GEOTECHNICAL CONDITIONS ON PLOT 113, GARIEP SETTLEMENT: A REPORT FOR THE EXPANSION AND FORMALISATION OF GARIEP COMMUNITY

2020/J09/MCP_01

ON BEHALF OF : MACROPLAN

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EXECUTIVE SUMMARY

1 INTRODUCTION

It is envisaged to develop some 15 hectare of land on Plot 113 of Gariep Settlement as an expansion and formalization of the existing Gariep community. For this purpose Cedar Land Geotechnical Consult (Pty) Ltd was appointed as sub consultant to Macroplan to conduct a geotechnical investigation on the property.

2 SITE DESCRIPTION

2.1 Site Location

The village of Gariep is located directly to the east of the Orange River and the National Route 10 between Upington and Groblershoop in the Northern Cape. It is some 40 km from Groblershoop. The area of investigation consisting of Plot 113, Gariep Settlement is located on the perimeter of the village, on the northern, western, eastern and southern sides thereof. The size of the property is 15 hectare.

2.2 Topography and Drainage

The land investigated is located between 843,0mamsl and 863,0mamsl. Topographical it can be described as a ridge striking virtually due north to south located centrally to the existing village. Drainage takes place by means of surface sheetwash. The sheetwash is disposed of east and west according to land slope by means of five small, non-perennial streams.

2.3 Vegetation and Landscape

The area of investigation is referred to as Bushmanland Arid Grassland. The landscape features are described as consisting of extensive to irregular plains on a slightly sloping plateau sparsely vegetated by grassland dominated by white grasses giving this vegetation type the character of semi-desert steppe. In places low shrubs change the vegetation structure. On site it was found that in the areas where natural vegetation is present it consists of a sparse stand of Acacia melliflora and prosopis glandula.

2.4 Climatic Conditions

The Thornthwaithe moisture index is less than -40 ; and the Weinert N value approximately 35. The climate can thus be described as arid. The importance of this is that mechanical breakdown of bedrock will take place rather than chemical decomposition, limiting the formation of secondary minerals such as expansive montmorillonite clay.

2.5 Existing Facilities

The village is characterized by the widespread presence of waste material, consisting of domestic waste, stockpiles of gravels and domestic waste. The area of investigation can be divided into zones of informal housing and vacant land.

3 NATURE OF INVESTIGATION

3.1 Test Pitting

In compliance with the requirements of SANS 634 and GFSH-2 test pitting was conducted to provide applicable geotechnical information. Seventeen test pits were excavated with a Bell 315SK TLB on hire from ALS Plant Rentals. The TLB was equipped with a 600mm wide bucket. All test pits were excavated to refusal. The test pits were profiled by a professionally registered geotechnical engineer.

3.2 Materials Testing

Due to general limited vertical extent of the soil profile and coarse nature thereof, it was not feasible to retrieved undisturbed samples to determine properties of settlement or collapse fairly accurately. Soil testing consisted of the following :

- *Conductivity and pH determinations on four samples of the in-situ materials to determine the corrosivity thereof.*
- *Foundation indicator testing on six samples of the in-situ materials to determine possible conditions of heave or settlement.*
- *CBR and road indicator testing on two samples to determine the suitability of the in-situ materials to be utilized as road layerworks.*

4 GEOLOGY, SOILLS AND GROUNDWATER

4.1 Geology

The area of investigation is located on a subduction zone dating approximately 1000 million years old. The zone is located between the lithology of the Kaapvaal Craton and the Namaqua-Natal mobile belt. The remains of the original geology in the area are referred to as the Kaaien Terrane and the site is located on the Groblershoop Formation of the Brulpan Group. Quartz-muscovite schist is present on site and described as dirty white streaked light grey, very closely vertically jointed, intensely laminated, slightly weathered, hard rock.

4.2 Soil Profile

4.2.1 River Terrace Gravels

Terrace gravels are described as abundant clast supported, coarse, rounded gravels and cobbles of banded ironstone, quartz and quartzite in a matrix of light brown, fine sand. Cobbles of dolerite have also been encountered in the gravels. The consistency of the terrace gravels is medium dense and the thickness of the horizon varies between 200mm and 1100mm, but usually less than 500mm in the test pits.

4.2.2 Mokalanen Formation

Hardpan calcrete underlies the terrace gravels in virtually a continuous cover over the quartz-muscovite schist, with the schist outcropping occasionally only in limited areas of localized extent. The calcrete is present as very dense hardpan calcrete from depths between 100mm and 1100mm minimum, extending to 300mm to 1100mm maximum, at which stage refusal of excavation occurred.

4.3 Groundwater

4.3.1 Perched Water

Perched groundwater was not encountered in any of the test pits excavated for this investigation. It is anticipated that perched water will generally not prove problematic on the site.

4.3.2 Permanent Groundwater

The probability for drilling successfully for water in the area is between 40% and 60%, and the probability that such a borehole will yield more than $2ls^{-1}$ is between 10% and 20%. Groundwater is expected to occur at depths less than 15 meters in compact, argillaceous strata.

5 CONDITIONS OF EXCAVATION

On average over the entire site bedrock or refusal of excavation on very dense hardpan calcrete was encountered at depths between 200mm minimum and 1100mm maximum, averaging 480mm deep. The implication of this is that should trenches require excavated depths to 1000mm, 52% of the excavation may be classified as hard, requiring drilling and blasting. Should the required depth of excavation increase to 1500mm, 68% of the excavation may be classified as hard.

Irrespective of which method of excavation is considered, the most important issue is that across the

entire site bedrock and hardpan calcrete that can be regarded as hard rock excavation.

6 SITE CLASS DESIGNATION

It is concluded that the entire area is regarded as suitable for residential development as follows :

6.1 Geotechnical Zone I

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The distribution thereof encompasses 87% of the proposed area for development. Slope across the land is approximately between 2% and 6%. The use of slab-on-the-ground foundations will require additional works in the form of the construction of an engineered fill or cutting to establish a level platform for construction. The more viable foundation alternative therefore remains founding by conventional strip foundations.

6.2 Geotechnical Zone II

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The distribution thereof encompasses 6% of the proposed area for development. Slope across the land is less than 2%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on bedrock or very dense pedocrete.

6.3 Geotechnical Zone III

The zone is classed as S, meaning that the proposed horizon for founding is slightly compressible and rapid settlement less than 10mm is expected. The distribution thereof encompasses 2,5% of the proposed area for development. Slope across the land is between 2% and 6%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on medium dense terrace gravels. The more viable foundation alternative therefore remains founding by conventional strip foundations.

6.4 Geotechnical Zone IV

The zone is classed as S, meaning that the proposed horizon for founding is slightly compressible and rapid settlement less than 10mm is expected. The distribution thereof encompasses 4,5% of the proposed area for development. Slope across the land is less than 2%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to

the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on medium dense terrace gravels.

7 SURFACE HYDROLOGY

The non-perennial water courses on site are contained in well-defined, narrow gullies and may be regarded as being of lesser importance, requiring no additional precautionary measures to ensure the safety of the population against flooding.

8 MATERIALS UTILIZATION

- *Trench Backfilling : None of the materials are suitable for selected fill or pipe bedding. With exception of the hardpan calcrete all materials can be used for normal backfill.*
- *Layerworks for Paved or Segmental Block Paving : The residual soils are suitable for the construction of in-situ selected layerworks.*
- *Wearing Course for Gravel Roads in Urban Areas : All of the soil materials can be used for the construction of a gravel wearing course although none of them are 100% suitable for this purpose. The use of these materials may result in a road surface subject to raveling and corrugations.*

9 OTHER CONSIDERATIONS

- *Undermining : The area is not subject to undermining.*
- *Seismic Activity : The Peak Ground Acceleration expected in 50 years is 0,04g. A low risk for the development of earth tremors therefore exist.*
- *Soil Corrosivity : The in-situ soils and pedocretes are corrosive due to the high soluble salts content.*
- *Dolomite : The area of investigation is not subject to any restrictions due to the presence of dolomite. Bedrock of dolomite does not occur in the area of investigation.*

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GEOTECHNICAL CONDITIONS ON PLOT 113, GARIEP SETTLEMENT : A REPORT FOR THE EXPANSION AND FORMALISATION OF GARIEP COMMUNITY

1 INTRODUCTION

It is envisaged to develop some 15 hectare of land on Plot 113 of Gariep Settlement as an expansion and formalization of the existing Gariep community. For this purpose Cedar Land Geotechnical Consult (Pty) Ltd was appointed as sub consultant to Macroplan to conduct a geotechnical investigation on the property as per the minutes of the start-up meeting of the project held in the offices of Macroplan on 20 May 2020.

2 TERMS OF REFERENCE

The requirements of the following documents were adhered to in the conduct of the investigation and reporting of the project :

- The document *Geotechnical Site Investigations for Housing Developments (Generic Specification GFSH-2)*, issued by the National Department of Housing in September 2002.
- The document *SANS 634-1 : Geotechnical Investigations for Township Development*, issued by SABS in February 2012.

3 AVAILABLE INFORMATION

The following source of available information recording available data obtained in the larger Upington to Groblershoop area have been consulted for background information :

- *Breytenbach FJ* : Contract NRA N010-110-2012/1F : Geotechnical Investigation for Four Bridge Widenings on the National Route 10 Section 11 between Groblershoop (km 0,0) and Lambrechtsdrift (km 61,1), issued by Soilkraft cc on behalf of Bvi Engineers on 8 March 2012.

4 SITE DESCRIPTION

4.1 Site Location

The village of Gariep is located directly to the east of the Orange River and the National Route 10 between Upington and Groblershoop in the Northern Cape. It is some 40 km from Groblershoop. The area of investigation consisting of Plot 113, Gariep Settlement is located on the perimeter of the village, on the northern, western, eastern and southern sides thereof. The size of the property is 15 hectare.

Refer to the attached Figure 1 : Locality Plan.

