ROCKSOIL CONSULT

SANS634:2012 Preliminary Engineering Geological Investigation Conducted on Erf 184 Olifantsnek situated on Portion 62 of the farm Commissiesdrift 327-JQ, North-West Province, South Africa

SANS634:2012 Preliminary Shallow Soil Engineering Geological Assessment

Client: HydroScience

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Document History

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Document Approval and Quality Control

Action	Responsible Person	Profession and Registration
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SANS634:2012 Preliminary Engineering Geological Investigation Conducted on Erf 184 Olifantsnek situated on Portion 62 of the farm Commissiesdrift 327-JQ, North-West Province, South Africa

1 Introduction

A preliminary engineering geological investigation was conducted in accordance with SANS634:2012. The investigation was conducted on approximately 29 hectares on Portion 62 of the farm Commisiesdrift 327-JQ near Rustenburg in North-West Province (South Africa; Figure 1).

2 Objectives of the Assessment

The main objectives of a SANS634:2012 Preliminary Geotechnical assessment are to (SANS634, 2012):

- Gather readily available geotechnical information;
- Identify and categorize terrain types;
- Establish if a parcel of land is suitable for the proposed development;
- Indicate appropriate land uses;
- Comment on potential sources of construction materials.

The preliminary investigation is generally supplemented by a site walkover survey and examination of existing profiles in the area or limited trial pit excavation and soil profile descriptions.

3 Information Used During the Study

The following available information were considered during this investigation:

1) Locality map with provided approximate site boundaries;
2) 1:250 000-scale regional geological sheet;
3) 1:50 000-scale regional geological sheet;
4) 1:500 000-scale Hydrogeological map series (DWAF/WRC 1995);
5) GoogleEarth images;
6) Climate-date.org database;
7) Local knowledge of the area.

The available information was supplemented with the information obtained during the fieldwork phase/s of this assessment, as discussed in the relevant report sections.

4 Investigation Methodology

The investigation comprises:

- Desk study of readily available information;
- Limited trial pit excavation;
- In-situ soil profile logging by a suitably qualified engineering geologist/s;
- Soil profile photography;
- Selective material sampling;
- Limited soil testing at an accredited commercial laboratory;
- Evaluation and reporting by a qualified and professionally registered engineering geologist.

The number of trial pits, equipment and general investigation procedures/methods are provided in **Table R1**. The soil classification testing, relevant test methods and quantities are provided in **Table R2**. Additional information on the test procedures can be provided upon request.

Table R1: General Investigation Procedures and Information

Description	Information
Number of trial pits excavated	10
Placing Methodology	Land facet targeting and site coverage
Machine used for excavation	TLB
Profiling standards used for descriptions	SAICE 2009 and SANS633:2012
Profile logged by	Qualified engineering geologist/s
Test pit positioning	Hand-Held Garmin E-Trex GPS
Soil profile capturing and illustration	dotPLOT Version 3.22.0
Coordinate system	Decimal Degrees or WGS84 SA Grid

Table R2: Laboratory Tests and Tests Quantities

Laboratory Test	Laboratory	Test Standard	Number of Tests
Screen Analysis	ST Laboratory (Pty) Ltd.	SANS 3001:GR1	7
Hydrometer Analysis	ST Laboratory (Pty) Ltd.	SANS 3001:GR3 & TMH1	7
Atterberg Limits	ST Laboratory (Pty) Ltd.	SANS 3001:GR10	7
pH	ST Laboratory (Pty) Ltd.	Refer to lab report	7
Electrical Conductivity	ST Laboratory (Pty) Ltd.	Refer to lab report	7

ST –> Specialised Testing

Refer to the laboratory test reports for investigation procedures/standards followed. More details on the investigation methodology and test standards can be provided upon request.

5 Site Description

The site, covering a spatial extent of approximately 29 hectares, is presently mostly undeveloped with limited residential dwellings and earthworks in the south-eastern portion and the R24 motorway transecting the site. The site, on both sides of the R24, is accessible from the R24.

Vegetation is mostly shrubs with some grassy undergrowth. The environment is very likely disturbed through historical agriculture or proximate developments, and subsequently vegetation may also be disturbed.

Topography is fairly flat, draining locally to the river to the south and east of the site.

6 Regional Climate

As per climate-data.org, the climate in the Randburg area is considered “Cwa” according to the Koppen-Geiger climate classification. The average annual temperature is ~18.6 °C with an average annual rainfall of ~663 mm. The temperatures are highest on average in January, at around 23.7 °C. The lowest average temperatures in the year occur in July at around 11.5 °C. The regional average, minimum and maximum temperatures are depicted in **Chart 1**. The regional average monthly rainfall is depicted in **Chart 2**.

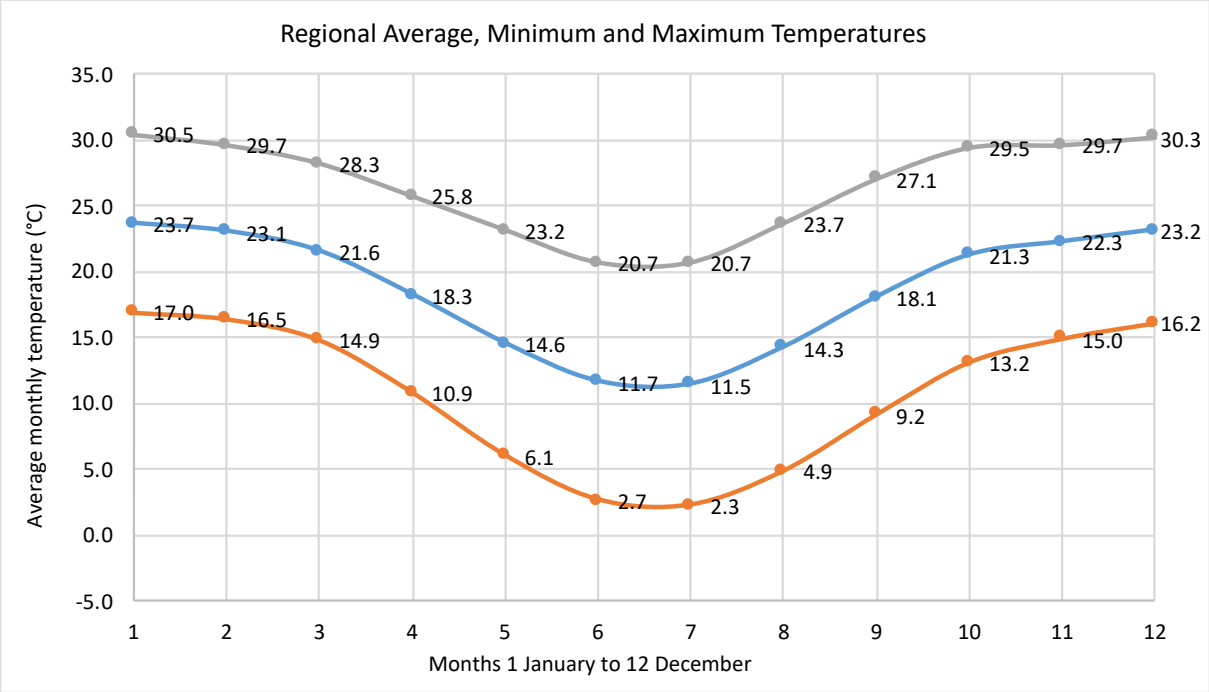

Chart 1: Regional Average, Minimum and Maximum Temperatures

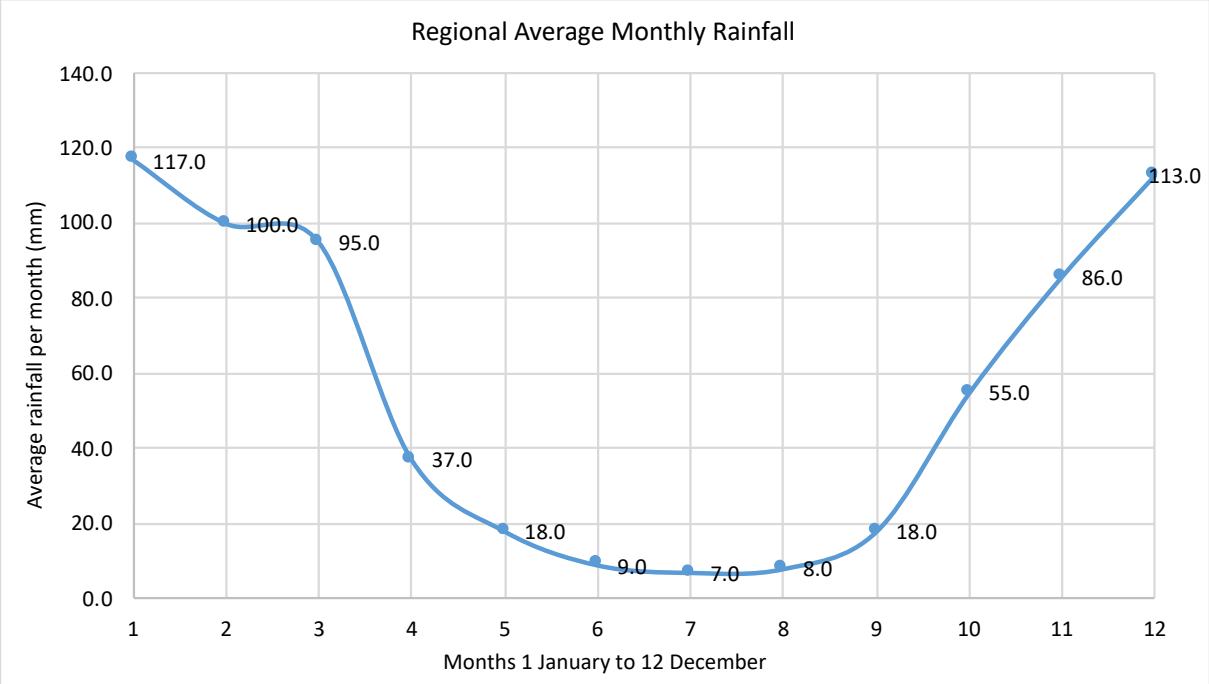

Chart 2: Regional Average Monthly Rainfall

The information provided is crude and should be refined by nearby weather stations if deemed critical for design-level input.

7 Geology

7.1 Regional Geology

The site is underlain by shale associated with the Silverton Formation of the Pretoria Group found in the Transvaal Supergroup (denoted by pale brown shading on Figure 2). The contact with the quartzites of the Magaliesberg Formation (Pretoria Group) is approximately 2 km to the east of the proposed site (cross-hatched purple shading).

A number of stratiform (bedding-parallel) diabase dykes are intruded into the sedimentary rocks (green-shading; denoted by di). These mostly strike west-east to northwest-southeast and are expected to be persistent along the strike even where not indicated as surface outcrop on the geological map.

Quaternary colluvium and alluvium occur along the existing drainage channels and the adjacent flood plains (yellow shading; denoted by Q).

There are no soluble rocks (e.g. dolomite) underlying the site, and subsequently no specialist investigations are required in this regard.

No mineral deposits or mining operations appear to affect the site, and subsequently mineral deposits and potential undermining are not expected to influence the site.

The area is not in a geologically seismically active area, and natural seismicity is not expected to affect the developability of the site.

7.2 Site Specific Geology

The site itself is underlain by shale and diabase, with a contact between the two transecting the site in the northern portion along a west-east strike. Given the resolution of the 1:250 000-scale geological sheet in Figure 2, it cannot be ruled out that the diabase can exist at depth without having been identified during regional mapping exercises.

Though maximum potential effort was used during the preliminary investigation, the exact extent of the different lithologies will need to be confirmed during a detailed investigation as stipulated in SAN634:2012.

