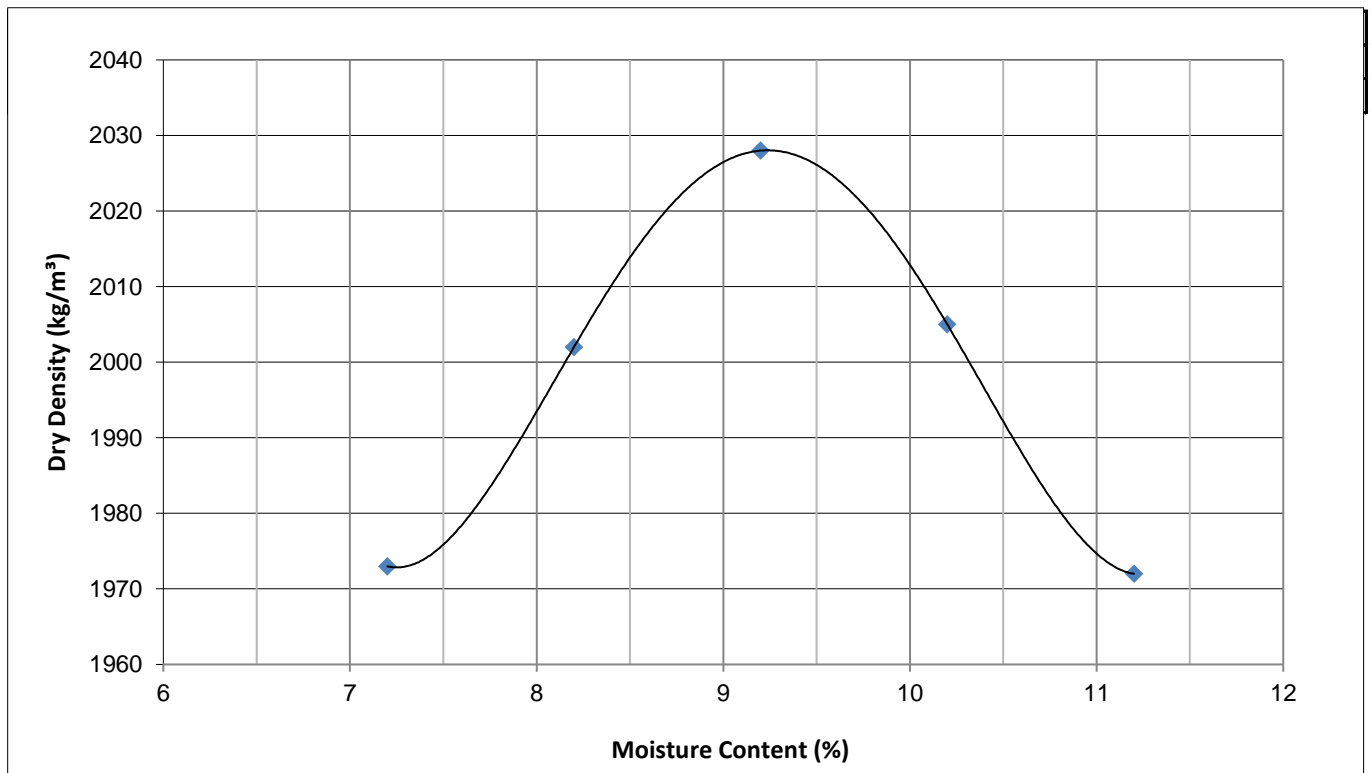
|                        |          |
|------------------------|----------|
| Laboratory Number      | 1        |
| Field Number           | ZBM01    |
| Client Reference       |          |
| Depth (m)              | 1.0-1.27 |
| Position               |          |
| Coordinates            | X        |
|                        | Y        |
| Description            |          |
| Additional Information |          |
| Calcrete / Crushed     |          |
| Stabilizing Agent      |          |