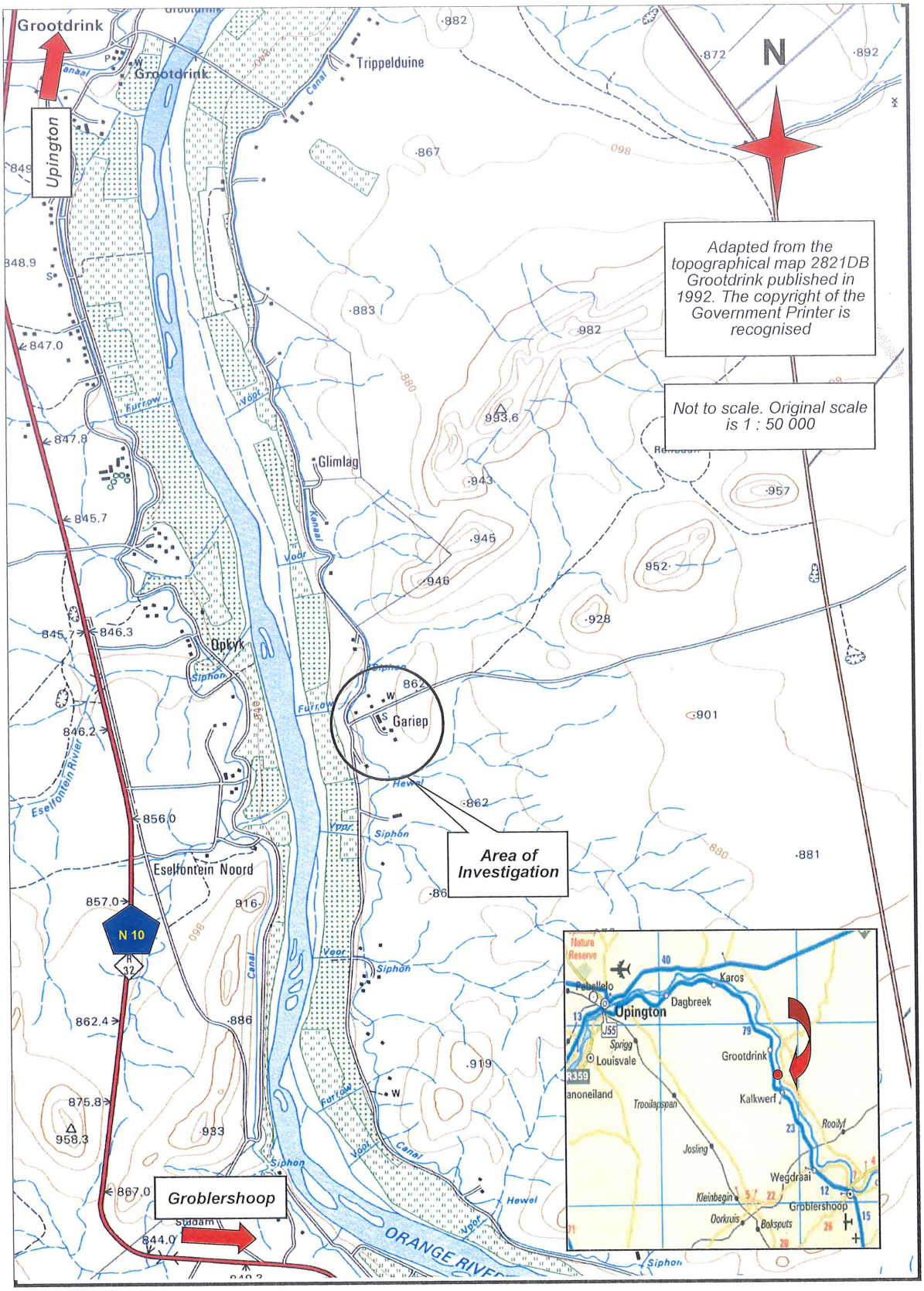
4.2 Topography and Drainage

The land investigated is located between 843,0mamsl and 863,0mamsl. Topographical it can be described as a ridge striking virtually due north to south located centrally to the existing village. The eastern slope of the ridge varies between 2,6% to 8,8% ; and the western slope is fairly constant at 5,5%.

Drainage takes place by means of surface sheetwash. The sheetwash is disposed of east and west according to land slope by means of five small, non-perennial streams. The drainage courses are contained in narrow, steeply sloping and well defined gullies.

4.3 Vegetation and Landscape

Based on the work done by Mucina[Reference 14.1] the area of investigation is referred to as Bushmanland Arid Grassland. The landscape features are described as consisting of extensive to irregular plains on a slightly sloping plateau sparsely vegetated by grassland dominated by white grasses giving this vegetation type the character of semi-desert steppe. In places low shrubs change the vegetation structure. In years of abundant rainfall rich displays of annual herbs can be expected. On site it was found that in the areas where natural vegetation is present it consists of a sparse stand of Acacia melliflora and prosopis glandula.



C.L.G.C

LOCALITY PLAN

FIGURE 1

4.4 Climatic Conditions

The area is located in a summer-rainfall region with mean annual precipitation between 70mm to 200mm ; mean maximum summer temperature of 38°C and mean minimum winter temperature of -0,6°C. Frost incidence varies between 10 and 35 days per year. The development of whirl winds are common on hot summer days. The Thornthwaithe moisture index is less than -40 ; and the Weinert N value approximately 35. The climate can thus be described as arid. The importance of this is that mechanical breakdown of bedrock will take place rather than chemical decomposition, limiting the formation of secondary minerals such as expansive montmorillonite clay.

4.5 Existing Facilities

Site conditions are illustrated on Photo 1 : Site Conditions. The area is characterized by the widespread presence of waste material, consisting of domestic waste, stockpiles of gravels and human waste.

The area can be divided into two zones as follows :

4.5.1 Informal Housing

Informal housing consisting of galvanized iron structures and some reed structures is present in the eastern and southern parts of the site, directly adjacent to the existing village. Electricity is provided by overhead power lines. Some residents have created small vegetable and flower gardens on the stands.

4.5.2 Vacant Land

Vacant, undeveloped land extends from the existing village to the limits of the area of investigation in all wind directions.

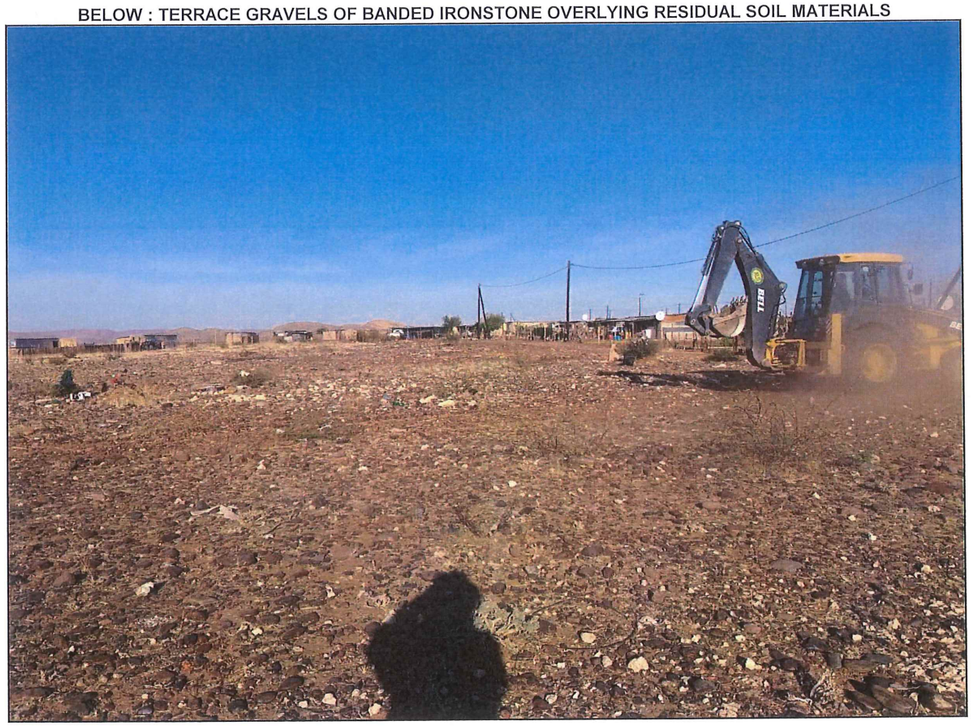
5 NATURE OF INVESTIGATION

5.1 Test Pitting

In compliance with the requirements of SANS 634 and GFSH-2 test pitting was conducted to provide applicable geotechnical information. On 7 July 2020 17 test pits were excavated with a Bell 315SK TLB on hire from ALS Plant Rentals. The TLB was equipped with a 600mm wide bucket. All test pits were excavated to refusal.

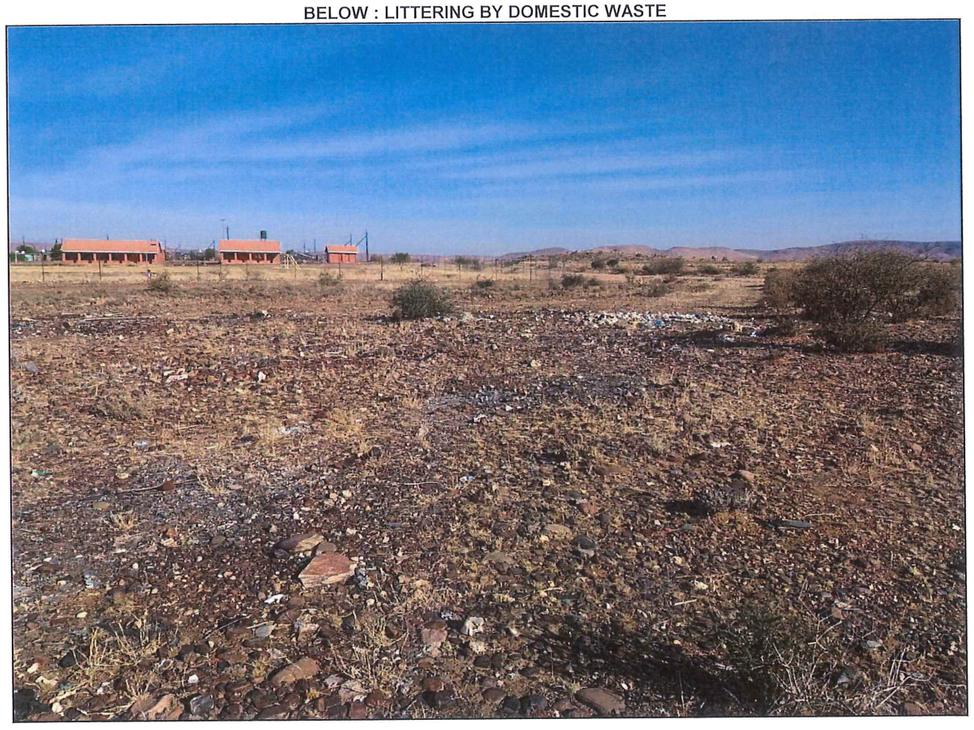
TOP : STEEPLY DIPPING QUARTZ-MUSCOVITE SCHIST

BELOW : TERRACE GRAVELS OF BANDED IRONSTONE OVERLYING RESIDUAL SOIL MATERIALS



TOP : STOCKPILED BOULDERS OF CALCRETE AND BANDED IRONSTONE GRAVELS

BELOW : LITTERING BY DOMESTIC WASTE



C.L.G.C.

CONDITIONS IN GARIEP VILLAGE

PHOTO 1

The test pits were profiled by a professionally registered geotechnical engineer. For the benefit of the non-geotechnical reader of this document, the guidelines for test pit profiling are summarized in the attached Table 1 : Soil Profiling Parameters. The profiles of the test pits may be found in Addendum A to this report. The positions of the test pits are indicated on the attached Figure 2 : Site Plan. Provisional co-ordinates for property beacons A to AX are indicated on this figure.

5.2 Materials Testing

Soil testing was undertaken by Roadlab in Upington. As a matter of quality control duplicate samples were sent to the Roadlab branch in Germiston for independent testing to verify the results. Due to general limited vertical extent of the soil profile and coarse nature thereof, it was not feasible to retrieved undisturbed samples to determine properties of settlement or collapse fairly accurately.

Soil testing consisted of the following :

- Conductivity and pH determinations on four samples of the in-situ materials to determine the corrosivity thereof.
- Foundation indicator testing on six samples of the in-situ materials to determine possible conditions of heave or settlement.
- CBR and road indicator testing on two samples to determine the suitability of the in-situ materials to be utilized as road layerworks.

The results of the soil testing may be found in Addendum B. However, for easy reference, these results are summarized in the attached Table 2 : Summary of Soil Testing. The data sheets contained in Addendum B are copies of the originals, which are available from Roadlab.