8 Hydrology and Hydrogeology

The site is situated in the A22G quaternary catchment of the Marico/ Crocodile (West) Water Management Area. Regional drainage is to the northeast via the Olifantsnek Dam (Figure 3).

The 1:500 000-scale Hydrogeological map series (DWAF/WRC 1995) were consulted for background hydrogeological conditions. The following generic conditions are noted:

- Electrical conductivity c. 70-300 mS/m

- Total dissolved solids c. < 300 ppm
- Hydrochemical type $(Ca,Mg)(HCO_3)_2$
- Depth to groundwater level 10-30 m
- Mean annual recharge 50-110 mm

Aquifers in the area are likely fractured to intergranular and fractured, with diabase and shale likely acting as local aquitards rather than aquifers.

Recharge is likely from shallow gradients or depressions, and will likely be very localised and preferential rather than dispersed and regional.

Given the bedrock geology, site soils will likely comprise low permeability silts and clays with high retention of moisture.

9 General Engineering and Material Characteristics

Engineering and material characterisation is based on ten soil profiles described on the site (positions indicated on Figure 4; photographs and logs supplied in Appendix B and Appendix C respectively). Seven representative soil samples were submitted for foundation indicator tests and determination of pH and electrical conductivity (Table R3 and Appendix D.

Table R3: Summarised laboratory test results

Sample	**TP03**	**TP03**	**TP05**	**TP06**	**TP08**	**TP09**	**TP10**
Depth (m)	**0.0 - 0.2**	**1.1 - 1.6**	**1.6 - 1.8**	**1.0 - 1.2**	**1.0 - 1.2**	**1.3 - 1.5**	**0.6 - 0.8**
Horizon	Topsoil	Weathered shale	Residual shale	Residual shale	Weathered shale	Weathered shale	Transported?
GM	1.77	1.40	0.96	0.45	1.31	1.88	0.42
LL (%)	24	32	31	32	32	34	41
PI (%)	5	5	5	13	7	6	20
LS (%)	2.5	3.5	3.5	7.5	4.0	2.5	10.0
Unified	GC-GM	GM	ML	CL	GM	GM	CL
AASHTO	A-2-4	A-4	A-4	A-6	A-4	A-2-4	A-7-6
pH	5.2	5.3	5.3	5.0	5.2	5.3	5.2
EC (S/m)	0.017	0.011	0.022	0.0250	0.055	0.008	0.023

GM – Grading Modulus; LL – Liquid Limit; PI – Plasticity Index; LS – Linear Shrinkage; Unified and AASHTO Soil Classification Systems; EC – Electrical Conductivity

Typical material properties and expected performance based on the Unified Soil Classification system are provided in Appendix E for guideline purposes only. Material properties and expected performance should be assessed in the detailed follow-up assessments and testing programs.

9.1 Soil Profile

Two typical soil profiles were identified at the site. Test pits TP01-TP06, TP08 and TP09 were described as *shale* and TP07 and TP10 as *diabase*.

Typical material successions for each comprise the following:

- Thin topsoil overlying silty sandy residual shale becoming highly jointed, laminated weathered shale bedrock, resulting in TLB refusal at depths of 1.20-1.90 m below surface.
- Thin topsoil overlying coarse diabase gravel to corestones, mostly clast-supported in a silty to clayey matrix, resulting in TLB refusal at approximately 1.20 m depth below surface.

9.2 Material Grading and Atterberg Limits

Residual shale generally grades as low plasticity clays and silts. Highly weathered shale encountered at the base of most test pits grade as silty to clayey gravels with low plasticity.

Diabase bedrock is shallow and soil cover is very thin to absent in the limited exposures at the site.

Colluvial and other transported soil horizons are similar despite deeper bedrock.

9.3 Material Classification - Unified Soil Classification

The materials tested classifies as the following soil classes (Unified Soil Classification System):

GM → Course-grained soils (more than 50% retained on the 0.075 mm sieve), gravels (50 % or more of course fraction retained on the 4.75 mm sieve), gravel with fines, silty gravels, gravel-sand-silt mixtures.

GC → Course-grained soils (more than 50% retained on the 0.075 mm sieve), gravels (50 % or more of course fraction retained on the 4.75 mm sieve), gravel with fines, clayey gravels, gravel-sand-clay mixtures.

ML → Fine-grained soils (more than 50 % passes the 0.075 mm sieve), silts and clays with Liquid Limit of 50 % or less, inorganic silts, very fine sands, rock four, silty or clayey fine sands.

CL → Fine-grained soils (more than 50 % passes the 0.075 mm sieve), silts and clays with Liquid Limit of 50 % or less, inorganic clays of low to medium plasticity, gravelly/sandy/silty/lean clays.

Residual shale is classified as “ML” to “CL” according to the Unified Soil Classification System (USCS).

Highly weathered shale is classified as “GM” to “GC”.

9.4 Material Classification - AASHTO Classification

The materials tested classifies as the following soil classes (AASHTO Classification System):

- A-2 → Granular materials (35 % or less passing the 0.075 mm sieve), different LL and PI for A-2 variances (refer to A-2-4, A-2-5 A-2-6 and A-2-7 sub-groups) with significant constituent: silty or clayey gravel sand.
- A-4 → Silt-clay materials (>35 % passing the 0.075 mm sieve), minimum of 36 % passing the 0.075 mm sieve, LL max of 40, PI max of 10, with significant constituent: silty soils.
- A-6 → Silt-clay materials (>35 % passing the 0.075 mm sieve), minimum of 36 % passing the 0.075 mm sieve, LL max of 40, PI min of 11, with significant constituent: clayey soils.

9.5 Material Classification – COLTO or TRH Classification

The materials were not classified in terms of COLTO or TRH in this preliminary assessment.

9.6 Corrosivity Indicators

Based on acidic pH values, moderate electrical conductivities, the presence of clays, and the likely elevated moisture conditions in natural state, the site soils are expected to be mildly to highly corrosive to cement and steel.

9.7 Typical Material Properties and Expected Performance

The majority of the site soils are low plasticity silts and clays with variable amounts of sand and gravel. Typical material properties and expected performances, based on the Unified Soil Classification System (USCS), are provided in the relevant reference tables attached in Appendix E. The properties are provided for guideline/planning purposes and should be assessed in more detail in the Phase 1 detailed assessment to follow.

9.8 Compaction Characteristics

No compaction testing was conducted. However, given the grading and properties of the soils, compaction might be difficult, especially for those soils classified as “CL” or “ML” according to the Unified soil classification system. Permeability will also decrease substantially, and waterlogging or induced runoff may result from compaction. Typical compaction characteristics/expected performance, based on the Unified Soil Classification System (USCS), are provided in the relevant reference tables attached in Appendix E.

9.9 Bearing Capacity

The bearing capacity of a specific material/soil type is not a fixed property. The bearing capacity depend on a number of parameters including, but not limited to 1) friction angle of the material, 2) cohesion of the material, 3) compaction density, 4) foundation shape/size, 5) depth of placement of the footing and 6) drainage precautionary measures. Typical material properties are provided in the relevant reference tables attached in Appendix E. The allowable bearing capacity considers, in addition to the ultimate bearing capacity, the structural tolerances and settlement limits of the specific structures under consideration. The bearing capacity should thus be evaluated once conceptual layouts, structural detail and load schedules are available.

10 Geotechnical Constraints

Table R4: Geotechnical Constraints in Urban Development (SANS634, 2012)

1	2	3	4	5
Constraint		**Descriptor**		
Letter	**Description**	**1 (most favourable)**	**2 (intermediate)**	**3 (least favourable)**
A	Collapsible soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750 mm in thickness[a]	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 below	Permanent or perched water table less than 1,5 m ground surface	Swamps and marshes
C	Active soil	Low soil-heave potential anticipated[a]	Moderate soil-heave potential anticipated	High soil-heave potential anticipated
D	Highly compressible soil	Low soil compressibility anticipated[a]	Moderate soil compressibility anticipated	High soil compressibility anticipated
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[a]	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 200 m below surface (except where total extraction mining has not occurred)	Old undermined areas to a depth of 200 m below surface where stope closure has ceased	Mining within less than 200 m of surface or where total extraction mining has taken place
H	Stability (dolomite land)	Possibly stable. Areas of dolomite overlain by Karoo rocks or intruded by sills.	Potentially characterized by instability. Anticipated inherent classes 2 to 5	Known sinkholes and dolines.

		Areas of Black Reef rocks. Anticipated inherent hazard class 1 (see SANS 1936-2)	(see SANS 1936-2)	Anticipated inherent hazard classes 6 to 8 (see SANS 1936-2)
I	Steep slopes	Between 2° and 6° (all regions)	Slopes between 6° and 18° and less than 2° (Natal and Western Cape) Slopes between 6° and 12°and less than 2° (all other regions)	More than 18° (Natal and Western Cape) More than 12° (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/s² within 50 years	Mining-induced seismic activity more than 100 cm/s²	Natural seismic activity more than 100 cm/s²
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

Note 1: Areas should be designated by the numeral associated with the most appropriate descriptor in columns 3 to 5 followed by the letter associated with the constraint. For example, an area designated as Zone 2BF would be an intermediate class with anticipated seepage and excavation problems while an area designated as Zone 3B would be least favourable and not recommended for development due to surface water inundation.

Note 2: More detailed information on undermined land can be obtained from Stacey, T.R. and Bakker, D. The erection or construction of buildings and other structures on undermined ground. NOTE 3 Undermining assessments should be carried out by persons with expert knowledge of such conditions.

[a] *These areas are designated as 1A, 1C, 1D, or 1F where localized occurrences of the constraint might arise.*

10.1 Collapsible Soil

Site soils are not expected to behave in a collapsible manner.

10.2 Seepage

Soil profiles are described mostly as slightly moist, indicating no sudden or substantial change in moisture content with depth or across the site.

Fine-textured soils and orange to red discoloration in profile support the likely presence of periodical wet conditions in the site soils. Soils are likely low permeability and may waterlog and possibly induce some lateral interflow on the bedrock interface. The proximity of the dam further increases the likelihood of seepage in the profile despite groundwater likely occurring at depths below influence of the proposed development.

10.3 Active Soil

Some clays are present in the site soils, but, coupled with low plasticity, expansive behaviour is not anticipated. Scattered occurrences of some potentially expansive clays may be anticipated, notably between diabase corestones and in diabase residuum.

10.4 Highly Compressible Soil

Soil might be moderately compressible. Given the general thin soil cover above bedrock, this should not result in substantial volume change. Differential settlement can be encountered where diabase cobbles and boulders are present in the soil profile.

10.5 Erodibility of Soil

Based on the nature of the soils (consistency and grading) and site gradient, the site soils are expected to be erodible if subject to concentrated water flow. Construction phasing and basic erosion precautionary measures will be required.

10.6 Excavation Difficulty

Excavation conditions are soft becoming soft to intermediate in diabase corestones and diabase and shale bedrock, and likely to be hard excavation in fresh diabase. The inspection trenches were mainly single-bucket width excavations, thus considered restricted excavation conditions. The refusal depths recorded in the soil profiles are thus conservative and the excavatability should be assessed in more detail within follow-up investigations, ideally in semi-restricted to unrestricted conditions.

10.7 Undermined Ground

The site is not located within known mining areas, and undermining is not expected at the site.

10.8 Dolomite Stability

The site is not underlain by dolomite or other soluble rock. No dolomite stability investigation is required.

10.9 Steep Slopes

No steep natural slopes seem to be present on the site itself.

10.10 Areas of Unstable Natural Slopes

No unstable natural slopes seem to be present at the site.

10.11 Seismic Activity

The area is not situated in a naturally seismic active area. Impoundment of water in dams may, however, result in limited induced seismicity, although this is not expected to significantly affect the developability of the site.