### Maximum Dry Density & Optimum Moisture Content - SANS 3001 GR30

|                    |                 |
|--------------------|-----------------|
| Compactive Effort: | Modified AASHTO |
|--------------------|-----------------|

|                  |                   |      |      |      |      |      |  |
|------------------|-------------------|------|------|------|------|------|--|
| Dry Density      | kg/m <sup>3</sup> | 1973 | 2002 | 2028 | 2005 | 1972 |  |
| Moisture Content | %                 | 7.2  | 8.2  | 9.2  | 10.2 | 11.2 |  |

|                  |                   |      |
|------------------|-------------------|------|
| Max. Dry Density | kg/m <sup>3</sup> | 2028 |
| Optimum Moisture | %                 | 9.2  |





## MOISTURE DENSITY RELATIONSHIP

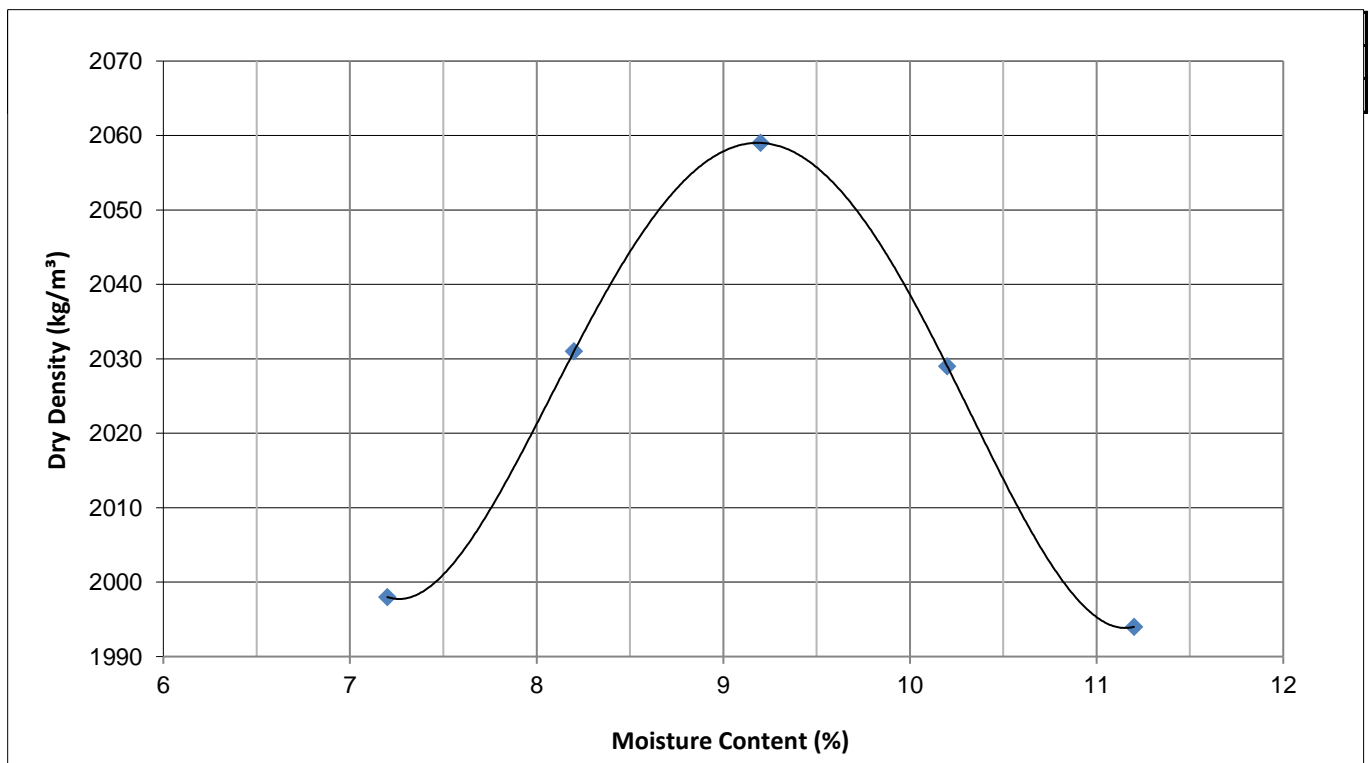
|                                      |           |
|--------------------------------------|-----------|
| Laboratory Number                    | 2         |
| Field Number                         | ZBM01     |
| Client Reference                     |           |
| Depth (m)                            | 0.00-1.73 |
| Position                             |           |
| Coordinates                          | X         |
|                                      | Y         |
| Description                          |           |
| Additional Information               |           |
| Calcrete / Crushed Stabilizing Agent |           |