6 SITE GEOLOGY AND GEOHYDROLOGY

The geology of the area between Upington and Groblershoop appears to consist of granitoid rock in the north, grading into metamoprphic rocks towards Groblershoop, but it is in fact highly complex and from a stratigraphical viewpoint provides a complicated formation. As a background to the site geology an effort is made in this subparagraph to provide a simplified explanation of the regional geology of the area. For this purpose publications by McCarthy[Reference 14.2], Cornell[Reference 14.3] and Moen[Reference 14.4] were consulted. Of these three references, the latter two can be regarded as site specific. However, there is disagreement between these two sources regarding the stratigraphic classification of the major subdivisions of the Namaqua-Natal province. As the work produced by Cornell is regarded as the

TABLE 1 : SOIL PROFILING PARAMETERS

CONSISTENCY : GRANULAR SOILS

SPT N	GRAVELS & SANDS Generally free draining soils		DRY DENSITY (kg/m^3)
<4	Very loose	Crumbles very easily when scraped with geological pick. Requires power tools for	<1450
4-10	Loose	Small resistance to penetration by sharp pick point, requires many blows by pick point	1450-1600
10-30	Medium dense	Considerable resistance to penetration by sharp pick point.	1600-1750
30-50	Dense	Very high resistance to penetration by sharp pick point. Requires many blows by pick point for excavation.	1750-1925
>50	Very dense	High resistance to repeated blows of geological pick. Requires power tools for excavation.	>1925

CONSISTENCY : COHESIVE SOILS

SPT N	SILTS & CLAYS and combinations with SANDS Generally slow draining soils		UCS (kPa)
<2	Very soft	Pick point easlily pushed in 100mm. Easily moulded by fingers.	<50
2-4	Soft	Pick point easlily pushed in 30mm to 40mm. Moulded by fingers with some pressure.	50-125
4-8	Firm	Pick point penetrates to 10mm. Very difficult to mould with fingers.	125-250
8-15	Stiff	Slight indentation by pick point. Cannot be moulded by fingers. Penetrated by thumb nail.	250-500
15-30	Very stiff	Slight indentation by blow of pick point. Requires power tools for excavation.	500-1000

SOIL TYPE

SOIL TYPE	PARTICLE SIZE(mm)
Clay	<0,002
Silt	0,002-0,06
Sand	0,06-2,0
Gravel	2,0-60,0
Cobbles	60,0-200,0
Boulders	>200,0

MOISTURE CONDITION

Dry	No water detectable
Slightly moist	Water just discernable
Moist	Water easily discernable
Very moist	Water can be squeezed out
Wet	Generally below water table

COLOUR

Speckled	Very small patches of colour <2mm
Mottled	Irregular patches of colour 2-6mm
Blotched	Large irregular patches 6-20mm
Banded	Approximately parallel bands of varying colours
Streaked	Randomly orientated streaks of colour
Stained	Local colour variations : Associated with discontinuity surfaces

SOIL STRUCTURE

Intact	No structure present.
Fissured	Presence of discontinuities, possibly cemented.
Slickensided	Very smooth, glossy, often striated discontinuity planes.
Shattered	Presence of open fissures. Soil break into gravel size blocks.
Micro shattered	Small scale shattering, very closely spaced open fissures. Soil breaks into sand size crumbs.
Residual structures	Residual bedding, laminations, foliations etc.

ORIGIN

Transported	Alluvium, hillwash, talus etc.
Residual	Weathered from parent rock, eg residual granite
Pedocretes	Ferricrete, silcrete, calcrete etc.

DEGREE OF CEMENTATION OF PEDOCRETES

TERM	DESCRIPTION	UCS (MPa)
Very weakly cemented	Some material can be crumbled between finger and thumb. Disintegrates under knife blade to a friable state.	0,1-0,5
Weakly cemented	Cannot be crumbled between strong fingers. Some material can be crumbled by strong pressure between thumb and hard surface. Under light hammer blows disintegrate to a friable state.	0,5-2,0
Cemented	Material crumbles under firm blows of sharp pick point. Grains can be dislodged with some difficulty by a knife blade.	2,0-5,0
Strongly cemented	Firm blows of sharp pick point on hand-held specimen show 1-3mm indentations. Grains cannot be dislodged by knife blade.	5,0-10,0
Very strongly cemented	Hand-held specimen can be broken by single firm blow of hammer head. Similar appearance to concrete.	10,0-25

reference document, his approach is adopted for this report.

Some concepts must be identified :

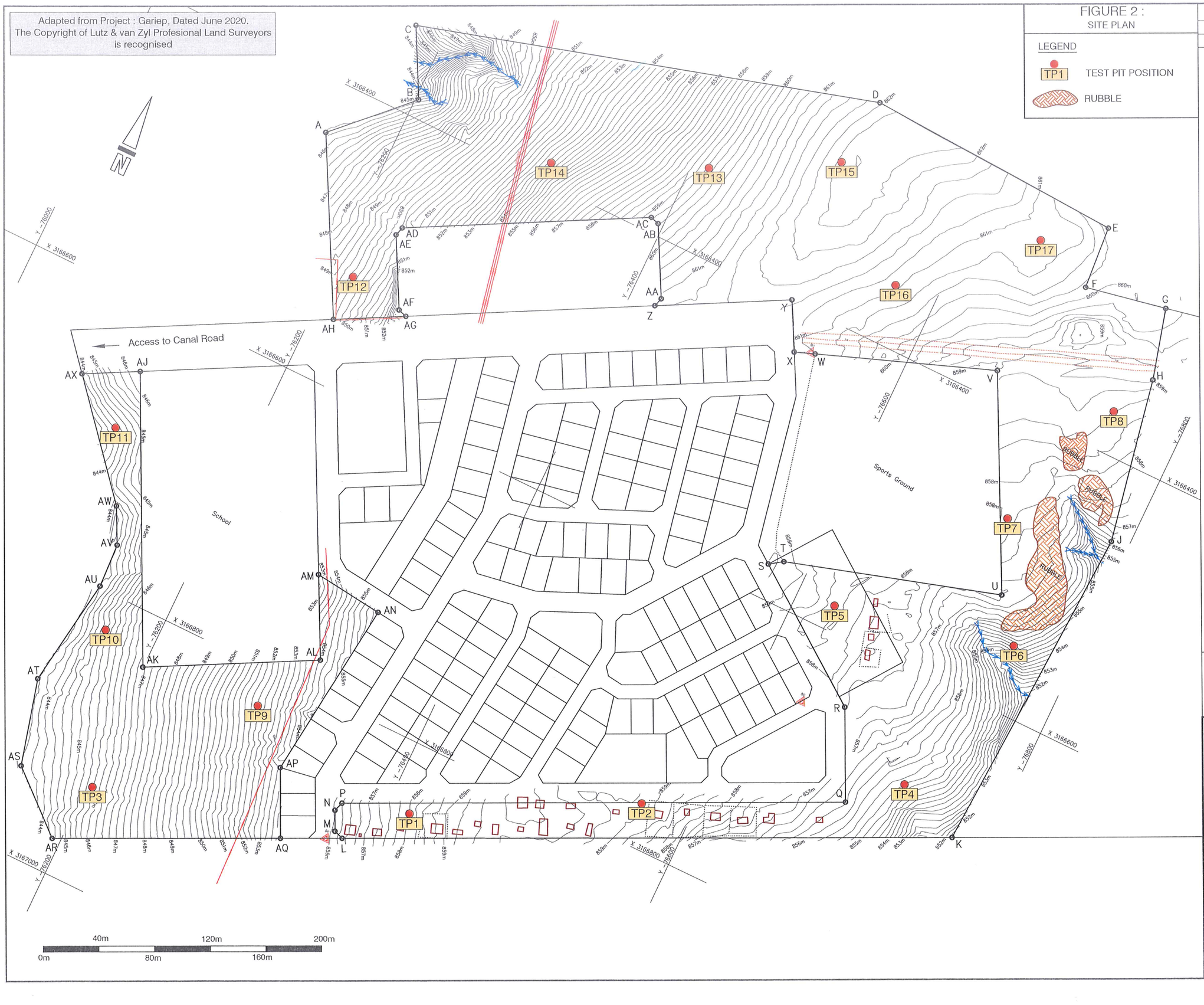
- *Craton* : A craton is a block of ancient crust, formed 3000 million years ago and its rocks have essentially remained unchanged. Cratons form the larger parts of the land-building mass.
- *Province* : A tectono-stratigraphic province is defined as a large area of contiguous structural fabric with well-defined boundaries which formed during a particular, geochronologically defined, tectono-metamorphic event. A province is further subdivided in sub-provinces and sub-provinces into terranes.

FIGURE 2 :
SITE PLAN

LEGEND

TP1 TEST PIT POSITION

RUBBLE



COORDINATES – GARIEP System: WGS84 GW21		
Point	Y	X
A	-76152.634	3166436.928
B	-76202.486	3166387.171
C	-76177.630	3166340.134
D	-76502.665	3166244.808
E	-76689.217	3166254.033
F	-76692.618	3166299.124
G	-76750.990	3166287.700
H	-76764.653	3166337.537
J	-76787.366	3166454.411
K	-76774.950	3166694.270
L	-76381.191	3166884.709
M	-76374.503	3166882.386
N	-76367.971	3166868.900
P	-76370.282	3166862.217
Q	-76695.079	3166704.850
R	-76665.571	3166643.944
S	-76572.422	3166575.684
T	-76581.728	3166569.318
U	-76732.753	3166523.003
V	-76661.050	3166380.140
W	-76538.049	3166426.157
X	-76523.814	3166431.483
Y	-76506.304	3166398.740
Z	-76419.454	3166445.189
AA	-76421.409	3166438.768
AB	-76396.157	3166391.596
AC	-76389.812	3166389.722
AD	-76231.523	3166474.323
AE	-76229.593	3166480.723
AF	-76254.834	3166527.909
AG	-76261.194	3166529.839
AH	-76215.389	3166554.340
AJ	-76106.553	3166648.261
AK	-76199.796	3166837.173
AL	-76312.431	3166777.089
AM	-76284.822	3166722.698
AN	-76334.696	3166728.476
AP	-76319.626	3166858.581
AQ	-76341.591	3166903.892
AR	-76193.789	3166975.495
AS	-76151.347	3166938.564
AT	-76135.294	3166877.453
AU	-76146.967	3166798.645
AV	-76145.423	3166766.901
AW	-76132.772	3166741.936
AX	-76069.531	3166668.060

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TAAK: JOB NAME: Expansion and Formalisation of Gariep Community

LIGGING: SITE: Plot 113, Gariep Settlement

KLIËNT: CLIENT: !Kheis Municipality

TEKENING NO: DRAWING NO: Figure 2 : Site Plan

DATUM: DATE: 30 July 2020

TABLE 2 : SUMMARY OF SOIL TESTING

TEST PIT NO	SAMPLE NO (CLG)	DEPTH (mm)	SOIL ORIGIN	SOIL TYPE	GM	PI	LL	ACTIVITY	pH	CONDUCTIVITY (Sm^{-1})	% < 0,002mm	OMC	MDD	SOIL CLASS		
														COLTO	PRA	UNIFIED
4	U9250	0-1100	Terrace gravels	Gravelly sand	2,20	11	40	Low	7,66	0,06	3,9				A-2-6(0)	GM
7	U9251	0-400	Terrace gravels	Sandy gravel	2,50	7	25	Low			0,8	6,1	2283	G6	A-2-4(0)	GW-GM-GC
9	U9252	100-400	Hardpan calcrete	Sandy gravel	2,20	5	26	Low	7,80	0,09	1,8				A-1-b(0)	GM-GC
11	U9253	100-400	Hardpan calcrete	Sandy gravel	2,10	3	22	Low	8,19	0,08	1,0				A-1-b(0)	GC
14	U9254	0-400	Bedrock schist	Rock fragments	2,20	1	22	Low			0,6	6,9	2254	G6	A-1-b(0)	GM
16	U9255	0-200	Terrace gravels	Sandy gravel	2,10	3	22	Low	7,55	0,08	0,7				A-1-b(0)	GC

- *Terrane* : A terrane is a term for a tectonostratigraphic unit, which is a fragment of crustal material formed on, or broken off from, one tectonic plate and accreted or "sutured" to crust lying on another plate. The crustal block or fragment preserves its own distinctive geologic history, which is different from that of the surrounding areas.