10.12 Areas Subject to Flooding

The area is situated very near the Olifantsnek Dam and the associated rivers and streams. Flood lines should be delineated by suitably qualified professionals, and, if relevant, possible waterlogged or marshy land should be investigated for possible wetland conditions.

11 Preliminary Geotechnical Zonation

The site is considered two geotechnical zones based on the findings of this preliminary investigation (Appendix E):

Zone I: S1-H1/2BCD (2F) – shale; TP01-TP06; TP08 and TP09

Zone II: S-H/2BCDF – diabase; TP07 and TP10.

The major constraints on the site relate to highly variable excavation conditions and the very high likelihood of waterlogging in upper soil horizons coupled with periodical seepage in shallow soil horizons.

Some consolidation of compressible behaviour of site soils should be anticipated. In the diabase profiles, the presence of corestones and the irregular bedrock interface associated with diabase terrains will result in further differential settlement.

The influence of proximate drainage features should be determined by suitably qualified specialists.

12 Installation of Services

Excavatability in localised areas across the site may impact on the installation of services. Limited blasting and/or hard rock excavation cannot be out ruled. Diabase were encountered in test pits TP07 and TP10 towards the northern site portion, confirming the presence of diabase dykes in the region and on-site. Localised excavation difficulty can be expected, especially toward the northern site portions. The excavatability should be assessed and confirmed in follow-up assessments.

The site-soils generally contain high percentages of fines (clay and silt) and is in general not deemed ideal for pipe bedding and blanketing as per the DWA and SANS specifications. The suitability is dependent on the pipe specifications considered for this site and should be confirmed and assessed in more detail within the follow-up investigations. Limited index testing was conducted. The planners/designers should refer to the grading and Atterberg limits for initial indications of suitability of the on-site soils for bedding and blanketing.

Excavation and construction phasing will probably be required due the expected presence of shallow seasonal seepage water conditions and erodability o the soils upon exposure to concentrated water flow. Construction guidance and recommendations should be provided in the more detailed follow-up investigations.

13 Building Construction

Foundation and building precautionary measures will be required. Based on preliminary findings, reinforced strip footings or rafts should suffice. Drainage precautions are required to minimise moisture changes in soils, as these will affect the corrosivity of site materials as well as its strength. The aforementioned should be assessed and confirmed in the Phase 1 detailed assessment, as per standard practice.

Earthwork and building precautionary measures should be provided in the more detailed follow-up investigation/s.

14 Assessment Limitations

The following assessment limitations should be noted:

1. The level of assessment is considered a SANS634:2012 preliminary engineering geological assessment;
2. The main objective of the assessment is to provide general conditions and constraints establish whether or not a parcel of land is suitable for township development as from a geotechnical perspective;
3. A limited number of tests pits were used in order to arrive at the land-facets and preliminary zonation map;
4. A limited number of soil horizons were sampled with only basic index testing to arrive at the soil classification and expected material performances;
5. The information provided in this report is thus suitable for basic planning purposes and is deemed not suitable for preliminary design-level input.

15 Conclusions and Recommendations

The site is provisionally deemed suitable for the proposed development.

The site conditions and broad preliminary zonation should be established/refined/verified during follow-up investigations in order to comply with the requirements as outlined in SAICE 2010 investigation code of practice as for a design-level investigation.

Earthworks and foundation precautionary measures will be required.

Minor surface and subsurface drainage and damp proofing precautionary measures will be required.

This investigation excludes the delineation of flood lines, wetlands and environmentally sensitive areas.

16 Way Forward

The recommended way forward can be provided as:

1. Conduct an environmental impact assessment to identify any potential environmentally sensitive are that should be excluded from the development or that will required special development precautionary measures;
2. Conduct a flood line assessment with certification of the 1:100-year floodline. This will determine the zone boundary of constraint "L" (Potential flooding) as required for Urban Development (see Table R4 report section 10);
3. Conduct infill engineering geological assessments, aligned with the national standards and code of practice (SANS634:2012 and SAICE2010 code of practice). Based on the development type (Campus and recreational facilities), the infill assessment should ideally be guided by SAICE 2010 Site Investigation Code of Practice. With reference to SAICE 2010 investigation code of practice, this assessment can be considered a "Pre-feasibility" to "Feasibility" level assessment. A SAICE 2010 design-level assessment should thus follow.

17 Report Provisions

While every effort was made during this preliminary engineering geological investigation to identify the different geological materials, areas subject to a perched water tables, hydrogeological conditions, areas of poor drainage and to estimate their distribution, it is impossible to guarantee that isolated zones of significantly different conditions have not been missed.

For this reason, this investigation has sought to highlight the significant issues regarding the influence of the proposed development on the geological environment to provide prior warning to the developer.

The report may only be distributed in its full context. RockSoil Consult (Pty) Ltd. and/or any of its employees or sub-contractors will not be held liable for any damages caused due to miss-interpretation of the findings and/or recommendations due to selective data presentation or distribution.

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18 References

SAICE. (2010). *Site Investigation Code of Practice.* The South African Institution of Civil Engineering - The Geotechnical Division of SAICE.