### Maximum Dry Density & Optimum Moisture Content - SANS 3001 GR30

|                    |                 |
|--------------------|-----------------|
| Compactive Effort: | Modified AASHTO |
|--------------------|-----------------|

|                  |                   |      |      |      |      |      |  |
|------------------|-------------------|------|------|------|------|------|--|
| Dry Density      | kg/m <sup>3</sup> | 1998 | 2031 | 2059 | 2029 | 1994 |  |
| Moisture Content | %                 | 7.2  | 8.2  | 9.2  | 10.2 | 11.2 |  |

|                  |                   |      |
|------------------|-------------------|------|
| Max. Dry Density | kg/m <sup>3</sup> | 2059 |
| Optimum Moisture | %                 | 9.2  |





## MOISTURE DENSITY RELATIONSHIP

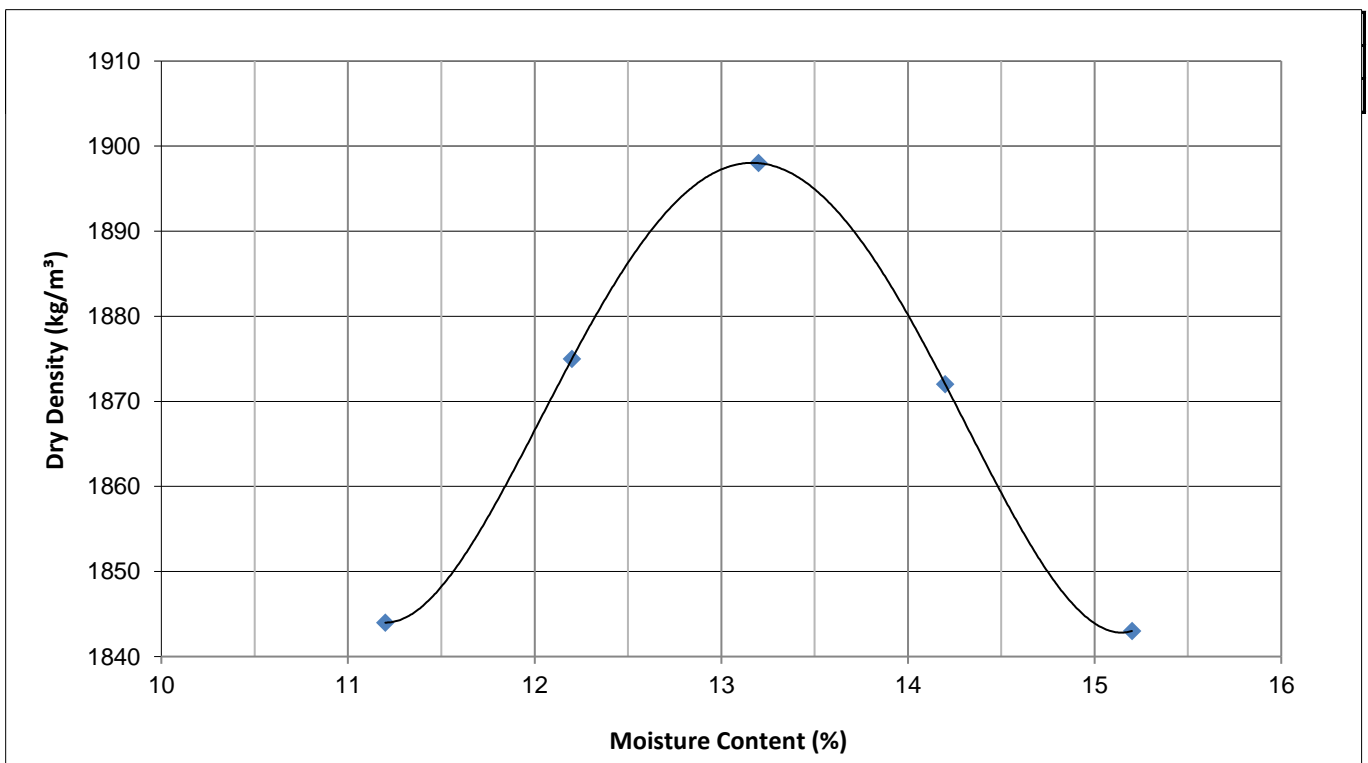
|                                      |           |
|--------------------------------------|-----------|
| Laboratory Number                    | 4         |
| Field Number                         | ZBM04     |
| Client Reference                     |           |
| Depth (m)                            | 0.88-2.50 |
| Position                             |           |
| Coordinates                          | X         |
|                                      | Y         |
| Description                          |           |
| Additional Information               |           |
| Calcrete / Crushed Stabilizing Agent |           |