6.1 Regional Geology

The geological processes by which the area under consideration was shaped, initiated some 1000 million years ago with the formation of the supercontinent Rodinia. A mountain chain of global extent formed along its boundaries, underlain by metamorphic rocks that have since then been exposed due to erosion. Metamorphic rocks of this age formed across South Africa to the south and west of the Kaapvaal Craton, known as the Namaqua-Natal Province. The Namaqua-Natal Province can be divided into five tectonostratigraphic sub-provinces and terranes, based on marked changes in the lithostratigraphy across structural discontinuities. The five domains so recognized are the Richtersveld Sub-province, the Bushmanland Terrane, Kakamas Terrane, Areachap Terrane and Kaaien Terrane. The tectonic subdivision as proposed on Figure 2 (Cornell) is reproduced in this document as Figure 3.

The process of landforming can be described as compatible to the modern concept of plate tectonics. In this case the Namaqua plate became buried beneath the Kaapvaal Craton in a subduction zone. Considering the forces involved it can be regarded as a violent process, resulting in the breaking up of the landmass into the five domains as described above, associated with the intrusion of recycled rock material from the subduction zone. What is important for this report is that in the case of the Kaaien terrane, the formation of metaquartzites, deformed early Namaquan volcano-sedimentary rocks and deformed, but thermally metamorphosed bimodal volcanic rocks resulted, amongst others. These rocks are at present referred to amongst others as the Brulpan Group, on which Gariep is located. There is controversy about the age of the Brulpan Group, but is estimated between 1710Ma to 1780Ma, underlying the Wilgenhoutsdrif Group. The Wilgenhoutsdrif Group and Brulpan Group are separated by the Blaauwbospan fault zone located just to the north of Gariep.

The regional geology is indicated on Figure 4 : Regional Geology.

6.2 Site Geology

The site geology is illustrated on Figure 5. The soil and pedocretes form an ubiquitous cover over bedrock with only localized exposures in areas of thin and less dense pedocretic cover, thus hampering field investigations. The inferred material boundaries must be accepted as indicative of the actual conditions only.

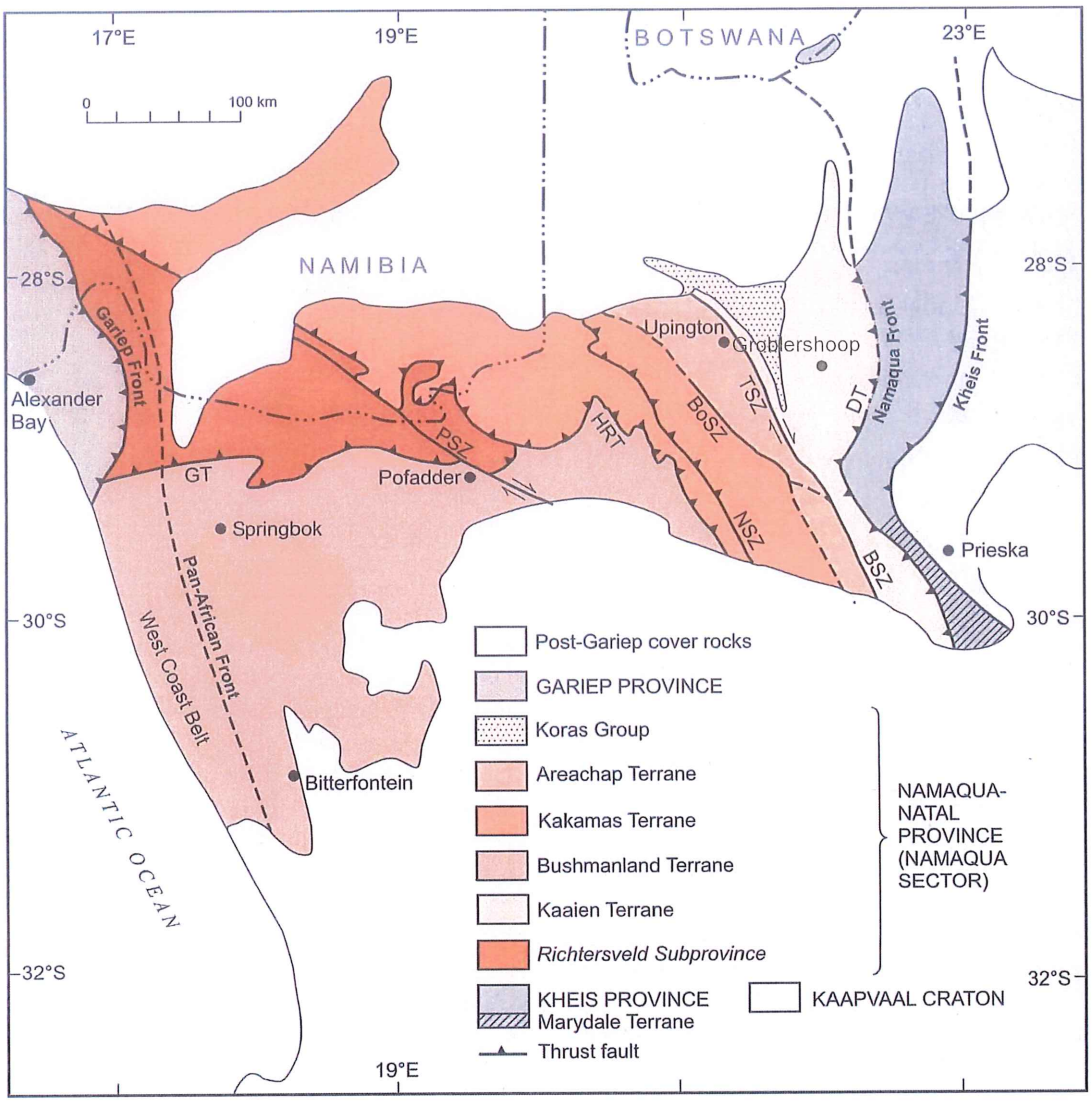


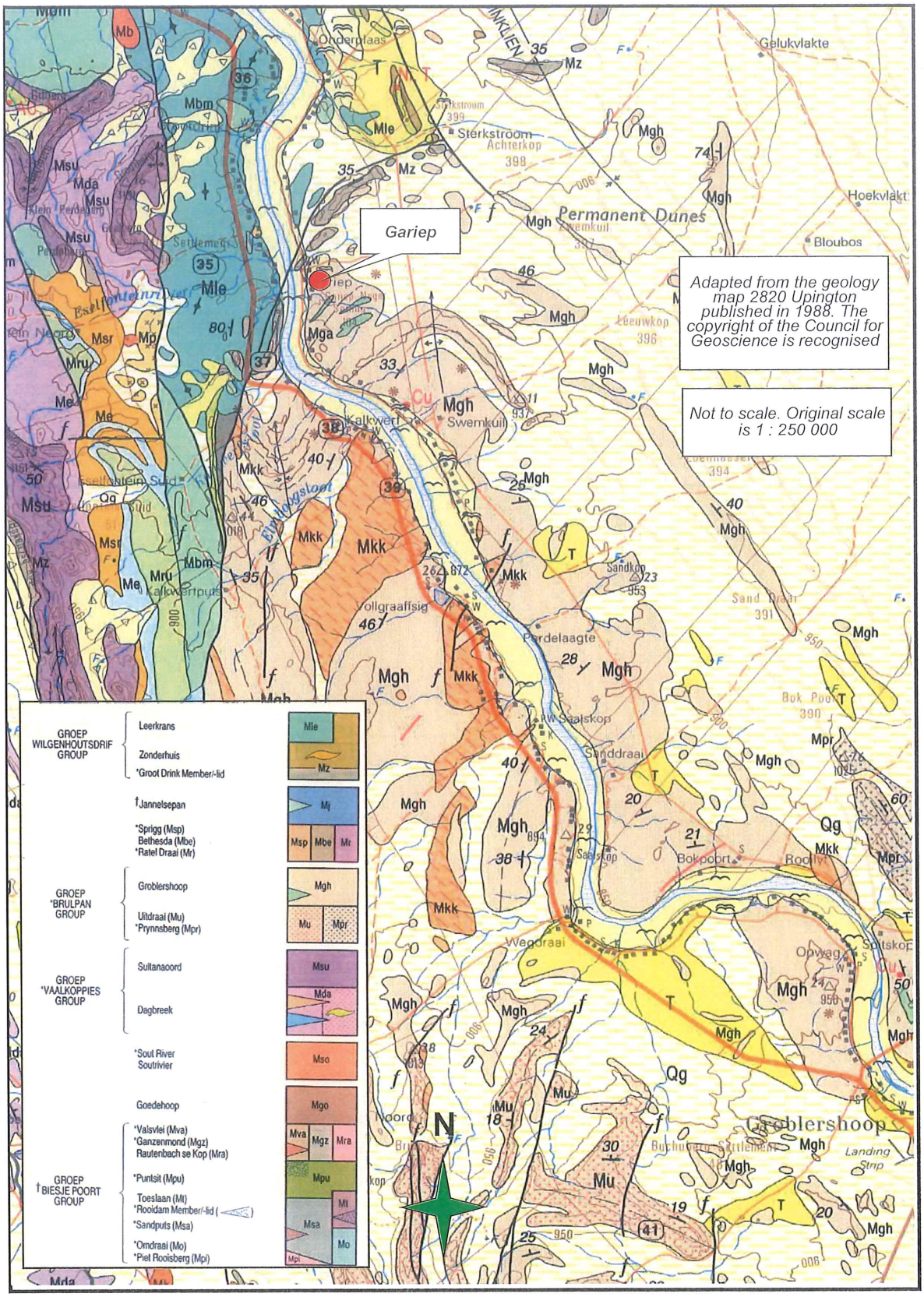
FIGURE 3 : TECTONIC SUBDIVISION OF THE NAMAQUA SECTOR

Bedrock on site occurs as quartz-muscovite schist of the Groblershoop Formation, Brulpan Group. The strata of the Groblershoop Formation dip at 25° to 40° to the north-northwest in the area of investigation, but due to the effects of the nearby fault zone may deviate from this generalization. On site the quartz-muscovite schist was exposed in TP's 12 and 14 only, but elsewhere covered by a very dense horizon of hardpan calcrete. The quartz-muscovite schist is described as dirty white streaked light grey, very closely vertically jointed, intensely laminated, slightly weathered, hard rock.

6.3 Soil Profile

6.3.1 Terrace Gravels

Although the surface soil deposits may easily be regarded as alluvial sands transported by the



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GARIEP : REGIONAL GEOLOGY

FIGURE 4

FIGURE 5 :
SITE GEOLOGY

LEGEND

- TP1 — TEST PIT POSITION
- RUBBLE
- MATERIAL BOUNDARY

INFERRED

TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8 TP9 TP10 TP11 TP12 TP13 TP14 TP15 TP16 TP17

RUBBLE

Access to Canal Road

School

Sports Ground

Lithology		Formation	Group
C	Calcrete	Mokolanen	Kalahari
S	Greenschist	Groblershoop	Brulpan

0m 40m 80m 120m 160m 200m

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TAAK: JOB NAME: Expansion and Formalisation of Gariep Community

LIGGING: SITE: Plot 113, Gariep Settlement

KLIËNT: CLIENT: !Kheis Municipality

TEKENING NO: DRAWING NO: Figure 5 : Site Geology

DATUM: DATE: 30 July 2020

Orange River, this is not the case. Moen (Reference 14.4 page 149) describes the presence of alluvium and terrace gravels associated with the Orange River as being present on the northeastern banks of the river in the area between Grootdrink and Groblershoop. This was confirmed during the investigation as the bulk of the surface soil deposits encountered consists of terrace gravels.