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Appendix A: Figures

Figure 1: Locality Map

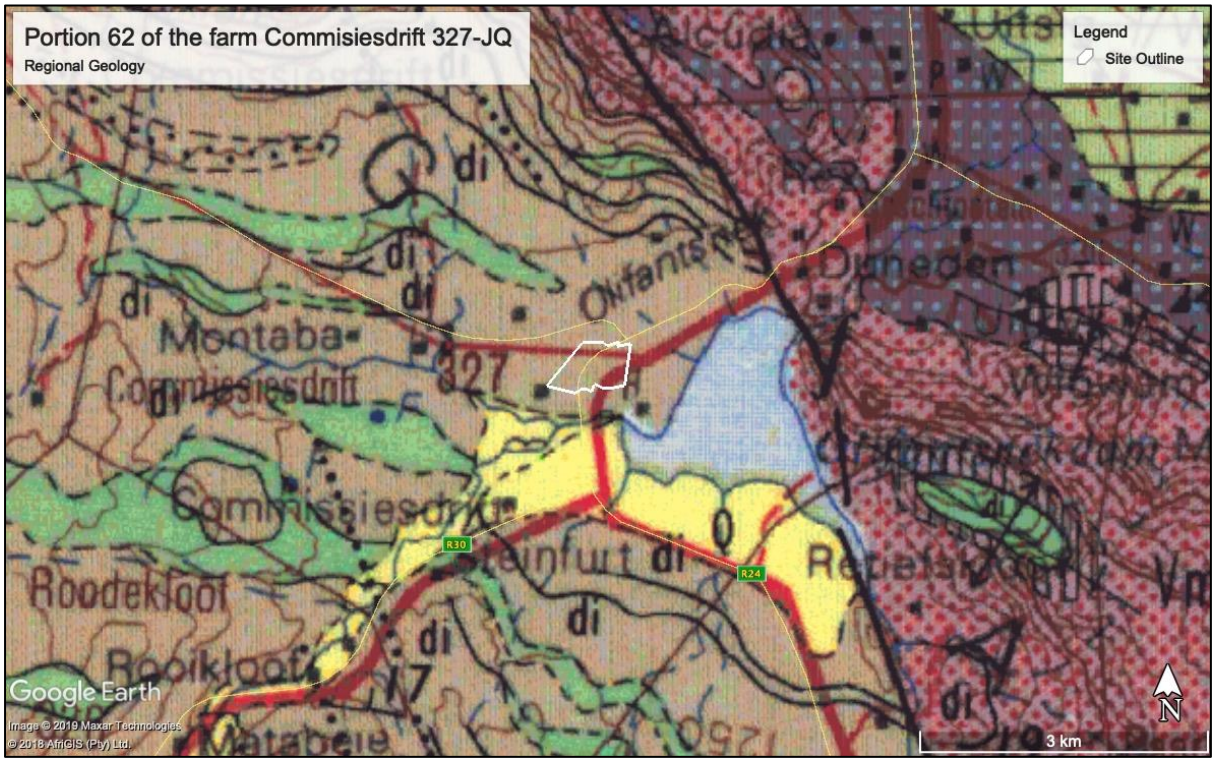


Figure 2: Geological Map

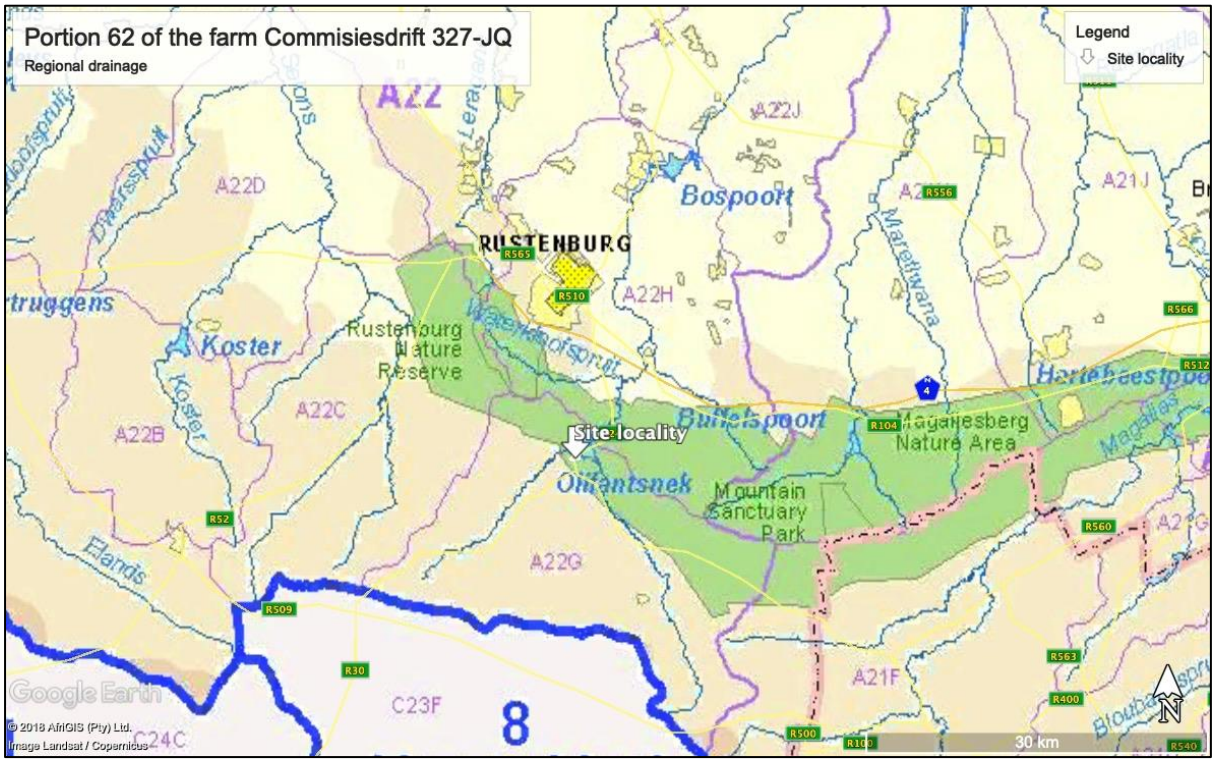


Figure 3: Drainage Map

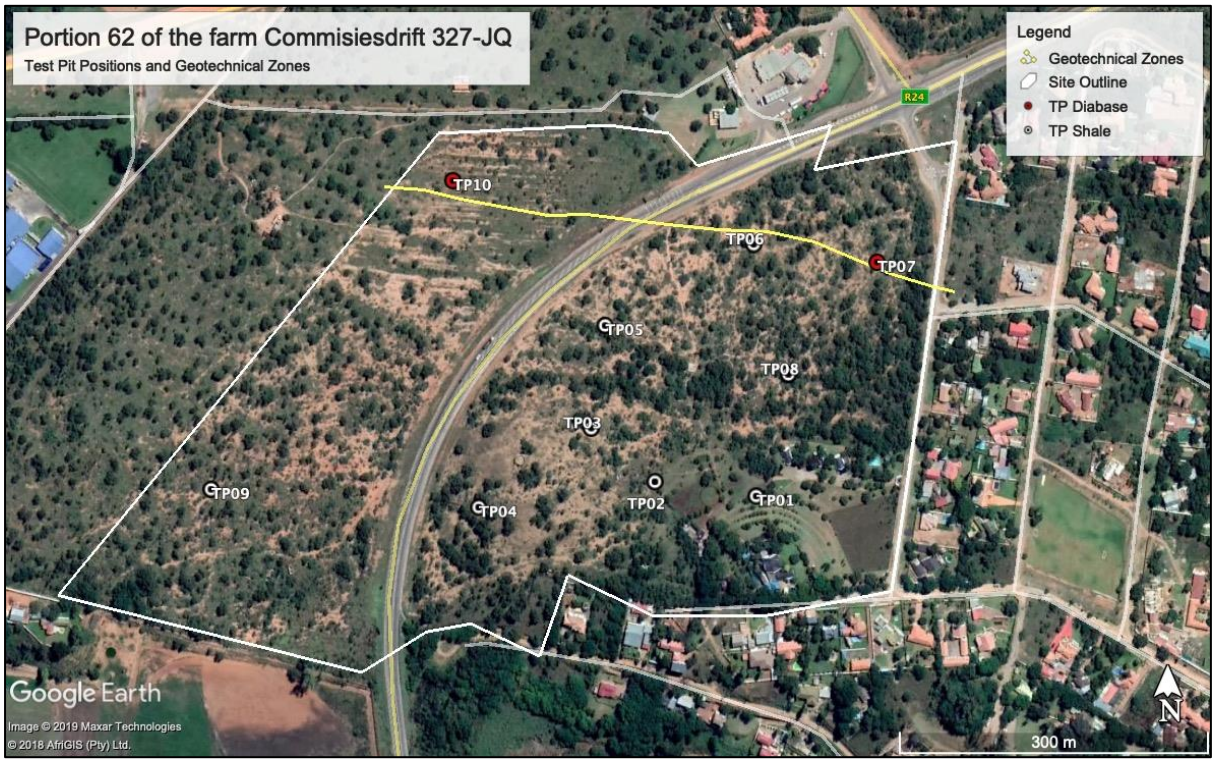


Figure 4: Test Pit Positions

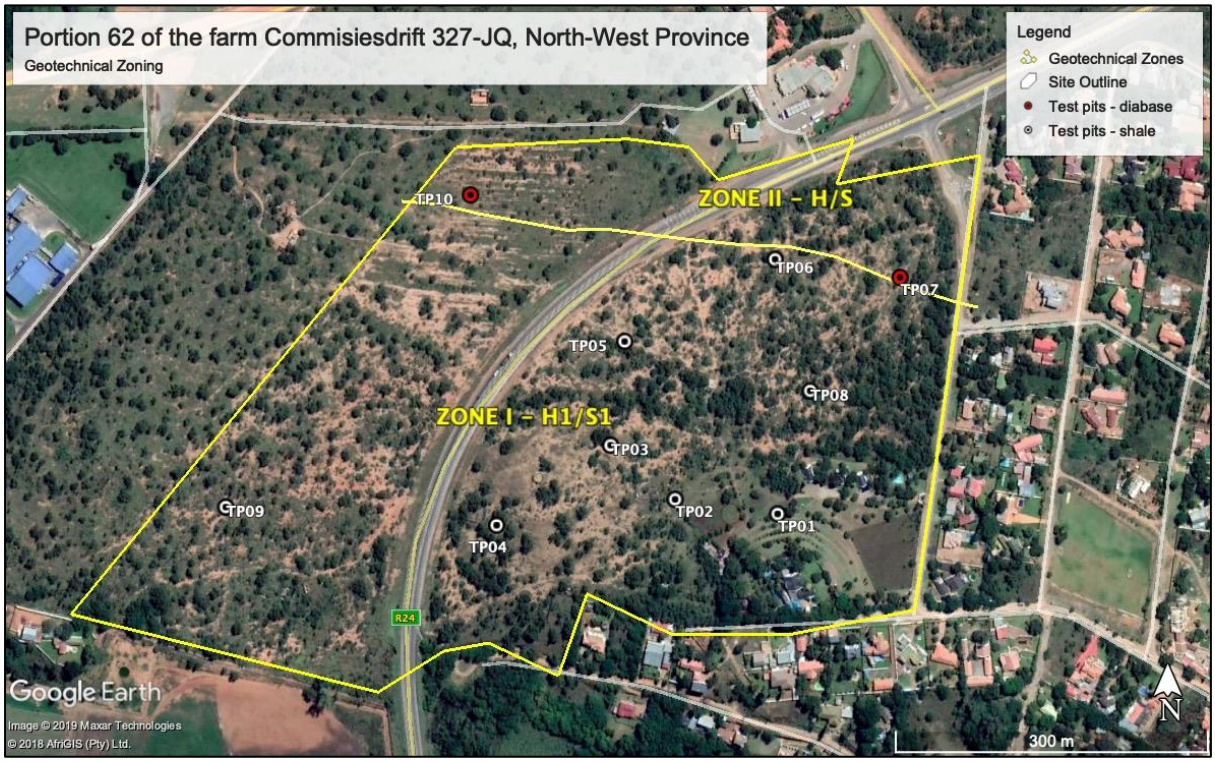


Figure 5: Preliminary Broad Zonation Map

Appendix B: Soil Profile Descriptions

Olifantsnek

HOLE No: TP01
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10

0.00 Slightly moist, brown, very loose, intact, silty SAND with abundant roots. TOPSOIL.

0.10 Slightly moist, light yellow brown blotched red and orange, loose, intact, silty SAND. RESIDUAL SHALE.

0.70 Yellow brown stained red and orange, highly weathered, highly jointed, very soft rock SHALE.

1.80 TLB refusal in shale.

NOTES

1) 1. TLB refusal.

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. No samples retrieved.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP01

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

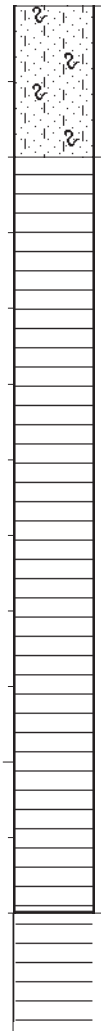
DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP02
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10



0.00 Slightly moist, brown, very loose, intact, silty SAND with abundant roots. TOPSOIL.

0.20 Yellow brown stained red and orange, highly weathered, highly jointed, very soft rock SHALE.

1.20 TLB refusal in shale.

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. No samples retrieved.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP02

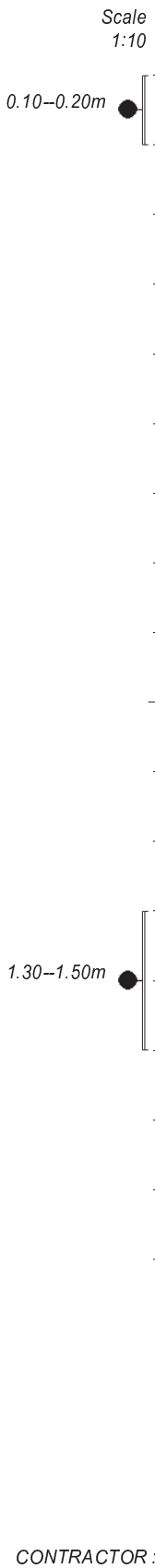
TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP03
Sheet 1 of 1

JOB NUMBER: 000



0.00 Slightly moist, orange brown, very loose, intact, silty SAND with abundant roots. TOPSOIL.

0.20 Slightly moist, light yellow brown blotched red, loose, intact, sandy SILT. RESIDUAL SHALE.

1.10 Yellow brown stained red and orange, highly weathered, highly jointed, very soft rock SHALE with decomposed zones.

1.60 TLB refusal in shale.

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. Bulk disturbed soil sample retrieved at 0.10--0.20m.

5) 5. Bulk disturbed soil sample retrieved at 1.30--1.50m.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP03

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

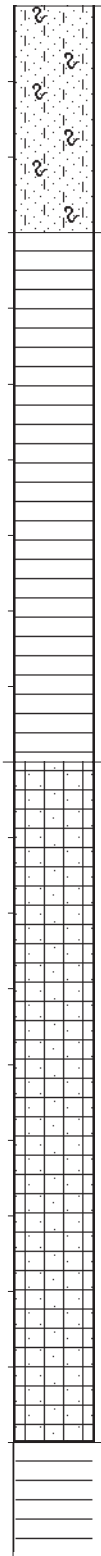
DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP04
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10



0.00 Slightly moist, yellow brown, loose, intact, silty SAND with abundant roots. TOPSOIL.

0.30 Yellow brown stained red and orange, highly weathered, highly jointed, very soft rock SHALE with decomposed zones.

1.00 Slightly moist, light yellow brown blotched red, medium dense, intact, sandy SILT with abundant sub-rounded cobbles and pebbles of shale. Completely weathered SHALE.

1.90 TLB refusal in shale.

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. No samples retrieved.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP04

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

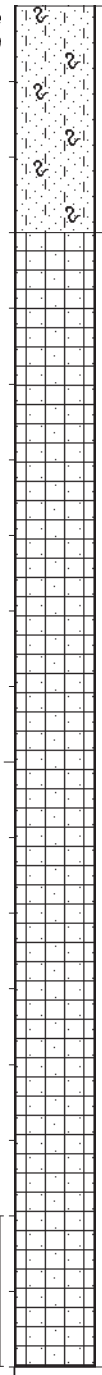
DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP05
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10



0.00 Slightly moist, yellow brown, very loose, intact, silty SAND with abundant roots. TOPSOIL.

0.30 Slightly moist, reddish brown, dense ,intact, sandy SILT with sub-rounded cobbles and pebbles of shale. RESIDUAL SHALE.

1.60--1.80m

1.80 TLB refusal in shale.

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. Bulk disturbed soil sample retrieved at 1.60--1.80m.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP05

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

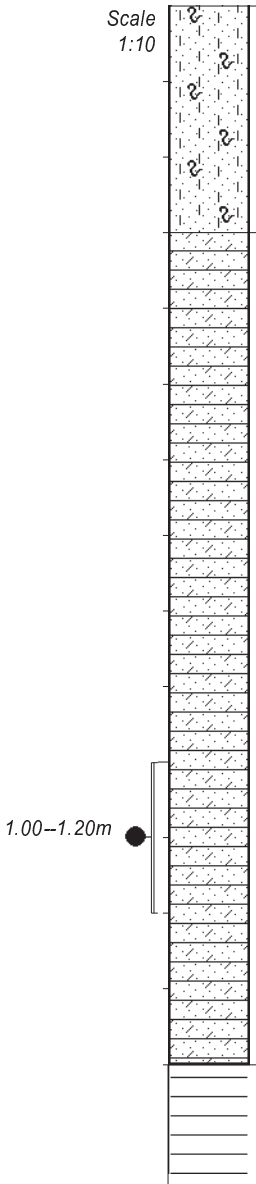
DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP06
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10



0.00 Slightly moist, yellow brown, loose, intact, silty SAND with minor roots. TOP SOIL.

0.30 Slightly moist, reddish brown stained olive and white, dense, intact, clayey SAND. RESIDUAL SHALE.

1.40 TLB refusal in shale.

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. Bulk disturbed soil sample retrieved at 1.00--1.20m.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP06

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

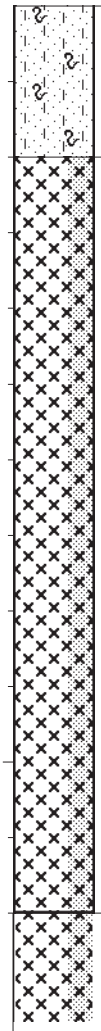
DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP07
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10



0.00 Slightly moist, yellow brown, loose, intact and voided, silty SAND with minor roots and termite activity. TOPSOIL.

0.20 Black speckled white stained red and orange, moderately weathered, highly jointed, very soft rock DIABASE (DOLERITE) with cobbles and corestones in profile.