### Maximum Dry Density & Optimum Moisture Content - SANS 3001 GR30

|                    |                 |
|--------------------|-----------------|
| Compactive Effort: | Modified AASHTO |
|--------------------|-----------------|

|                  |                   |      |      |      |      |      |  |
|------------------|-------------------|------|------|------|------|------|--|
| Dry Density      | kg/m <sup>3</sup> | 1844 | 1875 | 1898 | 1872 | 1843 |  |
| Moisture Content | %                 | 11.2 | 12.2 | 13.2 | 14.2 | 15.2 |  |

|                  |                   |      |
|------------------|-------------------|------|
| Max. Dry Density | kg/m <sup>3</sup> | 1898 |
| Optimum Moisture | %                 | 13.2 |





## MOISTURE DENSITY RELATIONSHIP

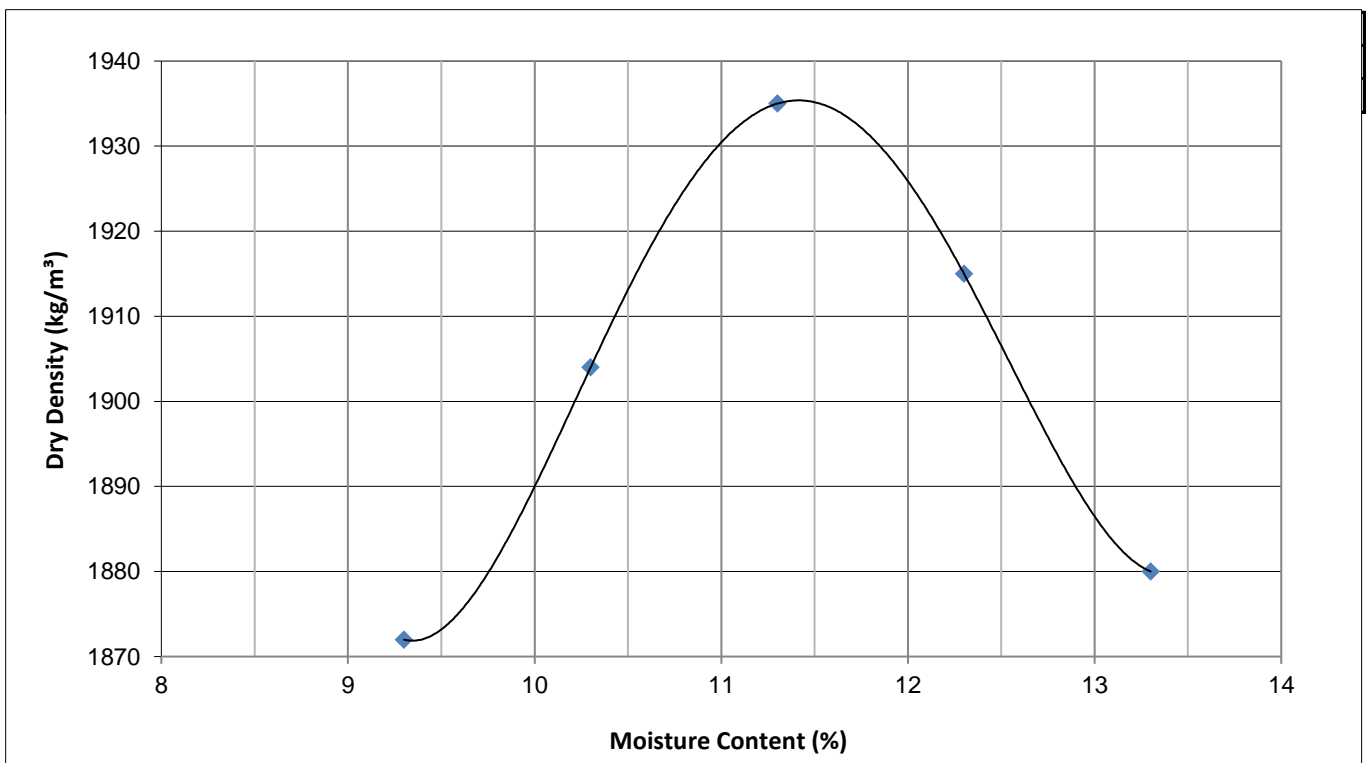
|   |           |
|---|-----------|
| Laboratory Number                       | 6         |
| Field Number                            | ZBM08     |
| Client Reference                        |           |
| Depth (m)                               | 1.01-2.40 |
| Position                                |           |
| Coordinates                             | X<br>Y    |
| Description                             |           |
| Additional Information                  |           |
| Calcrete / Crushed<br>Stabilizing Agent |           |