Terrace gravels were encountered as a surface soil except in TP's 11 and 14. It is described as abundant clast supported, coarse, rounded gravels and cobbles of banded ironstone, quartz and quartzite in a matrix of light brown, fine sand. Cobbles of dolerite have also been encountered in the gravels. The consistency of the terrace gravels is medium dense and the thickness of the horizon varies between 200mm and 1100mm, but usually less than 500mm in the test pits. The presence of the banded ironstone clasts is regarded as the identifying factor to classify the materials as transported gravels. These banded ironstone clasts originate from the Transvaal Supergroup along the course of the Orange River. The size of the clasts varies from medium coarse gravels to small boulders. In TP 17 the gravels were found to be calcareous cemented, tending to boulder calcrete.

6.3.2 Alluvium

On site alluvium was encountered in TP 11 only as a surface horizon. The alluvial deposits proper are located closer to the course of the Orange River and are used as the soils sought after for agriculture in the area. The alluvium is described as light grey brown fine sand of loose consistency.

6.3.3 Mokalanen Formation

Calcrete of the Mokalanen Formation, Kalahari Group, is present as an ubiquitous surface duricrust on site. Again there is a difference in opinion between Moen (Reference 14.4 page147) and Partridge[Reference 14.5] regarding the origin of the calcrete. Moen regards the calcrete as being of Tertiary age, but casts some doubt whether the outcrops are of the same age and in some localities it may still be in the process of forming. Partridge describes the age of the calcrete as straddling the boundary between the Pliocene and Quaternary, making it some 2,6 to 2,8 million years old. It was deposited under arid conditions and possibly reflects a climatic interval of global aridification.

The engineering properties of calcrete may differ widely for samples taken from the same locality. It is therefore important to provide some background in this regard to aid in the understanding of these conditions.

Brink[Reference 14.6] states that during pedocrete development, clay and silt become flocculated and cemented into larger silt to gravel-sized complexes of varying strength and porosity. These particles and aggregations may or may not break down during laboratory testing and under compaction. The mineralogy of the cementing material and of the clay fraction is different from those of normal, temperate zone soils on which current specifications for soil testing and classification is based. Calcrete can therefore be expected to exhibit differences in behaviour from those of traditional soil materials.

Whereas in traditional soil mechanics it is assumed that all the water is outside the particles, calcrete aggregates retain moisture and this affects conventional moisture content and Atterberg limit determinations. Palygorskite which is the dominant clay in calcrete has approximately the same plasticity index as some smectites, which can be regarded as highly expansive. However, the palygorskite has a non-expansive lattice and a hollow, needle-like shape instead of the usual flaky particle shape of most other clays. It has the lowest shrinkage limit and dry density and the highest optimum moisture content and shear strength of all clays.

Be it as it may, calcrete was encountered as the dominant lithic material on site, in virtually a continuous cover over the quartz-muscovite schist, with the schist outcropping occasionally only in limited areas of localized extent. The calcrete is present as very dense hardpan calcrete and was encountered in TP's 1 to 11, 13, 15 and 16. It underlies the terrace gravels, occurring from depths between 100mm and 1100mm minimum, extending to 300mm to 1100mm maximum, at which stage refusal of excavation occurred. Moen reports the calcrete to be up to five meters thick in the area. Minor outcrops of calcrete are present randomly across the site.

6.3.4 Fill

Areas of stockpiled material were encountered between TP's 6 to 8. Although the fill consists mostly of gravels of banded ironstone and quartz, substantial pockets of household waste are also present. The presence of these stockpiles are indicated on Figure 2 : Site Plan and illustrated on the photo sheet.

6.4 Groundwater

6.4.1 Perched Water

Perched groundwater was not encountered in any of the test pits excavated for this investigation. Considering the climate of the area and the nature of in situ materials, it is anticipated that perched water will generally not prove problematic on the site, except in the

lesser drainage courses of the site after events of inundation. Even if it did occur, the grading of in-situ materials is such that dispersal will take place fairly rapidly. Furthermore, it is expected that perched water and/or surface seepage may occur shortly after precipitation events and in years of excessive rain only.

6.4.2 Permanent Groundwater

Vegter[Reference 14.7] indicates the probability for drilling successfully for water in the area to be between 40% and 60%, and the probability that such a borehole will yield more than $2ls^{-1}$ is between 10% and 20%. Groundwater is expected to occur at depths less than 15 meters in compact, argillaceous strata.

7 GEOTECHNICAL EVALUATION

The engineering properties of the in-situ materials are summarized in Table 3 : Summary of Engineering Properties. The characterizations have been derived based on the Unified materials classifications as reported by literature studies.

7.1 Engineering and Material Characteristics

7.1.1 Properties of Heave

The results of the materials testing as reported in Table 2 indicate the in-situ materials are not expansive. Any future structures will thus not be subject to heave. The content of active clay, that is the material smaller than 0,002mm in diameter, was less than 2% for all the samples tested, except Sample U9250 consisting of terrace gravels from TP 4.

7.1.2 Properties of Settlement

7.1.2(i) Terrace Gravels

On site terrace gravels as surface deposit was found in all the test pits except TP's 11 and 14. The consistency of the terrace gravels is medium dense and the thickness of the horizon varies between 200mm and 1100mm, but usually less than 500mm in the test pits. The horizon consists of gravels, cobbles and boulders of quartz, banded ironstone and to a lesser extent dolerite and granite in a matrix of fine sand. The properties of the terrace gravels are thus such that it does not tend to excessive settlement.

TABLE 3 : SUMMARY OF ENGINEERING PROPERTIES

TEST PIT NO	SAMPLE NO	DEPTH (mm)	SOIL ORIGIN	SOIL TYPE	SOIL CLASS		COHESION[1] (kNm^{-2})	FRICTION ANGLE (°)[1]	COMPRESSIBILITY[2]	EROSION RESISTANCE[2 + 5]	PERMEABILITY[2] k (cms^{-1})	SPECIFICATIONS FOR UNPAVED ROADS[3]					SUITABILITY FOR ROAD CONSTRUCTION[4]	
					PRA	UNIFIED						MAXIMUM SIZE	OVERSIZE INDEX (I_o)	GRADING COEFFICIENT(G_o)	SHRINKAGE PRODUCT(S_p)	CBR @ 95% MOD	PAVED	UNPAVED
4	U9250	0-1100	Terrace gravels	Sandy gravel	A-2-6(0)	GM	<5	30° to 40°	Negligible	4	>3X10^{-7}	28,0	0,0	20,1	217,0			Good
7	U9251	0-400	Terrace gravels	Sandy gravel	A-2-4(0)	GW-GM-GC	<5	28° to 40°	Negligible to very low	3 to 4	2,7X10^{-6} to 5X10^{-7}	63,0	18,0	9,6	66,0	27	Selected layer	Ravels & corrugates
9	U9252	100-400	Hardpan calcrete	Sandy gravel	A-1-b(0)	GM-GC	<5	28° to 40°	Negligible to very low	Highly variable	>3X10^{-7}	37,5	19,0	14,4	112,0			Erodible
11	U9253	100-400	Hardpan calcrete	Sandy gravel	A-1-b(0)	GC	<5	28° to 35°	Very low	3	>3X10^{-7}	28,0	0,0	23,0	34,0			Good
14	U9254	0-400	Bedrock schist	Rock fragments	A-1-b(0)	GM	<5	30° to 40°	Negligable	4	>3X10^{-7}	50,0	8,0	15,0	43,5	38	Selected layer	Good
16	U9255	0-200	Terrace gravels	Sandy gravel	A-1-b(0)	GC	<5	28° to 35°	Very low	3	>3X10^{-7}	37,5	3,0	18,9	76,0			Good

1 Obrzud RF and Truty A : The Hardening Soil Model - A Practical Guidebook, 2018 edition, revised 21 October 2018.

2 Brink ABA et al : Soil Survey for Engineering, published in 1982.

3 The Structural Design, Construction and Maintenance of Unpaved Roads (Draft TRH 20), Committee of State Road Authorities 1990.

4 Structural Design of Flexible Pavements for Interurban and Rural Roads (Draft TRH 4), Committee of State Road Authorities 1996.

5 Erosion resistance : 1 is best 10 is poor.

7.1.2(ii) Pedocretes

The pedocretes are present as very dense hardpan calcrete and was encountered in TP's 1 to 11, 13, 15 and 16. It underlies the terrace gravels, occurring from depths between 100mm and 1100mm minimum, extending to 300mm to 1100mm maximum, at which stage refusal of excavation occurred. The calcrete is up to five meters thick in the area. Minor outcrops of calcrete are present randomly across the site. The material matrices are either intact or calcareous cemented. It can thus accommodate stresses imposed by conventional housing structures without undue settlement. Only limited – if any –settlement can thus be expected for structures such as single storey units of masonry construction.

7.1.3 Corrosivity

When discussing soil corrosivity, it is applicable to consider the guidelines as proposed by Evans[Reference 14.8]. The corrosivity of a soil towards buried, exposed, metallic surfaces is dependent on the following properties of the soil :

- Electrical conductivity.
- Chemical properties of the soil.
- Ability of the soil to support sulphate reducing bacteria.
- Heterogeneity of the soil.

The tests carried out for the compilation of this report must be considered as indicative of the corrosivity of the soils only. The pH of a soil gives an indication of potential acid related problems. Should the soil pH be less than 6,0, corrosion may take place ; and should the pH be less than 4,50, the problem of corrosion may be serious. If the conductivity of the soil is less than $0,01Sm^{-1}$, corrosiveness is generally not a problem. However, the potential for corrosivity of the soil increases with an increase in conductivity. Should the conductivity of the soil exceed $0,05Sm^{-1}$, the soil can be regarded as very corrosive. Should exposed metal pipes pass from argillaceous soils to arenaceous soils or vice versa, electrochemical cells are set up due to the different rates of oxygen diffusion of the soils. Sulphate reducing bacteria is usually present under anaerobic conditions, that is, typically saturated or waterlogged clays.

The results of the chemical testing carried out for this report indicate the following :

- *Acidity* : The pH of the samples of material tested varied between 7,55 and 8,19. The soils are thus regarded as not corrosive due to the acidity there of.
- *Water Soluble Salts Content* : The conductivity of the samples of material tested varied between $0,06Sm^{-1}$ for the terrace gravels to $0,09Sm^{-1}$ for the calcrete. The soluble salt

content does therefore contribute to the corrosivity of the soils and all in-situ materials can be regarded as corrosive.

Other considerations are :

- *Heterogeneity of the Soil* : Conditions of corrosive soils due to a heterogeneous soil profile do not occur on the property.
- *Water Logged Soils* : Conditions of water logged soils were not encountered on site.

7.1.4 Materials Utilisation

7.1.4(i) Backfilling of Service Trenches

The hardpan calcrete is not suitable to be used for any type of backfill due to its tendency to break into boulder and cobble sized fragments on excavation. Such fragments cannot be compacted properly on backfilling.