1.20 TLB refusal in diabase (dolerite)

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. No samples retrieved.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP07

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

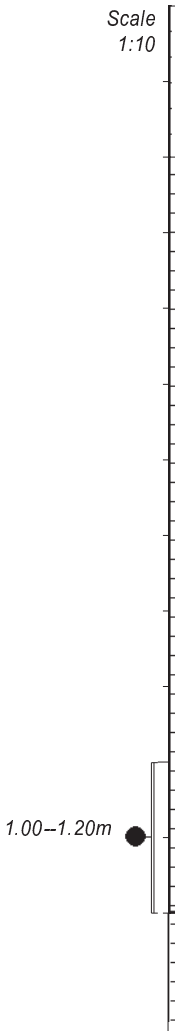
DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP08
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10



0.00 Slightly moist, yellow brown, loose, intact, silty SAND with minor roots. TOPSOIL.

0.20 Reddish brown, highly weathered, highly jointed, very soft rock SHALE.

1.20 TLB refusal in shale.

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. Bulk disturbed soil sample retrieved at 1.00--1.20m.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP08

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

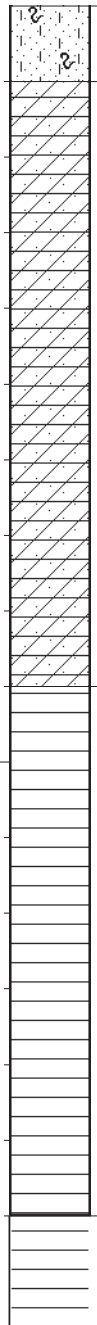
DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP09
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10



0.00 Slightly moist, yellow brown, loose, intact, silty SAND with abundant roots. TOPSOIL.

0.10 Slightly moist, light yellow brown blotched red, loose, intact, sandy CLAY. RESIDUAL SHALE.

0.90 Light yellow brown stained red and orange, highly weathered, highly jointed, very soft rock SHALE.

1.60 TLB refusal in shale.

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. Bulk disturbed soil sample retrieved at 1.30--1.50m.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP09

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

HOLE No: TP10
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10

0.00 Slightly moist, reddish brown, medium dense, intact, silty SAND with minor roots. TOPSOIL.

0.20 Black speckled white stained red and orange, moderately weathered, highly jointed, very soft rock DIABASE.

0.80 TLB refusal in diabase.

NOTES

1) 1. TLB refusal

2) 2. No seepage or water in test pit during inspection.

3) 3. Sidewalls stable during inspection.

4) 4. Bulk disturbed soil sample retrieved at 0.60--0.80m.

CONTRACTOR : RWA PLANT HIRE
MACHINE : TLB
DRILLED BY :
PROFILED BY : Jason Tunnell

INCLINATION :
DIAM :
DATE :
DATE : 10 July 2019

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP10

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

DATE : 16/08/2019 10:43
TEXT : G\119014.txt

Olifantsnek

LEGEND
Sheet 1 of 1

JOB NUMBER: 000

	SAND	{SA04}
	SANDY	{SA05}
	SILT	{SA06}
	SILTY	{SA07}
	CLAY	{SA08}
	CLAYEY	{SA09}
	SHALE	{SA12}
	DIABASE	{SA18}{SA41}
Name ●	DISTURBED SAMPLE	{SA38}
	ROOTS	{SA40}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : Matthys Dippenaar
SETUP FILE : STANDARD.SET

DATE : 16/08/2019 10:43
TEXT : G\119014.txt

LEGEND
SUMMARY OF SYMBOLS

Appendix C: Soil Profile Photographs

Project reference number: RS19022
Project name: Rustenburg - Olifantsnek Prelim Shallow Soil

Test Pit no: TP01  Notes: Upper soil profile.	Test Pit no: TP01  Notes: Excavated excavation and material.
Test Pit no: TP02  Notes: Soil profile down to 1.20 m below surface.	Test Pit no: TP03  Notes: Upper soil profile.

Project reference number: RS19022
Project name: Rustenburg - Olifantsnek Prelim Shallow Soil

Test Pit no: TP03  Notes: Soil profile down to 1.60 m below surface.	Test Pit no: TP04  Notes: Soil profile down to 1.90 m below surface.
Test Pit no: TP05  Notes: Upper soil profile.	Test Pit no: TP06  Notes: Soil profile down to 1.40 m below surface.

Project reference number: RS19022
Project name: Rustenburg - Olifantsnek Prelim Shallow Soil

Test Pit no: TP07

Notes: Excavation down to 1.20 m below surface.

Test Pit no: TP07

Notes: Lower diabase.

Test Pit no: TP08

Notes: Upper soil profile.

Test Pit no: TP09

Notes: Soil profile down to 1.60 m below surface.

Project reference number: RS19022
Project name: Rustenburg - Olifantsnek Prelim Shallow Soil

Test Pit no: TP10

Notes: Soil profile down to 0.80 m below surface.

Appendix D: Laboratory Test Results

Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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Gerrie | 082 309 4448 | gerrie@stlab.co.za
www.stlab.co.za

Client Name: RockSoil Consult (Pty) Ltd
Project Name: Olifantsnek
Job Number: RSC-12
Date: 12-Aug-19
Method: SANS 3001 GR1, GR3, GR10, GR12 GR20, GR30, GR31, GR40, GR50, GR53, GR54 & BS 1377 (where applicable)

SUMMARY OF TEST DATA

Grading & Hydrometer Analysis (% Passing)

Sample	TP03	TP03	TP05	TP06	TP08	TP09	TP10	
Depth (m)	0 - 0.2	1.1 - 1.6	1.6 - 1.8	1.0 - 1.2	1.0 - 1.2	1.3 - 1.5	0.6 - 0.8	
Lab No	RSC-12-199	RSC-12-200	RSC-12-201	RSC-12-202	RSC-12-203	RSC-12-204	RSC-12-205	
53.0	**82**	**100**	**100**	**100**	**100**	**100**	**100**	
37.5	**75**	**100**	**100**	**100**	**100**	**100**	**100**	
26.5	**71**	**96**	**100**	**100**	**100**	**94**	**100**	
19.0	**66**	**88**	**100**	**99**	**93**	**85**	**99**	
13.2	**60**	**81**	**98**	**98**	**87**	**79**	**99**	
9.5	**57**	**73**	**93**	**98**	**81**	**67**	**99**	
6.7	**54**	**68**	**89**	**98**	**75**	**58**	**99**	
4.75	**51**	**65**	**85**	**97**	**71**	**54**	**98**	
2.00	**47**	**60**	**79**	**95**	**64**	**46**	**94**	
1.00	**46**	**58**	**76**	**93**	**62**	**43**	**92**	
0.425	**46**	**57**	**74**	**92**	**60**	**40**	**91**	
0.250	**45**	**57**	**72**	**91**	**59**	**38**	**90**	
0.150	**43**	**54**	**68**	**88**	**57**	**34**	**88**	
0.075	**30**	**43**	**51**	**68**	**45**	**26**	**73**	
0.060	**21**	**31**	**31**	**51**	**27**	**18**	**56**	
0.050	**17**	**27**	**26**	**47**	**24**	**15**	**52**	
0.035	**12**	**19**	**17**	**41**	**17**	**10**	**46**	
0.020	**9**	**14**	**13**	**36**	**13**	**7**	**42**	
0.006	**7**	**8**	**9**	**27**	**10**	**5**	**36**	
0.002	**4**	**5**	**5**	**22**	**7**	**2**	**30**	
GM	**1.77**	**1.40**	**0.96**	**0.45**	**1.31**	**1.88**	**0.42**	

Atterberg Limits

LL (%)	**24**	**32**	**31**	**32**	**32**	**34**	**41**	
PI (%)	**5**	**5**	**5**	**13**	**7**	**6**	**20**	
LS (%)	**2.5**	**3.5**	**3.5**	**7.5**	**4.0**	**2.5**	**10.0**	

pH & Conductivity

pH	**5.2**	**5.3**	**5.3**	**5.0**	**5.2**	**5.3**	**5.2**	
EC (S/m)	**0.017**	**0.011**	**0.022**	**0.0250**	**0.055**	**0.008**	**0.023**	

MDD / OMC

MDD (kg/m^3)								
OMC (%)								

CBR

100%								
98%								
97%								
95%								
93%								
90%								
Swell (%)								

UCS (MPa)

100%								
97%								
90%								

COLTO Classification

Remarks:

Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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Gerrie | 082 309 4448 | gerrie@stlab.co.za
www.stlab.co.za

Client Name: RockSoil Consult (Pty) Ltd
Project Name: Olifantsnek
Job Number: RSC-12
Date: 2019-08-12
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	TP03	TP03	TP05	Sample	TP03	TP03	TP05
Depth (m)	0 - 0.2	1.1 - 1.6	1.6 - 1.8	Depth (m)	0 - 0.2	1.1 - 1.6	1.6 - 1.8
Lab No	RSC-12-199	RSC-12-200	RSC-12-201	Lab No	RSC-12-199	RSC-12-200	RSC-12-201
53.0	**82**	**100**	**100**	Liquid Limit (%)	**24**	**32**	**31**
37.5	**75**	**100**	**100**	Plastic Limit (%)	**19**	**27**	**26**
26.5	**71**	**96**	**100**	Plasticity Index (%)	**5**	**5**	**5**
19.0	**66**	**88**	**100**	Linear Shrinkage (%)	**2.5**	**3.5**	**3.5**
13.2	**60**	**81**	**98**	PI of whole sample	**2**	**3**	**4**
9.5	**57**	**73**	**93**				
6.7	**54**	**68**	**89**	% Gravel	**53**	**40**	**21**
4.75	**51**	**65**	**85**	% Sand	**26**	**29**	**48**
2.00	**47**	**60**	**79**	% Silt	**17**	**26**	**26**
1.00	**46**	**58**	**76**	% Clay	**4**	**5**	**5**
0.425	**46**	**57**	**74**	Activity	**1.3**	**1.0**	**1.0**
0.250	**45**	**57**	**72**				
0.150	**43**	**54**	**68**	% Soil Mortar	**47**	**60**	**79**
0.075	**30**	**43**	**51**				
0.060	**21**	**31**	**31**	Grading Modulus	**1.77**	**1.40**	**0.96**
0.050	**17**	**27**	**26**	Moisture Content (%)	**N / T**	**N / T**	**N / T**
0.035	**12**	**19**	**17**	Relative Density (SG)*	**2.65**	**2.65**	**2.65**
0.020	**9**	**14**	**13**				
0.006	**7**	**8**	**9**	Unified (ASTM D2487)	**GC-GM**	**GM**	**ML**
0.002	**4**	**5**	**5**	AASHTO (M145-91)	**A - 2 - 4**	**A - 4**	**A - 4**