### Maximum Dry Density & Optimum Moisture Content - SANS 3001 GR30

|                    |                 |
|--------------------|-----------------|
| Compactive Effort: | Modified AASHTO |
|--------------------|-----------------|

|                  |                   |      |      |      |      |      |  |
|------------------|-------------------|------|------|------|------|------|--|
| Dry Density      | kg/m <sup>3</sup> | 1872 | 1904 | 1935 | 1915 | 1880 |  |
| Moisture Content | %                 | 9.3  | 10.3 | 11.3 | 12.3 | 13.3 |  |

|                  |                   |      |
|------------------|-------------------|------|
| Max. Dry Density | kg/m <sup>3</sup> | 1935 |
| Optimum Moisture | %                 | 11.4 |



## CALIFORNIA BEARING RATIO (CBR) & ROAD INDICATOR REPORT

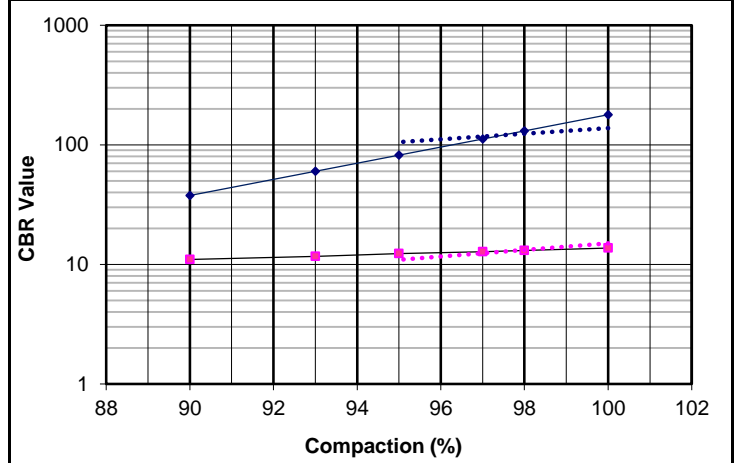
|                        |          |           |
|------------------------|----------|-----------|
| Laboratory No.         | 1        | 2         |
| Field Number           | ZBM01    | ZBM01     |
| Client Reference       |          |           |
| Depth (m)              | 1.0-1.27 | 0.00-1.73 |
| Position               |          |           |
| Coordinates            | X        |           |
|                        | Y        |           |
| Description            |          |           |
| Additional information |          |           |
| Calcrete/Crushed       |          |           |
| Stabilizing Agent      |          |           |

|   |                   |                       |
|---|-------------------|-----------------------|
| Laboratory No.  | 1                 | 2                     |
| <b>Maximum Dry Density &amp; Optimum Moisture Content</b> |                   | <b>SANS 3001 GR30</b> |
| MDD   | kg/m <sup>3</sup> | 2028                  |
| OMC   | %                 | 9.2                   |
|   |                   | 2059                  |
|   |                   | 9.2                   |