The terrace gravels can be used for normal backfilling of services trenches. However, due to the coarse granular composition thereof these materials are not suitable for pipe bedding or selected backfill around pipes.

7.1.4(ii) Construction of Paved or Segmental Block Streets

Only provisional indicators for future guidance of development are provided as far as material quality for road construction is concerned, complying with the requirements applicable to the level of investigation.

The results of the compaction testing on soil samples show the in-situ materials to be generally of G6 quality. The soil materials are therefore suitable only for the construction of in-situ selected layerworks and not for subbase and base course construction.

7.1.4(iii) Wearing Course for Urban Gravel Roads

The properties to provide guidance for the use of soil materials for the structural design of a wearing course for urban gravel roads are contained in the various sub-columns of the column “Specifications for Unpaved Roads” in Table 3. The various parameters are colour-coded : Green = suitable ; red = unsuitable. The two sub-columns with a light yellow-brown background contain the parameters on which the physical behaviour of the wearing is course is determined.

From the table it is clear that none of the in-situ materials comply in all aspects to the requirements for a gravel wearing course. Four of the samples tested appear to be partially suitable to utilize for the construction of a gravel wearing course, while one sample indicates the use of the material will result in a corrugating surface and another in an eroding surface. Of interest is that the individual results of sample U2955 show that the material is not suitable to be used for gravel wearing course construction, but when considered in combination it is suitable for this purpose.

7.1.5 Other Considerations

The properties discussed in this subsection of the report were obtained from literature reported values based on studies done by the US Army Corps of Engineers as reported by Brink[Reference 14.9] for compacted material. This approach is followed as the arenaceous character of the in-situ materials that did not allow the retrieval of undisturbed sampling. The typical soil properties associated with the Unified classifications of the materials are thus reported.

7.1.5(i) Compressibility

The compressibility of the material can be regarded as a necessary input to pavement design as well as lesser important supporting information for geotechnical classification for site class designation.

- *Terrace Gravels* : The terrace gravels are regarded as negligibly compressible with cohesion (c_0) less than 5,0kNm^{-2} and the effective stress envelope approximately 28° to 40°.
- *Hardpan Calcrete* : The samples of excavated hardpan calcrete fragments are regarded as negligibly to very low compressible with cohesion (c_0) of less than 5kNm^{-2} and the effective stress envelope approximately 28° to 40°.
- *Quartz-muscovite Schist* : The samples of excavated quartz-muscovite schist fragments are regarded as negligibly compressible with cohesion (c_0) of less than 5kNm^{-2} and the effective stress envelope approximately 30° to 40°.

7.1.5(ii) Permeability

Permeability is an important parameter in the design of surface drainage and seepage drains. As such indicators in this regard are provided.

- *Terrace Gravels* : The permeability of the terrace gravels is regarded as highly variable depending on the granular analysis and soil mortar content. Based on the materials

classification the soil permeability coefficient of the samples tested approaches $3,0X10^{-7}cms^{-1}$.

- *Hardpan Calcrete* : The permeability of the hardpan calcrete is highly variable depending on the mode of deposition and regarded as pervious to impervious. Based on the materials classification the soil permeability coefficient of the samples tested approaches $3,0X10^{-7}cms^{-1}$.
- *Bedrock Quartz-muscovite Schist* : Bedrock of quartz-muscovite schist can be regarded as impermeable with seepage taking place only through open discontinuities in the rock matrix. Based on the materials classification the soil permeability coefficient of the samples tested approaches $3,0X10^{-7}cms^{-1}$.

7.1.5(iii) Erosion Potential

All soil materials encountered during the investigation can be regarded as moderately resistant to fairly resistant against erosion. The aspect of erosion potential is important in the area. The net result of the erosion resistant soil is favourable founding conditions on the horizon of calcrete.

7.2 Properties of Bedrock

The TLB used to excavate the test pits did not penetrate hardpan calcrete or bedrock of schist to any significant extent and refusal of excavation occurred within millimeters after encountering these materials. It is not customary to penetrate bedrock in the case of a geotechnical investigation for purposes of a residential development. Refusal of excavation on hard rock is accepted as suitable. One can thus accept bedrock to be hard tending to very hard once refusal of excavation was encountered.

7.2.1 Calcrete

Voided matrices were not encountered in the hardpan calcrete during the investigation. The results of the materials testing on samples of the hardpan calcrete fragments approach that of the nodular calcrete. However, it must be borne in mind that in in-situ conditions the properties of intact hardpan calcrete approaches that of soft rock rather than a gravelly sand. The grading moduli of the samples of hardpan calcrete fragments tested as 2,10 to 2,20 ; plasticity index as three to five ; and clay content as 0,6% to 3,9%. The activity of the hardpan calcrete is described as low. The PRA classification of the calcrete is A-1-b(0) ; and the Unified classification is GC to GM-GC. Based on these properties and material classification the hardpan calcrete is regarded as non-expansive and no consolidation settlement and no collapse settlement can thus be expected for structures such as single storey units of masonry construction.

Brink (Reference 14.6) reports an average UCS of 32MPa for intact samples of hardpan calcrete from the Kalahari region. Using this as input to parametric calculations with Roclab software results for very dense calcrete tending to widely jointed, slightly weathered, medium hard rock, limestone result in the following properties :

- Cohesion : 1,08MPa
- Friction Angle : 24°
- Tensile Strength : 0,018MPa
- Uni-axle Compressive Strength : 550kPa
- Young's Modulus : 2340MPa

All which show a sound pedocrete, not compressible, not permeable nor subject to erosion.

7.2.2 Quartz-muscovite Schist

Parametric calculations with Roclab software results for slightly weathered, very closely jointed, very intensely laminated, hard rock result in the following properties :

- Cohesion : 3,4MPa
- Friction Angle : 29,0°
- Tensile Strength : 0,07MPa
- Uni-axle Compressive Strength : 2,5MPa
- Young's Modulus : 8082,4MPa

The above calculations are for schists dipping at 90° with the horizontal plane. Should the angle of dip change the tensile strength, UCS and Young's modulus may change accordingly.

7.3 Excavation Classification with Respect to Services

7.3.1 Hand Excavation

7.3.1(i) Terrace Gravels

The terrace gravels can be considered as suitable to be excavated by swing tools.

7.3.1(ii) Pedogenic Deposits

The hardpan calcrete is of dense to very dense consistency. Such material cannot be

considered as suitable to be manually excavated and may as minimum require the use of a 55kW TLB, but preferably a 30 ton excavator to remove it on an economical basis.

7.3.1(iii) Bedrock

Bedrock of quartz-muscovite schist cannot be excavated manually successfully.

7.3.2 Classification of Material for Machine Excavation

In terms of Table 5 of SANS 634 : 2012 the following is applicable :

7.3.2(i) Restricted Excavation

- *Soft Excavation* : The terrace gravels can be regarded as soft excavation. The thickness of this stratum varied between 100mm and 1100mm in the test pits, averaging 370mm prior to encountering conditions of intermediate or hard rock excavation.
- *Intermediate Excavation* : Refusal of excavation with a TLB occurred in most cases once very dense, hardpan calcrete or slightly weathered to unweathered rock was encountered. However, some penetration into the hardpan calcrete or quartz-muscovite schist was possible and can be regarded as intermediate excavation. It was possible to penetrate between 100mm and 400mm into the hardpan calcrete and quartz-muscovite schist, averaging 150mm thick, prior to encountering hard rock excavation.
- *Hard Rock Excavation :* Refusal of excavation occurred on conditions of hard rock excavation in all the test pits at depths varying between 200mm and 1100mm, averaging 460mm.

From the above it is clear that the transition of conditions of excavation is very rapid from soft to hard rock excavation with virtually no intermediate excavation.

7.3.2(ii) Non-restricted Excavation

The classification as per subparagraph 7.3.2(i) : Restricted Excavation as above is also applicable for non-restricted excavation.

7.4 Seismicity

A 10% probability of an event with magnitude less than 100cms^{-2} to take place once in 50 years is regarded as favourable ; and a natural seismic activity with magnitude exceeding 100cms^{-2} is regarded as unfavourable. Based on a report compiled by Kijko[Reference 14.10] a 10%

probability exists that an earthquake with Peak Ground Acceleration exceeding of 0,04g may take place once in 50 years in Gariep.

The closest source of seismic measurements to Grootdrink under control of the Council for Geoscience is Tontelbos at 31° 10' 12"S and 20' 30' 00"E.

- The annual probability for an earthquake with intensity of 4,5 on the Modified Mercalli Scale to occur in the area is less than $10^{-0,7}$; and with an intensity of 8,5 to occur the probability is $10^{-3.8}$.
- The annual probability for an earthquake with an acceleration of $10^{-1,9}$g to occur in the area is less than $10^{-0,7}$; and with an acceleration of $10^{-0,75}$g to occur in the area is less than $10^{-3,8}$.

To put the above information into perspective, Table 4 : Earthquake and Magnitude and Intensity, is attached to this report.

7.5 Undermining

The area of investigation is not undermined.

7.6 Dolomite Stability

The area of investigation is not subject to dolomite related instabilities.

8 SITE CLASS DESIGNATIONS

Based on the above discussions the property can be divided into four zones as per the guidelines posted by SANS 10400 : Section H[Reference 14.11] . The zonation is indicated on Figure 6 : Site Class Designation.

8.1 Geotechnical Zone I

This zone comprises 87% of the area investigated. It is characterized by the materials profiles of TP's 1, 5 to 7, 9 to 14 and 16. It covers virtually the entire area of investigation on a continuous, but randomly interrupted basis. It consists of a superficial horizon less than 400mm thick comprising of terrace gravels and very dense calcrete overlying bedrock of quartz-muscovite schist. Several outcrops of calcrete occur in the area. Slope across the land is approximately between 2% and 6%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in almost negligible settlement if

founded directly on the slightly weathered and unweathered hard rock to very hard rock, or on the very dense calcrete. The area is thus zoned as "R" and regarded as stable.