Remarks: *: Assumed
N / T: Not Tested

Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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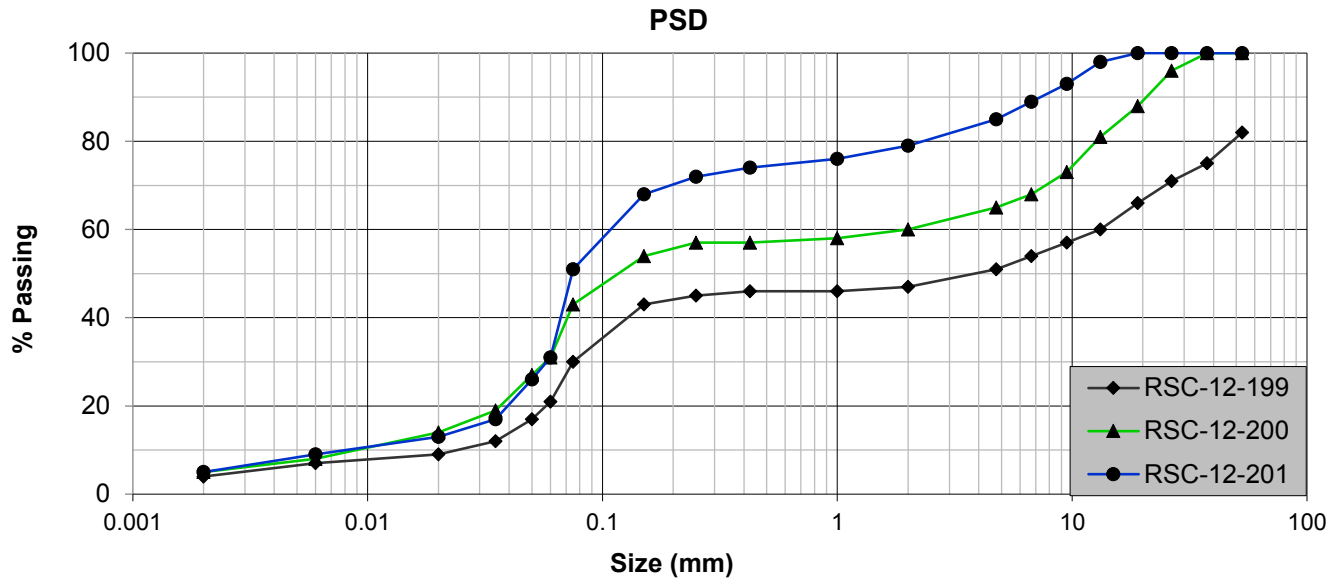
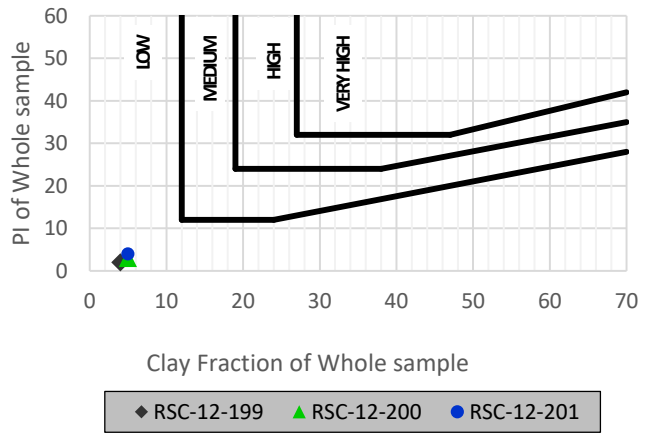
Client Name: RockSoil Consult (Pty) Ltd
Project Name: Olifantsnek
Job Number: RSC-12
Date: 2019-08-12
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

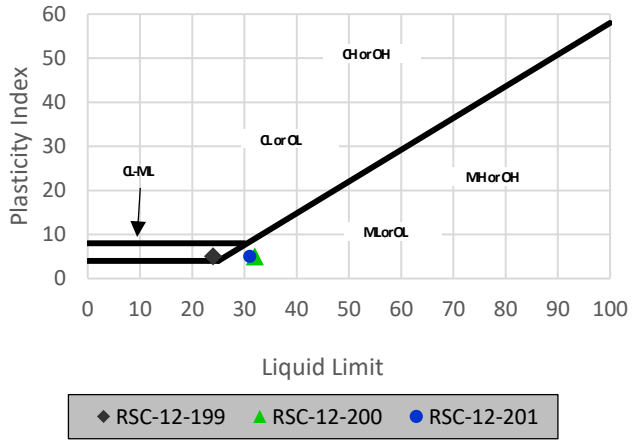
FOUNDATION INDICATOR



Potential Expansiveness



Casagrande Plasticity Chart



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Client Name: RockSoil Consult (Pty) Ltd
Project Name: Olifantsnek
Job Number: RSC-12
Date: 2019-08-12
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	TP06	TP08	TP09	Sample	TP06	TP08	TP09
Depth (m)	1.0 - 1.2	1.0 - 1.2	1.3 - 1.5	Depth (m)	1.0 - 1.2	1.0 - 1.2	1.3 - 1.5
Lab No	RSC-12-202	RSC-12-203	RSC-12-204	Lab No	RSC-12-202	RSC-12-203	RSC-12-204
53.0	**100**	**100**	**100**	Liquid Limit (%)	**32**	**32**	**34**
37.5	**100**	**100**	**100**	Plastic Limit (%)	**19**	**25**	**28**
26.5	**100**	**100**	**94**	Plasticity Index (%)	**13**	**7**	**6**
19.0	**99**	**93**	**85**	Linear Shrinkage (%)	**7.5**	**4.0**	**2.5**
13.2	**98**	**87**	**79**	PI of whole sample	**12**	**4**	**2**
9.5	**98**	**81**	**67**				
6.7	**98**	**75**	**58**	% Gravel	**5**	**36**	**54**
4.75	**97**	**71**	**54**	% Sand	**44**	**37**	**28**
2.00	**95**	**64**	**46**	% Silt	**29**	**20**	**16**
1.00	**93**	**62**	**43**	% Clay	**22**	**7**	**2**
0.425	**92**	**60**	**40**	Activity	**0.6**	**1.0**	**3.0**
0.250	**91**	**59**	**38**				
0.150	**88**	**57**	**34**	% Soil Mortar	**95**	**64**	**46**
0.075	**68**	**45**	**26**				
0.060	**51**	**27**	**18**	Grading Modulus	**0.45**	**1.31**	**1.88**
0.050	**47**	**24**	**15**	Moisture Content (%)	**N / T**	**N / T**	**N / T**
0.035	**41**	**17**	**10**	Relative Density (SG)*	**2.65**	**2.65**	**2.65**
0.020	**36**	**13**	**7**				
0.006	**27**	**10**	**5**	Unified (ASTM D2487)	**CL**	**GM**	**GM**
0.002	**22**	**7**	**2**	AASHTO (M145-91)	**A - 6**	**A - 4**	**A - 2 - 4**

Remarks: *: Assumed
N / T: Not Tested

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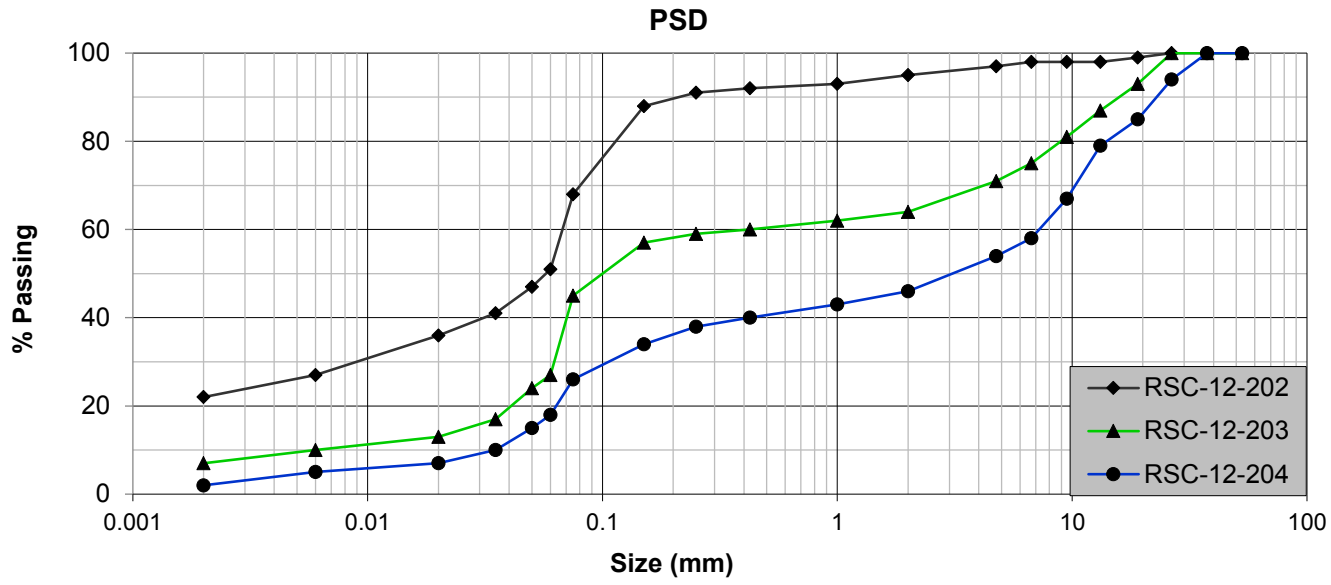
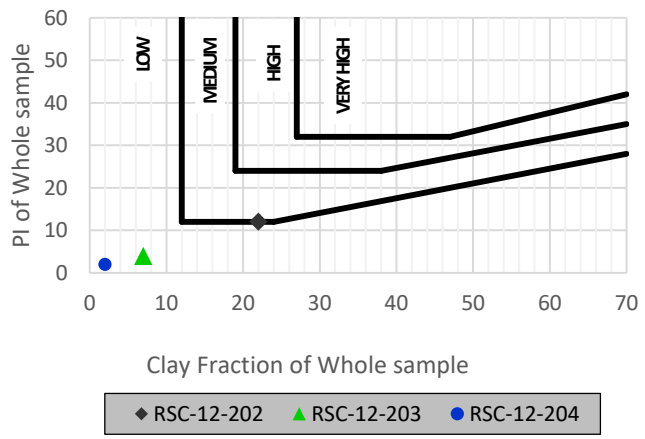
Client Name: RockSoil Consult (Pty) Ltd
Project Name: Olifantsnek
Job Number: RSC-12
Date: 2019-08-12
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

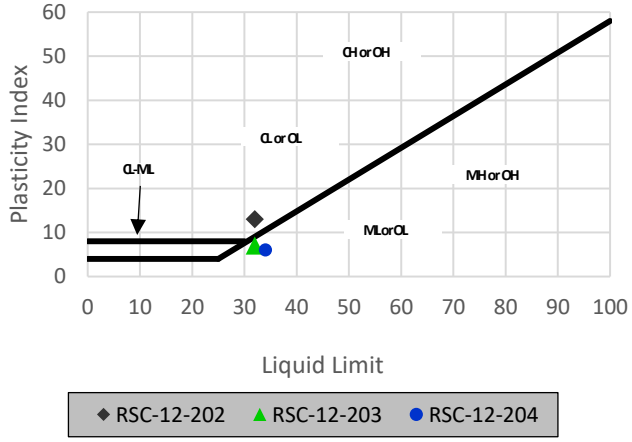
FOUNDATION INDICATOR



Potential Expansiveness



Casagrande Plasticity Chart



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FOUNDATION INDICATOR

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	TP10			Sample	TP10		
Depth (m)	0.6 - 0.8			Depth (m)	0.6 - 0.8		
Lab No	RSC-12-205			Lab No	RSC-12-205		
53.0	**100**			Liquid Limit (%)	**41**		
37.5	**100**			Plastic Limit (%)	**21**		
26.5	**100**			Plasticity Index (%)	**20**		
19.0	**99**			Linear Shrinkage (%)	**10.0**		
13.2	**99**			PI of whole sample	**18**		
9.5	**99**						
6.7	**99**			% Gravel	**6**		
4.75	**98**			% Sand	**38**		
2.00	**94**			% Silt	**26**		
1.00	**92**			% Clay	**30**		
0.425	**91**			Activity	**0.7**		
0.250	**90**						
0.150	**88**			% Soil Mortar	**94**		
0.075	**73**						
0.060	**56**			Grading Modulus	**0.42**		
0.050	**52**			Moisture Content (%)	**N / T**		
0.035	**46**			Relative Density (SG)*	**2.65**		
0.020	**42**						
0.006	**36**			Unified (ASTM D2487)	**CL**		
0.002	**30**			AASHTO (M145-91)	**A - 7 - 6**		