|                                 |                   |                       |      |      |       |      |
|---------------------------------|-------------------|-----------------------|------|------|-------|------|
| <b>California Bearing Ratio</b> |                   | <b>SANS 3001 GR40</b> |      |      |       |      |
| Compaction Data                 |                   |                       |      |      |       |      |
| Moisture                        | %                 | 9.3                   |      |      | 9.3   |      |
| Dry Density                     | kg/m <sup>3</sup> | 2026                  | 1926 | 1826 | 2064  | 1963 |
| Compaction                      | %                 | 100.0                 | 95.1 | 90.1 | 100.0 | 95.1 |

|                    |         |      |     |      |      |      |
|--------------------|---------|------|-----|------|------|------|
| Penetration Data   |         |      |     |      |      |      |
| CBR at             | 2.50 mm | 138  | 106 | 38   | 15   | 11   |
|                    | 5.00 mm | 171  | 118 | 43   | 16   | 12   |
|                    | 7.50 mm | 175  | 115 | 46   | 16   | 13   |
| Swell              | %       | 0    | 0   | 0.1  | 0.1  | 0.2  |
| Final Moisture (%) |         | 11.0 | 13  | 14.8 | 10.9 | 12.5 |

|   |          |                      |     |
|---|----------|----------------------|-----|
| <b>Sieve Analysis (Wet preparation)</b> |          | <b>SANS 3001 GR1</b> |     |
| Percentage Passing                      | 100 mm   | 100                  | 100 |
|   | 75 mm    | 100                  | 100 |
|   | 63 mm    | 100                  | 100 |
|   | 50 mm    | 100                  | 100 |
|   | 37.5 mm  | 94                   | 100 |
|   | 28 mm    | 89                   | 100 |
|   | 20 mm    | 81                   | 100 |
|   | 14 mm    | 71                   | 100 |
|   | 5 mm     | 61                   | 99  |
|   | 2 mm     | 54                   | 95  |
|   | 1 mm     | 46                   | 90  |
|   | 0.425 mm | 34                   | 82  |
|   | 0.250 mm | 30                   | 74  |
|   | 0.150 mm | 23                   | 54  |
| 0.075 mm                                | 14       | 34                   |     |
| Grading Modulus                         | 2.0      | 0.9                  |     |