TABLE 4 : EARTHQUAKE MAGNITUDE AND INTENSITY

MODIFIED MERCALLI INTENSITY SCALE	INTENSITY	DESCRIPTION	RICHTER SCALE MAGNITUDE	RADIUS OF PERCEPTIBILITY (km)
I	Instrumental	Detected only by seismography		
II	Feeble	Noted only by sensitive people	3.5 to 4.2	3 to 24
III	Slight	Like the vibrations due to a passing lorry. Felt by people at rest, especially on upper floors		
IV	Moderate	Felt by people while walking. Rocking of loose objects, including vehicles	4.3 to 4.8	24 to 48
V	Rather strong	Felt generally ; most sleepers are awakened and bells ring		
VI	Strong	Trees sway and suspended objects swing ; damage by overturning and filing of loose objects	4.9 to 5.4	48 to 112
VII	Very strong	General public alarm ; walls crack ; plaster falls	5.5 to 6.1	110 to 200
VIII	Destructive	Car drivers seriously disturbed; masonry fissured ; buildings damaged	6.2 to 6.9	200 to 400
IX	Ruinous	Houses collapse ; pipes break		
X	Disasterous	Ground cracks badly ; buildings destroyed ; railway lines bent ; landslides on steep slopes	7.0 to 7.3	400 to 700
XI	Very disasterous	Few buildings remain standing; bridges destroyed ; all services out of action ; great landslides and floods	7.4 to 8.1	400 to 700
XII	Catastrophic	Total destruction ; objects thrown into the air; ground rises and falls in waves	>8.1	400 to 700

FIGURE 6 :
SITE CLASS DESIGNATION

FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES

AREA	AREA OF PROPERTY (%)	GEOTECHNICAL CLASS	ESTIMATED SOIL MOVEMENT(mm)	SOIL PROFILE	CONSTRUCTION TYPE	FOUNDATION DESIGN	ASSOCIATED PROBLEMS	DEVELOPMENT POTENTIAL
I	86,97	R	Negligible	Less than 400mm of terrace gravels overlying bedrock and pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on very dense pedocretes or bedrock	Conditions of hard rock excavation. Landslope between 2% and 6% favours strip footing foundations	Intermediate
II	5,98	R	Negligible	Less than 400mm of terrace gravels overlying bedrock and pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on very dense pedocretes or bedrock.	Conditions of hard rock excavation. Landslope less than 2% favours slab-on-the-ground foundations.	Intermediate
III	2,52	S	0mm to 10mm compression settlement	More than 400mm of terrace gravels overlying bedrock and pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on medium dense terrace gravels or very dense hardpan calcrete Foundation bearing pressure not to exceed 50kPa. Good site drainage.	Conditions of hard rock excavation. Landslope between 2% and 6% favours strip footing foundations	Intermediate
IV	4,53	S	0mm to 10mm compression settlement	More than 400mm of terrace gravels overlying bedrock and pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on medium dense terrace gravels or very dense hardpan calcrete Foundation bearing pressure not to exceed 50kPa. Good site drainage.	Conditions of hard rock excavation. Landslope less than 2% favours slab-on-the-ground foundations.	Intermediate

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LIGGING: / SITE: Plot 113, Gariep Settlement

KLIENT: / CLIENT: !Kheis Municipality

TEKENING NO: / DRAWING NO: Figure 6 : Site Class Designation

DATUM: / DATE: 31 July 2020

8.2 Geotechnical Zone II

This zone comprises 6% of the area investigated. It is characterized by the materials profile of TP 15. It is present as the crest of the ridge in the northern part of the site only. It consists of a superficial horizon less than 400mm thick comprising of terrace gravels and very dense calcrete overlying bedrock of quartz-muscovite schist. Several outcrops of calcrete occur in the area. Slope across the land is less than 2%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in almost negligible settlement if founded directly on the slightly weathered and unweathered hard rock to very hard rock, or on the very dense calcrete. The area is thus zoned as "R" and regarded as stable.

8.3 Geotechnical Zone III

This zone comprises 2,5% of the area investigated. The zone is present in three separate areas on the property. It is characterized by the materials profiles of TP's 2 to 4. It consists of a horizon of terrace gravels exceeding 400mm thick overlying very dense hardpan calcrete and at depth bedrock of quartz-muscovite schist. Slope across the land is between 2% and 6%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in limited compression settlement less than 10mm if founded directly on the medium dense terrace gravels. As per the materials profile encountered in the test pits the thickness of the horizon of terrace gravels and underlying calcrete soil is sufficient to dissipate the stresses induced by the foundations effectively. The area is thus zoned as "S" and the materials strata can be regarded as compressible to a maximum of 10mm.

8.4 Geotechnical Zone IV

This zone comprises 4,5% of the area investigated. The zone is present in two separate areas in the north eastern section of the property. It is characterized by the materials profiles of TP's 8 and 17. It consists of a horizon of terrace gravels exceeding 400mm thick overlying very dense hardpan calcrete and at depth bedrock of quartz-muscovite schist. Slope across the land is less than 2%. Foundation stresses induced by conventional strip foundations for single and double storey structures will result in limited compression settlement less than 10mm if founded directly on the medium dense terrace gravels. As per the materials profile encountered in the test pits the thickness of the horizon of terrace gravels and underlying calcrete soil is sufficient to dissipate the stresses induced by the foundations effectively. The area is thus zoned as "S" and the materials strata can be regarded as compressible to a maximum of 10mm.

8.5 Other Considerations

The contents of this subparagraph 8.5 largely fall outside the scope of a geotechnical investigation and refer to the widespread presence of various types of waste as described briefly in subsections 4.5 and 6.3.4 of this document. However, it is given in good faith in an effort to find a solution to the presence of waste in the area. To implement these measures will require inputs from both the local municipal authorities as well as the community of Gariep.

The excavation of a large pit locally to bury and cover the waste is an exercise requiring environmental, geotechnical and groundwater inputs, amongst others. The provision of such a facility may require a considerable period of time, costs and construction to finalise.

Therefore, two options can be considered to deal with this waste :

8.5.1 Disposal at a Waste Site

The waste material can be removed and disposed at a waste site. However, this creates logistical and legal issues. Loading and transporting the waste to either Groblershoop or Upington will be expensive. It is also doubtful whether the waste sites at these two locations will accept the waste and can treat such a volume in a suitable manner.

8.5.2 Recycling

The suitability of the stockpiles of waste for recycling depends on the composition of the waste. Basically three components have been identified visually, namely :

- *Household Waste* : Including putrefied food, nappies, bubble sheet pill containers, clothing etc.
- *Recyclable Waste* : Including plastic beverage bottles, glass, various metals and wood.
- *Construction Waste* : This includes blocks of concrete, bricks and stockpiles of calcrete.

To solve the issue it can be considered to involve the community by separating the waste. As the household waste represents a much smaller volume than the entire bulk of waste, this may potentially be disposed of at either Upington or Groblershoop. The recyclable may be sold. The construction waste can be crushed and used as fill material during construction. Such material may also be used as successfully as a gravel wearing course for streets in Gariep.

8.5.3 Presence of Terrace Gravels

Terrace gravels are widely distributed in the area which is earmarked for residential development as well as stockpiled east of the site. These gravels consist of fragments of quartz and banded ironstone. There exists a big demand for such gravels as ornamental features in urban areas, especially for water-wise gardens. The community can benefit from the collecting and marketing these materials through a co-ordinated effort.

9 FOUNDATION RECOMMENDATIONS AND SOLUTIONS

The foundation design alternatives and ancillary issues as discussed in subparagraphs 9.1 to 9.4 below are summarized in Table 5 : Foundation Design, Building Procedures and Precautionary Measures. In some cases more than one foundation solution is offered in the discussion below. Whichever option is used, the design must adhere strictly on the proposals of SANS 10400H. As geotechnical conditions favour the use of both alternatives, the decision of which option to use must be based on financial and practical considerations. In all cases service trenches shall not be excavated parallel to buildings within 1500mm of the building perimeter.

9.1 Geotechnical Zone I

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The slope across the land varies between approximately 2% and 6%. Two founding alternatives can be considered :

9.1.1 Strip Foundations

The preferable founding alternative is foundations of 400mm wide strip footings placed directly on very dense hardpan calcrete or bedrock of quartz-muscovite schist. Should the areas of the proposed dwellings not exceed 200m^2 foundations for internal non-loadbearing walls may consist of thickened floorslabs. Should this option be adopted the floorslabs shall be reinforced steel mesh.

9.1.2 Slab-on-the-ground Foundations

Considering the slope across the land of approximately 2% to 6% the use of slab-on-the-ground foundations may require additional works in the form of the construction of an engineered fill or cutting to establish a level platform for construction, but it still remains a viable alternative. This latter option of additional earthworks may be costly and hence is regarded as less attractive than conventional strip footings.

TABLE 5 : FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES

AREA	AREA OF PROPERTY (%)	GEOTECH NICAL CLASS	ESTIMATED SOIL MOVEMENT (mm)	SOIL PROFILE	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES	ASSOCIATED PROBLEMS	DEVELOPMENT POTENTIAL
I		R	Negligible	Less than 400mm of terrace gravels overlying bedrock and pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on very dense pedocretes or bedrock	Conditions of hard rock excavation Landslope between 2% and 6% favours strip footing foundations	Intermediate
II		R	Negligible	Less than 400mm of terrace gravels overlying bedrock and pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on very dense pedocretes or bedrock	Conditions of hard rock excavation. Landslope less than 2% favours slab-on-the-ground foundations.	Intermediate
III		S	0mm to 10mm compression settlement	More than 400mm of terrace gravels overlying bedrock and pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on medium dense terrace gravels or very dense hardpan calcrete Foundation bearing pressure not to exceed 50kPa Good site drainage	Conditions of hard rock excavation Landslope between 2% and 6% favours strip footing foundations	Intermediate
IV		S	0mm to 10mm compression settlement	More than 400mm of terrace gravels overlying bedrock and pedogenic deposits	Normal	Normal construction (strip footing or slab-on-the-ground) foundation. Founding to take place on medium dense terrace gravels or very dense hardpan calcrete Foundation bearing pressure not to exceed 50kPa Good site drainage	Conditions of hard rock excavation. Landslope less than 2% favours slab-on-the-ground foundations.	Intermediate

9.2 Geotechnical Zone II

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. Considering the limited slope across the land of less than 2% only and the stable founding conditions as per Section 8 above, two foundation design alternatives are applicable to the zone.

9.2.1 Strip Foundations

Foundations of 400mm wide placed directly on the very dense hardpan calcrete may be used. Should the areas of the proposed dwellings not exceed 200m^2 foundations for internal non-loadbearing walls may consist of thickened floorslabs. Should this option be adopted the floorslabs shall be reinforced steel mesh.

9.2.2 Slab-on-the-ground Foundations

This is the preferred method of founding. The solution of slab-on-the-ground foundations may only be used for dwellings less than 200m^2 in area. Edge beams shall be placed directly on the very dense hardpan calcrete.

Foundations for internal non-loadbearing walls shall consist of thickened floorslabs. The foundations shall not contain any changes in surface levels with steps exceeding 400mm and do not support any chimneys or walls which support concrete roofs.

9.3 Geotechnical Zone III

The zone is classed as S, meaning that less than 10mm of compression settlement may occur. Considering the slope across the land of approximately 2% to 6% and the stable founding conditions as per Section 8 above, two foundation design alternatives are applicable to the zone.

9.3.1 Strip Foundations

This is the preferred method of founding. Foundations of 400mm wide placed directly on the medium dense terrace gravels may be used. Should the areas of the proposed dwellings not exceed 200m^2 foundations for internal non-loadbearing walls may consist of thickened floorslabs. Should this option be adopted the floorslabs shall be reinforced steel mesh.

9.3.2 Slab-on-the-ground Foundations

The solution of slab-on-the-ground foundations may only be used for dwellings less than 200m^2 in area. Edge beams shall be placed directly on the medium dense terrace gravels. Foundations for internal non-loadbearing walls shall consist of thickened floorslabs. The foundations shall not contain any changes in surface levels with steps exceeding 400mm and do not support any chimneys or walls which support concrete roofs.

9.4 Geotechnical Zone IV

The zone is classed as S, meaning that less than 10mm of compression settlement may occur. Considering the slope across the land is less than 2% and the stable founding conditions as per Section 8 above, two foundation design alternatives are applicable to the zone.

The two options can be discussed as follows :

9.2.1 Strip Foundations

Foundations of 400mm wide placed directly on the very dense hardpan calcrete may be used. Should the areas of the proposed dwellings not exceed 200m^2 foundations for internal non-loadbearing walls may consist of thickened floorslabs. Should this option be adopted the floorslabs shall be reinforced steel mesh.

9.2.2 Slab-on-the-ground Foundations

This is the preferred method of founding. The solution of slab-on-the-ground foundations may only be used for dwellings less than 200m^2 in area. Edge beams shall be placed directly on the very dense hardpan calcrete.