Remarks: *: Assumed
N / T: Not Tested

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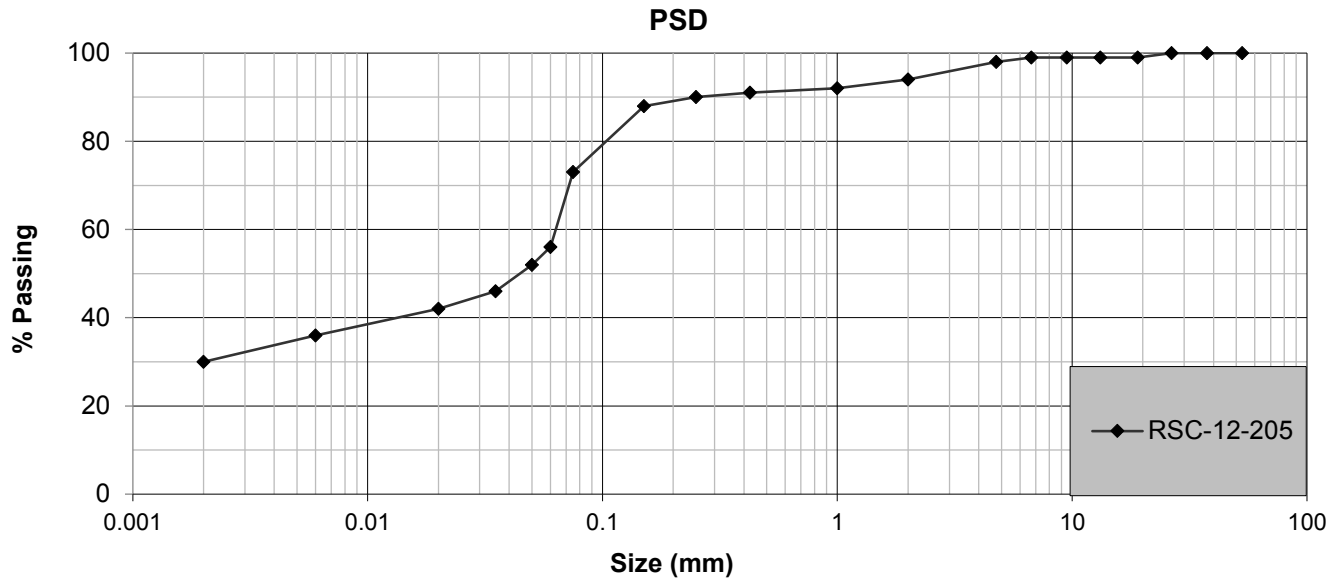
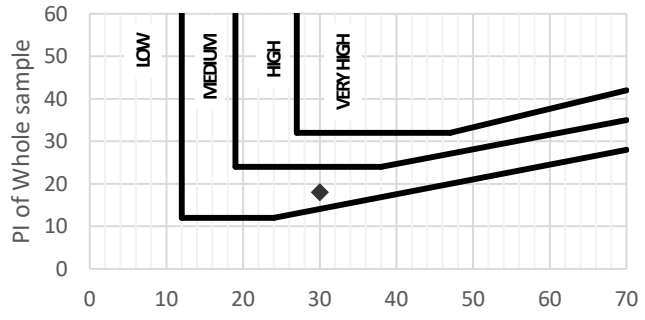
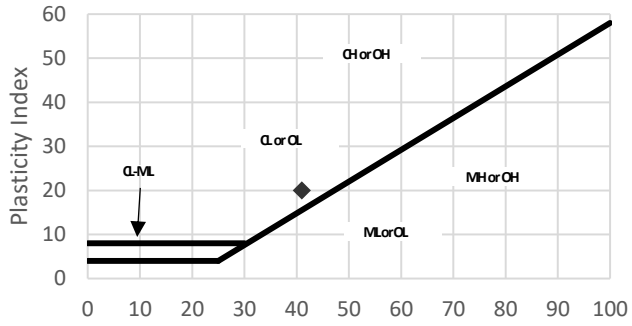


Potential Expansiveness



Casagrande Plasticity Chart



Appendix E: Reference Tables

Table E5: Descriptors for moisture condition (SANS 633:2012 Edition 1)

Table E6: Descriptors for predominant colour (SANS 633:2012 Edition 1)

Table E7: Descriptors for secondary colour patterns (SANS 633:2012 Edition 1)

Table E8: Descriptors for consistency of granular soils (SANS 633:2012 Edition 1)

Table E9: Descriptors for consistency of cohesive soils (SANS 633:2012 Edition 1)

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Table E20: Descriptors of rock texture (SANS 633:2012 Edition 1)

Table E21: Typical material properties (Unified Soil Classification System)

Table E22: Material properties after NAVFAC DM7 (1971)

Table E23: Shear strength parameters for slow draining cohesive materials

Table E24: Shear strength parameters for quick draining non-cohesive materials

Table E5 – Descriptors for moisture condition (SANS 633:2012 Edition 1)

Descriptor	Field identification
Dry	No moisture detectable.
Slightly moist	Moisture just discernible. Soil just below optimum moisture content.
Moist	Moisture easily discernible. Soil at or near optimum moisture content.
Very moist	Moisture above optimum moisture content. Soil close to saturation but no seepage evident.
Wet	Generally at or below water table. Soil saturated and usually with seepage.

Table E6 – Descriptors for predominant colour (SANS 633:2012 Edition 1)

<table>
<tr><th rowspan="2">Basic descriptor</th><th colspan="2">Term</th></tr>
<tr><th>Type 1</th><th>Type 2</th></tr>
<tr><td>Pink</td><td>Pinkish</td><td rowspan="13">Very light
Light
Dark
Very dark</td></tr>
<tr><td>Red</td><td>Reddish</td></tr>
<tr><td>Orange</td><td>Orangey</td></tr>
<tr><td>Yellow</td><td>Yellowish</td></tr>
<tr><td>Brown</td><td>Brownish</td></tr>
<tr><td>Olive</td><td rowspan="2">Greenish</td></tr>
<tr><td>Green</td></tr>
<tr><td>Blue</td><td>Bluish</td></tr>
<tr><td>Purple</td><td>Purplish</td></tr>
<tr><td>Grey</td><td>Greyish</td></tr>
<tr><td>Black</td><td></td></tr>
<tr><td>White</td><td></td></tr>
</table>

Table E7 – Descriptors for secondary colour patterns (SANS 633:2012 Edition 1)

Descriptor	Pattern description
Speckled	Very small patches of colour < 6 mm.
Mottled	Irregular patches of colour 6 mm to 60 mm.
Blotched	Large irregular patches of colour > 60 mm.
Banded [a]	Approximately parallel bands of varying colour.
Streaked [a]	Randomly orientated streaks of colour.
Stained	Local colour variations associated with discontinuity surfaces.
[a] Describe thickness using bedding thickness criteria, e.g. thickly banded or thinly streaked.	

Table E8 – Descriptors for consistency of granular soils (SANS 633:2012 Edition 1)

Descriptor	Field identification
Very loose	Crumbles very easily when scraped with a geological pick.
Loose	Small resistance to penetration by the sharp end of a geological pick.
Medium dense	Considerable resistance to penetration by the sharp end of a geological pick.
Dense	Very high resistance to penetration of the sharp end of a geological pick. Requires many blows of a geological pick for excavation.
Very dense	High resistance to repeated blows of a geological pick. Requires power tools for excavation.

Table E9 – Descriptors for consistency of cohesive soils (SANS 633:2012 Edition 1)

Descriptor	Field identification
Very soft	Pick head can easily be pushed in up to the shaft of the handle. Easily moulded with fingers.
Soft	Easily penetrated by thumb. Sharp end of pick can be pushed in 30 mm to 40 mm. Moulded with some pressure.
Firm	Indented by thumb with effort. Sharp end of pick can be pushed in up to 10 mm. Very difficult to mould with fingers. Can just be penetrated with an ordinary hand spade.
Stiff	Penetrated by thumbnail. Slight indentation produced by pushing pick point into the soil. Cannot be moulded with fingers. Requires hand pick for excavation.
Very stiff	Indented by thumbnail with difficulty. Slight indentation produced by blow of pick point. Requires power tools for excavation.

Table E10 – Descriptors for the structure of soils (SANS 633:2012 Edition 1)

Descriptor	Field identification
Intact [a]	Structureless. No discontinuities identified. An absence of fissures or joints.
Fissured	Soil contains discontinuities that can be open or closed, stained or unstained and of variable origin. When cut with a pick, the soil tends to break along these discontinuities.
Slickensided [b]	Discontinuity surfaces are smooth or glassy and possibly striated.
Shattered [a]	Very closely to extremely closely spaced discontinuities resulting in gravel-sized soil fragments which are usually stiff to very stiff and difficult to break down. Presence of fissures in which joints have opened up and permitted the entry of air. The soil fragments are usually cubical or granular fragments and are broken up when the soil is cut with a pick.
Micro-shattered [c]	As for shattered, but sand-sized fragments. When micro-shattering is well developed and the soil is cut with a pick, it appears granular but these grains break down into a clay or silt or some combination of clay and silt when rubbed with water on the palm of the hand.
Stratified, laminated, foliated [d]	Identifiable geological patterns in transported soils and relict structures in residual soils. [e]
Pinholed	Pinhole-sized voids or pores (up to approximately 2 mm) which might require a hand lens to identify. [f]
Honeycombed	Similar to pinholed but voids and pores greater than 2 mm (pore size may be specified in millimetres). [g]
Matrix-supported	Clasts supported by matrix.
Clast-supported	Clasts touching (matrix might or might not be present).

[a] This term is only typically used in the description of cohesive soils.

[b] Slickensides might be a sign of fairly recent shearing movements in the soil, but similar shiny surfaces can also be developed on joint planes along which there has been no displacement. The direction of slickensides should be recorded as that can be a major indicator/warning of ground movement.

[c] Often associated with expansive soils.

[d] These and other geological terms may be used to describe sedimentary structures.

[e] Many residual soils show the structure of the parent rock (stratified, laminated, foliated, etc.) from which they are derived. Observation of this structure often provides an indication of the parent rock material, e.g. type of bedding might provide a clue to the origin of residual soils. In some transported soils, stratified materials consist of alternating layers of various colours or textures. If the layers are less than approximately 6 mm thick, the structure may be described as laminated (varved if the soil is silty or clayey).

[f] Often indicative of potentially collapsible or dispersive soil types (or both).

[g] Often associated with weathered and leached crystalline rocks and is indicative of potentially collapsible or dispersive soil types (or both).

Table E11 – Descriptors for spacing of structures in soil (SANS 633:2012 Edition 1)

Descriptor	Spacing (mm)
Very widely	> 2 000
Widely	600 to 2 000
Medium	200 to 600
Closely	60 to 200
Very closely	20 to 60
Extremely closely	< 20

Table E12 – Descriptors for degree of prominence of structures (SANS 633:2012 Edition 1)

Descriptor	Field identification
Faint(ly)	Poorly formed, closed, barely observable until disturbed.
Distinct(ly)	Well formed and observable, but closed.
Very distinct(ly)	Well formed and open.