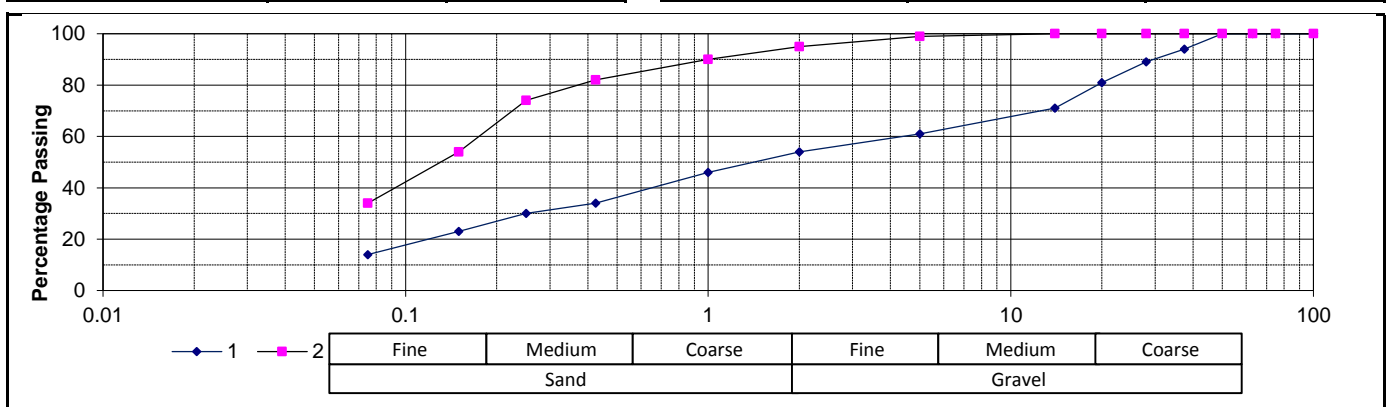


|                             |    |    |  |
|-----------------------------|----|----|--|
| <b>Soil Mortar Analysis</b> |    |    |  |
| Coarse Sand                 | 37 | 14 |  |
| Coarse Fine Sand            | 7  | 9  |  |
| Medium Fine Sand            | 13 | 21 |  |
| Fine Fine Sand              | 17 | 21 |  |
| Silt and Clay               | 26 | 36 |  |

|                              |                     |     |    |
|------------------------------|---------------------|-----|----|
| <b>Interpolated CBR Data</b> |                     |     |    |
| CBR                          | @ 100%              | 179 | 14 |
|                              | @ 98%               | 131 | 13 |
|                              | @ 97%               | 112 | 13 |
|                              | @ 95%               | 82  | 12 |
|                              | @ 93%               | 60  | 12 |
|                              | @ 90%               | 38  | 11 |
|                              | @ SANS3001 Midpoint | 121 | 13 |

|                         |    |                       |  |
|-------------------------|----|-----------------------|--|
| <b>Atterberg Limits</b> |    | <b>SANS 3001 GR10</b> |  |
| Liquid Limit (%)        |    | 21                    |  |
| Plasticity Index (%)    | NP | 9                     |  |
| Linear Shrinkage (%)    |    | 4.0                   |  |

|                        |          |          |  |
|------------------------|----------|----------|--|
| <b>Classifications</b> |          |          |  |
| HRB (AASHTO)           | A-1-b(0) | A-2-4(0) |  |
| COLTO                  | G5       | G8       |  |
| TRH14                  | G5       | G8       |  |



## CALIFORNIA BEARING RATIO (CBR) & ROAD INDICATOR REPORT

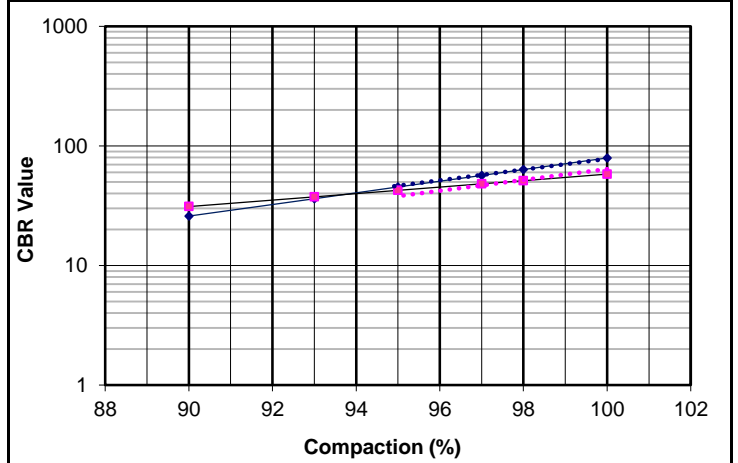
|                        |                                       |  |
|------------------------|---------------------------------------|--|
| Laboratory No.         | 4 <span style="color: blue;">◆</span> | 6 <span style="color: magenta;">■</span> |
| Field Number           | ZBM04                                 | ZBM08                                    |
| Client Reference       |                                       |  |
| Depth (m)              | 0.88-2.50                             | 1.01-2.40                                |
| Position               |                                       |  |
| Coordinates            | X                                     |  |
|                        | Y                                     |  |
| Description            |                                       |  |
| Additional information |                                       |  |
| Calcrete/Crushed       |                                       |  |
| Stabilizing Agent      |                                       |  |

|   |                                       |  |
|---|---------------------------------------|--|
| Laboratory No.  | 4 <span style="color: blue;">◆</span> | 6 <span style="color: magenta;">■</span> |
| <b>Maximum Dry Density &amp; Optimum Moisture Content</b> |                                       | <b>SANS 3001 GR30</b>                    |
| MDD   | kg/m <sup>3</sup>                     | 1898                                     |
| OMC   | %                                     | 13.2                                     |
|   |                                       | 1935                                     |
|   |                                       | 11.4                                     |