Table E13 – Primary descriptors for soil texture (SANS 633:2012 Edition 1)

Descriptor	Subdivision	Particle size (mm)	Field identification test
Boulders	-	> 200	Observed with naked eye.
Cobbles	-	60 to 200	
Gravel	Coarse	20 to 60	
	Medium	6 to 20	
	Fine	2 to 6	
Sand	Coarse	0.6 to 2	Particles are visible to the naked eye. Sand is clearly distinguishable by the presence of gritty particles which do not break down when rubbed with water on the palm of the hand.
	Medium	0.2 to 0.6	
	Fine	0.06 to 0.2	Gritty feel on teeth.
Silt	-	0.002 to 0.06	Silt particles are barely felt when rubbed on the palm of the hand with water. When a small quantity of the wetted soil is placed on the tongue, the particles can be felt grating against the enamel of the teeth. Chalky feel on teeth.
Clay	-	< 0.002	In general the particles are flaky and, when rubbed on the palm of the hand with water, have a soapy or greasy feel. There is no sensation of grittiness when placed between the tongue and the teeth. Soils hands. Shiny when wet.
NOTE Most natural soils are a combination of one or more textures and, in describing a soil, the adjective is used to denote the lesser type, e.g. a silty clay is a clay with some silt. A silt-clay, however, has approximately equal proportions of silt and clay.			

Table E14 – Descriptors for gravels, cobbles and boulders (SANS 633:2012 Edition 1)

Parameter	Descriptor	Field identification
Packing	Matrix-supported	Clasts supported by matrix
	Clast-supported	Clasts touching (matrix might or might not be present)
Shape, where applicable, e.g. Karoo mudrocks	Blocky	Length ≈ width ≈ thickness
	Platy	Length ≈ width > thickness
	Elongated	Length > width ≈ thickness
	Bladed	Length > width > thickness
	Irregular	-
Angularity	Well-rounded	Nearly spherical
	Rounded	Generally rounded, convex, no flat surfaces
	Subrounded	All corners rounded off
	Subangular	Corners slightly bevelled
	Angular	Corners sharp or irregular
Surface characteristics	Glassy	Conchoidal
	Smooth	Water worn or smooth due to fracture of laminated or fine-grained rock
	Granular	Surface showing medium to coarse sedimentary grains
	Rough	Rock containing no easily visible crystalline constituents
	Crystalline	Containing easily visible crystalline constituents
	Pitted	With visible pores and cavities
Rock hardness	Very soft	Material crumbles under firm (moderate) blows with sharp end of geological pick and can be peeled off with a knife. It is too hard for a triaxial sample to be cut by hand.
	Soft	Can just be scraped and peeled with a knife. Indentations of 1 mm to 3 mm show in the specimen with firm (moderate) blows of the pick point.
	Hard	Cannot be scraped or peeled with a knife. Hand-held specimen can be broken with the hammer end of a geological pick with a single firm (moderate) blow.
	Very hard	Hand-held specimen breaks with the hammer end of a pick under more than one blow.
	Extremely hard (very, very hard)	Specimen requires many blows with a geological pick to break through intact material.
Rock type	As appropriate	

Table E15 – Descriptors of origins of transported soils (SANS 633:2012 Edition 1)

Descriptor of origin	Agency of transportation	Problems to be expected
Littoral and mobile dune sands	Waves, current and tides	Collapsible fabric Instability of dredged marine deposits Excavations High soluble salt content Variable carbonate cementation
Estuarine and deltaic	Tidal rivers depositing into saline water	Compressibility Variability Sensitivity Quick-sand High soluble salt content
Talus (coarse colluvium)	Gravity (mass-wasting processes)	Slope instability
Silty or clayey hillwash (fine colluvium)	Sheetwash	Expansive characteristics Compressibility Dispersive characteristics
Aeolian	Wind	Collapsible fabric Mobility(dunes) Poor compaction characteristics
Sandy soils of mixed origin	Sheetwash, wind, termites	Collapsible fabric Dispersive characteristics Compressibility Subject to flooding
Alluvium	Streams	Expansive characteristics Dispersive characteristics Compressibility Subject to flooding
Lacustrine	Streams depositing into lakes, pans, or vleis	Compressibility Expansive characteristics High soluble salt content

Table E16 – Pedocrete classification (SANS 633:2012 Edition 1)

Descriptor	Field identification
Calcareous[a] soil	Soils (clay, silt, sand, gravel, etc.) with little or no cementation or nodular concentrations, but that contain some mineralization (calcareous soil effervescence).
Calcified[a] soil	A relatively massive platy soil which has been indurated by cementation to a firm or stiff consistency.
Powder pedocrete[b]	Mainly loose silt and fine sand-sized cemented or aggregated particles of nearly pure mineral, with few or no host soil particles or nodules. Any nodules present are generally weak.
Nodular pedocrete[b]	Silt to gravel-sized nodules of cemented host soil. Usually in a matrix of calcareous soil. Overall consistency of horizon might be loose. Nodules can be firm to very hard rock.
Honeycombed pedocrete[b]	Stiff to very hard coalesced nodular pedocrete with loose or soft soil filled voids. Can also occur as fissure filling in weathered rock resulting in a boxwork structure
Hardpan pedocrete[b]	Stiff to very hard rock, cemented, relatively massive and impermeable sheet-like horizon. Normally overlying weaker pedocrete forms. Hardpan can be structureless, jointed or contain a variety of structures or voids.
Boulder/cobble pedocretes[b]	Discrete or partially connected boulder and cobble-sized fragments usually in a non-mineralized or weakly mineralized soil formed by the weathering of hardpan. Fragments usually very hard.
[a] Substitute the terms ferruginous, manganiferous, siliceous, ferrugenised, or silicified, as appropriate. [b] Substitute the terms calcrete, ferricrete, silcrete, or manganocrete, as appropriate.	

Table E17 – Descriptors of the degree of cementation of pedocretes (SANS 633:2012 Edition 1)

Descriptor of degree	Field identification
Very weakly cemented	Some material can be crumbled between finger and thumb. Disintegrates under knife blade to a friable state.
Weakly cemented	Cannot be crumbled between strong fingers. Some material can be crumbled by strong pressure between thumb and a hard surface. Under light hammer blows disintegrates into friable state
Moderately cemented	Material crumbles under firm blows of sharp pick point. Grains can be dislodged with some difficulty with knife blade.
Strongly cemented	Firm blows of sharp pick point on hand-held specimen show 1 mm to 3 mm indentations. Grains cannot be dislodged with knife blade.
Very strongly cemented	Hand-held specimen can be broken by a single firm blow of hammerhead. Similar appearance to concrete.

Table E18 – Qualifications to descriptors for rotary percussion borehole samples (SANS 633:2012 Edition 1)

Qualification	Usage
Traces	The subordinate amount is less than 10 % of the total sample.
Minor	The subordinate amount is between 10 % and 30 % of the total sample.
Abundant	The subordinate amount is between 30 % and 50 % of the total sample.
Equal amounts	The major fractions occur in equal amounts.

Table E19 – Descriptors for degree of weathering (SANS 633:2012 Edition 1)

Descriptor	Surface characteristics	Diagnostic feature				
		Discolouration extent	**Fracture condition**	**Surface appearance**	**Original texture**	**Grain boundary condition**
Unweathered	No visible signs of alteration in the rock material but discontinuity planes can be stained.	None.	Closed or discoloured.	Unchanged.	Preserved.	Tight.
Slightly weathered	Discontinuities are stained or discoloured and might contain a thin filling of altered material. Unweathered rock colour is generally preserved. Discolouration might extend into the rock from the discontinuities.	< 20 % of fracture spacing on both sides of fracture.	Discoloured. Might contain thin filling.	Partial discolouration.	Preserved.	Tight.
Moderately weathered	Slight discolouration extends from discontinuities for a distance greater than 20 % of their spacing (i.e. generally greater part of the rock). Discontinuities might contain filling of altered material. The surface of the core is not friable (except in the case of poorly cemented sedimentary rocks) and the original fabric of the rock has been preserved. Partial opening of grain boundaries might be observed.	> 20 % of fracture spacing on both sides of fracture.	Discoloured. Might contain thick filling.	Partial to complete discolouration. Not friable except poorly cemented rocks.	Preserved.	Partial opening.
Highly weathered	Friable and possibly pitted. Discolouration extends throughout core. The surface of the core is friable and usually pitted due to washing out of highly altered minerals by drilling water. The original fabric of the rock has mainly been preserved but separation of grains has occurred. Not easily indented with a knife, does not slake in water.	Throughout.	-	Friable and possibly pitted.	Mainly preserved.	Partial separation.
Completely weathered	Resembles soil. The core is totally discoloured, though internally the rock fabric is partly preserved but grains have completely separated. Easily indented with a knife, slakes in water.	Throughout.	-	Resembles soil.	Party preserved.	Complete separation.
NOTE The boundary between soil and rock is defined in terms of strength or hardness and not in terms of weathering.						

Table E20 – Descriptors of rock texture (SANS 633:2012 Edition 1)

Descriptor	Size (mm)	Field identification
Very fine grained	< 0.2	Individual grains cannot be seen with a hand lens.
Fine grained	0.2 to 0.6	Visible as individual grains under hand lens.
Medium grained	0.6 to 2.0	Grains clearly visible under hand lens, just visible to the naked eye.
Coarse grained	2.0 to 6.0	Grains clearly visible to the naked eye.
Very coarse grained	> 6.0	Grains measurable.

TABLE E21: 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 E22: 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

TABLE E23: Shear strength parameters for slow draining cohesive materials

	Consistency	Rule of thumb Field identification	Unconfined Compressive Strength (kN/m^2)	UCS (kPa) (COP4)	UCS (kPa) (Terz & Peck)	Approximate SPT (N)
S.1	Very soft	Easily moulded by fingers. Full pick penetration	< 40	< 35	<25	<2
S.2	Soft	Easily penetrated by with thumb. Moulded with strong pressure. 30 to 40mm penetration	40 to 80	35 to 75	25 to 50	2 to 4
S.3	Firm	Indent by thumb with effort. Very difficult to mould with fingers. 10mm penetration	80 to 160	75 to 150	50 to 100	4 to 8
S.4	Stiff	Penetration by thumb nail. Cannot be moulded with fingers. Geologist pick (sharp end) makes slight indentation when pushed.	160 to 320	150 to 300	100 to 200	8 to 15
S.5	Very stiff	Indentation by thumb nail difficult. Slight indentation with blow of geologist pick. Power tools required for excavation.	320 to 1000	> 300	200 to 400	15 to 50

TABLE E24: Shear strength parameters for quick draining non-cohesive materials

Consistency	Rule of thumb Field identification	Approx CPT (MPa)	Approx SPT (N)	Approximate ϕ`	Typical Dry Density (kg/m^3)
Very loose	Crumbles very easily when scraped with geological pick	0 to 2	0 to 5	26 to 28	< 1450
Loose	Small resistance to penetration by sharp end of geological pick	2 to 4	5 to 10	28 to 30	1 450 to 1 600
Medium dense	Considerable resistance to penetration by sharp end of geological pick	4 to 9	10 to 30	30 to 35	1 600 to 1 750
Dense	Very high resistance to penetration of sharp end of geological pick. Requires many blows of pick for excavation	9 to 12.5	30 to 50	35 to 40	1 750 to 1 950
Very dense	High resistance to repeated blows of geological pick. Requires power tools for excavation	< 12.5	> 50	40 to 50	> 1 950