|                                 |                   |                       |      |      |       |      |
|---------------------------------|-------------------|-----------------------|------|------|-------|------|
| <b>California Bearing Ratio</b> |                   | <b>SANS 3001 GR40</b> |      |      |       |      |
| <b>Compaction Data</b>          |                   |                       |      |      |       |      |
| Moisture                        | %                 | 13.3                  |      |      | 11.4  |      |
| Dry Density                     | kg/m <sup>3</sup> | 1903                  | 1806 | 1712 | 1940  | 1843 |
| Compaction                      | %                 | 100.0                 | 94.9 | 90.0 | 100.0 | 95.0 |

|                         |         |      |      |      |      |      |      |
|-------------------------|---------|------|------|------|------|------|------|
| <b>Penetration Data</b> |         |      |      |      |      |      |      |
| CBR at                  | 2.50 mm | 78   | 46   | 26   | 64   | 38   | 33   |
|                         | 5.00 mm | 59   | 39   | 23   | 58   | 32   | 28   |
|                         | 7.50 mm | 45   | 32   | 22   | 54   | 27   | 25   |
| Swell                   | %       | 0.2  | 0.4  | 0.4  | 0.5  | 0.6  | 1.1  |
| Final Moisture (%)      |         | 15.9 | 17.5 | 19.1 | 14.9 | 16.6 | 18.4 |

|   |          |                      |     |
|---|----------|----------------------|-----|
| <b>Sieve Analysis (Wet preparation)</b> |          | <b>SANS 3001 GR1</b> |     |
| Percentage Passing                      | 100 mm   | 100                  | 100 |
|   | 75 mm    | 100                  | 100 |
|   | 63 mm    | 100                  | 100 |
|   | 50 mm    | 100                  | 100 |
|   | 37.5 mm  | 100                  | 91  |
|   | 28 mm    | 100                  | 88  |
|   | 20 mm    | 100                  | 79  |
|   | 14 mm    | 96                   | 70  |
|   | 5 mm     | 86                   | 49  |
|   | 2 mm     | 74                   | 40  |
|   | 1 mm     | 64                   | 37  |
|   | 0.425 mm | 52                   | 34  |
|   | 0.250 mm | 45                   | 30  |
|   | 0.150 mm | 34                   | 24  |
|   | 0.075 mm | 22                   | 15  |
| Grading Modulus                         |          | 1.5                  | 2.1 |



|                             |    |    |
|-----------------------------|----|----|
| <b>Soil Mortar Analysis</b> |    |    |
| Coarse Sand                 | 30 | 15 |
| Coarse Fine Sand            | 10 | 9  |
| Medium Fine Sand            | 15 | 17 |
| Fine Fine Sand              | 16 | 22 |
| Silt and Clay               | 30 | 38 |

|                              |             |                     |    |    |
|------------------------------|-------------|---------------------|----|----|
| <b>Interpolated CBR Data</b> |             |                     |    |    |
| CBR                          | Mod. AASHTO | @ 100%              | 79 | 58 |
|                              |             | @ 98%               | 63 | 51 |
|                              |             | @ 97%               | 57 | 48 |
|                              |             | @ 95%               | 45 | 43 |
|                              |             | @ 93%               | 36 | 38 |
|                              |             | @ 90%               | 26 | 31 |
|                              |             | @ SANS3001 Midpoint | 60 | 50 |

|                         |     |                       |  |
|-------------------------|-----|-----------------------|--|
| <b>Atterberg Limits</b> |     | <b>SANS 3001 GR10</b> |  |
| Liquid Limit (%)        | 31  | 30                    |  |
| Plasticity Index (%)    | 12  | 12                    |  |
| Linear Shrinkage (%)    | 5.5 | 5.5                   |  |

|                        |          |          |
|------------------------|----------|----------|
| <b>Classifications</b> |          |          |
| HRB (AASHTO)           | A-2-6(0) | A-2-6(0) |
| COLTO                  | G7       | G7       |
| TRH14                  | G6       | G6       |