Foundations for internal non-loadbearing walls shall consist of thickened floorslabs. The foundations shall not contain any changes in surface levels with steps exceeding 400mm and do not support any chimneys or walls which support concrete roofs.

10 DRAINAGE

The water courses on site are contained in narrow and well-defined gullies of such extent that they do not influence the various geotechnical site class designations. They are therefore not zoned separately. However, the presence of these water courses must be taken into account and infrastructure established only in a safe distance from these features.

The slope of less than 2% in certain areas of the land is regarded as marginal and may result in problems with the design of stormwater and sewerage disposal systems depending on dissipation by gravity.

11 SPECIAL PRECAUTIONARY MEASURES

No extraordinary features requiring special precautionary measures to decrease the impact thereof are present on site.

12 CONCLUSIONS

The property is regarded as being of intermediate suitability for residential development. Founding conditions can be defined as R and S. The factors that reduce the suitability of the land for development are :

- The presence of hard rock and very dense hardpan calcrete close to the surface. The presence thereof will result in conditions of hard excavation.
- The limited slope of less than 2% in geotechnical zones II and IV will have a detrimental influence on the design of stormwater disposal systems and sewerage reticulation.
- The presence of waste material need to be addressed.

The conclusions as based on the site conditions are summarized in Table 6 : Influence of Constraints per Geotechnical Zoning. This classification is based on the proposals of the document *Geotechnical Site Investigations for Housing Developments (Generic Specification GFSH-2)*, issued by the National Department of Housing in September 2002.

12.1 Stratigraphy

The available information shows that the area of investigation is located on a subduction zone dating approximately 1000 million years old. The zone is located between the lithology of the Kaapvaal Craton and the Namaqua-Natal mobile belt. The remains of the original geology in the area are referred to as the Kaaien Terrane and the site is located on the Groblershoop Formation of the Brulpan Group. The quartz-muscovite schist is described as dirty white streaked light grey, very closely vertically jointed, intensely laminated, slightly weathered, hard rock.

TABLE 6 : INFLUENCE OF CONSTRAINTS PER GEOTECHNICAL ZONING

CONSTRAINT	KEY TO CLASSIFICATION			CLASSIFICATION PER GEOTECHNICAL ZONE			
	MOST FAVOURABLE (1)	INTERMEDIATE (2)	LEAST FAVOURABLE (3)	I	II	III	IV
Collapsible soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750mm in thickness	Any collapsible horizon or consecutive horizons with a depth of more than 750mm in thickness	A least favourable situation for this constraint does not occur				
Seepage	Permanent or perched water table more than 1,5m below ground surface	Permanent or perched water table less than 1,5m below ground surface	Swamps and marshes				
Active soil	Low soil heave potential anticipated	Moderate soil heave potential anticipated	High soil heave potential anticipated				
Highly compressible soil	Low soil compressibility anticipated	Moderate soil compressibility anticipated	High soil compressibility anticipated				
Erodibility of Soil	Low	Intermediate	High				
Difficulty of excavation to 1,5m depth	Scattered or occasional boulders less than 10% of the total volume	Rock or hardpan pedocretes between 10% and 40% of the total volume	Rock or hardpan pedocretes more than 40% of the total volume				
Undermined ground	Undermining at a depth greater than 240m below surface, except where total extraction mining has not occurred	Old undermined areas to a depth of 90m to 240m below surface where stope closure has ceased	Mining within less than 90m to 240m of surface or where total extraction mining has taken place				
Dolomite and limestone stability	Possibly stable. Areas of dolomite overlain by Karroo rocks or intruded by sills. Areas of Black Reef rocks. Anticipated Inherent Risk Class 1	Potentially characterised by instability. Anticipated Inherent Risk Classes 2 to 5	Known sinkholes and dolines Anticipated Inherent Risk Classes 6 to 8				
Steep slopes*	Between 2° and 6° in all regions	Slopes between 6° and 18° and less than 2° (Natal and Western Cape) Slopes between 6° and12° and less than 2° (all other regions)	More than 18° (Natal and Western Cape) More than 12° (all other regions)				
Areas of unstable natural slopes*	Low risk	Intermediate risk	High risk (Especially in areas subject to seismic activity)				
Areas subject to seismic activity	10% probability of an event less than $100cms^{-2}$ within 50 years	Mining induced seismic activity more than $100cms^{-2}$	Natural seismic activity more than $100cms^{-2}$				
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 with a known drainage channel or floodplain				

12.2 Soil Profile

12.2.1 River Terrace Gravels

Terrace gravels are described as abundant clast supported, coarse, rounded gravels and cobbles of banded ironstone, quartz and quartzite in a matrix of light brown, fine sand. Cobbles of dolerite have also been encountered in the gravels. The consistency of the terrace gravels is medium dense and the thickness of the horizon varies between 200mm and 1100mm, but usually less than 500mm in the test pits.

12.2.2 Mokalanen Formation

Hardpan calcrete underlies the terrace gravels in virtually a continuous cover over the quartz-muscovite schist, with the schist outcropping occasionally only in limited areas of localized extent. The calcrete is present as very dense hardpan calcrete from depths between 100mm and 1100mm minimum, extending to 300mm to 1100mm maximum, at which stage refusal of excavation occurred.

12.3 Groundwater

12.3.1 Perched Water

Perched groundwater was not encountered in any of the test pits excavated for this investigation. It is anticipated that perched water will generally not prove problematic on the site.

12.3.2 Permanent Groundwater

The probability for drilling successfully for water in the area is between 40% and 60%, and the probability that such a borehole will yield more than $2ls^{-1}$ is between 10% and 20%. Groundwater is expected to occur at depths less than 15 meters in compact, argillaceous strata.

12.4 Conditions of Excavation

On average over the entire site bedrock or refusal of excavation on very dense hardpan calcrete was encountered at depths between 200mm minimum and 1100mm maximum, averaging 480mm deep. The implication of this is that should trenches require excavated depths to 1000mm, 52% of the excavation may be classified as hard, requiring drilling and

blasting. Should the required depth of excavation increase to 1500mm, 68% of the excavation may be classified as hard.

Irrespective of which method of excavation is considered, the most important issue is that across the entire site bedrock and hardpan calcrete that can be regarded as hard rock excavation that is highly variable as follows :

12.4.1 Geotechnical Zones I and II

These zones are classified as R. The average depth to bedrock or very dense pedocrete is 200mm. Refusal of excavation occurred at an average depth of 325mm. The implication of this is that should trenches require excavated depths to 1000mm, 67,5% of the excavation may be classified as hard, requiring drilling and blasting. Should the required depth of excavation increase to 1500mm, 78% of the excavation may be classified as hard.

12.4.2 Geotechnical Zone III and IV

These zones are classified as S. The average depth to bedrock is 700mm. Refusal of excavation occurred at an average depth of 760mm. The implication of this is that should trenches require excavated depths to 1000mm, 76% of the excavation may be classified as soft, suitable for TLB excavation. Should the required depth of excavation increase to 1500mm, 49% of the excavation may be classified as hard, requiring drilling and blasting.

12.5 Site Class Designation

It is concluded that the entire area is regarded as suitable for residential development as follows :

12.5.1 Geotechnical Zone I

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The distribution thereof encompasses 87% of the proposed area for development. Slope across the land is approximately between 2% and 6%. The use of slab-on-the-ground foundations will require additional works in the form of the construction of an engineered fill or cutting to establish a level platform for construction. The more viable foundation alternative therefore remains founding by conventional strip foundations.

Geotechnical conditions related to foundation design can be regarded as favourable, but the

conditions of hard rock excavation close to the surface detracts from the ease suitability of establishing services and overall the development potential is regarded as intermediate only.

12.5.2 Geotechnical Zone II

The zone is classed as R, meaning that the proposed horizon for founding is stable and negligible soil movement is expected. The distribution thereof encompasses 6% of the proposed area for development. Slope across the land is less than 2%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on bedrock or very dense pedocrete.

Geotechnical conditions related to foundation design can be regarded as favourable, but the conditions of hard rock excavation close to the surface and slope less than 2% detract from the ease suitability of establishing services and overall the development potential is regarded as intermediate only.

12.5.3 Geotechnical Zone III

The zone is classed as S, meaning that the proposed horizon for founding is slightly compressible and rapid settlement less than 10mm is expected. The distribution thereof encompasses 2,5% of the proposed area for development. Slope across the land is between 2% and 6%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip foundations or slab-on-the-ground foundations placed directly on medium dense terrace gravels. The more viable foundation alternative therefore remains founding by conventional strip foundations.

Geotechnical conditions related to foundation design can be regarded as favourable, but the conditions of hard rock excavation close to the surface detracts from the ease suitability of establishing services and overall the development potential is regarded as intermediate only.

12.5.4 Geotechnical Zone IV

The zone is classed as S, meaning that the proposed horizon for founding is slightly compressible and rapid settlement less than 10mm is expected. The distribution thereof encompasses 4,5% of the proposed area for development. Slope across the land is less than 2%. Considering the limited slope and the favourable geotechnical site classification, two foundation design alternatives are applicable to the zone, namely conventional strip

foundations or slab-on-the-ground foundations placed directly on medium dense terrace gravels.

Geotechnical conditions related to foundation design can be regarded as favourable, but the conditions of hard rock excavation close to the surface and slope less than 2% detract from the ease suitability of establishing services and overall the development potential is regarded as intermediate only.

12.6 Land Slope

The average slope across the larger part of the land is between 2% and 6%. Only in Geotechnical Zones II and IV is the slope less than 2%, that is over 10,5% of the site. This slope of less than 2% has a detrimental influence on especially the design of a stormwater disposal system depending on gravity to dissipate of the surface water due to downpours. The land slope also affects the design of the sewerage disposal but to a lesser extent as the gradient of the pipes can be adjusted according to design requirements.

No steep slopes are present on the property.

12.7 Areas Subject to Flooding

The non-perennial water courses on site are contained in well-defined, narrow gullies and may be regarded as being of lesser importance, requiring no additional precautionary measures to ensure the safety of the population against flooding.

12.8 Materials Utilization

- *Trench Backfilling* : None of the materials are suitable for selected fill or pipe bedding. With exception of the hardpan calcrete all materials can be used for normal backfill.
- *Layerworks for Paved or Segmental Block Paving* : The residual soils are suitable for the construction of in-situ selected layerworks.
- *Wearing Course for Gravel Roads in Urban Areas* : All of the soil materials can be used for the construction of a gravel wearing course although none of them are 100% suitable for this purpose. The use of these materials may result in a road surface subject to raveling and corrugations.

12.9 Other Considerations

- *Undermining* : The area is not subject to undermining.

- *Seismic Activity* : The Peak Ground Acceleration expected in 50 years is 0,04g. A low risk for the development of earth tremors therefore exist.
- *Soil Corrosivity* : The in-situ soils and pedocretes are corrosive due to the high soluble salts content.
- *Dolomite* : The area of investigation is not subject to any restrictions due to the presence of dolomite. Bedrock of dolomite does not occur in the area of investigation.

13 RECOMMENDATIONS

13.1 Foundation and Structural Design

Section 9 of this document provides guidelines for foundation and structural design. These guidelines are based strictly on the contents of SANS 10400H and the NHBRC Home Owners Manual published in 2015. It is recommended that development take place strictly according to these guidelines. More than one founding solution is applicable on the site, and the property developer can base his choice on financial constraints.

13.2 Materials Utilization

- *Trench Backfill* : With exception of the hardpan calcrete, the in-situ materials may be used for normal backfill of trenches. The hardpan calcrete shall be spoilt and not used at all for this purpose. Material for pipe bedding and selected backfill shall be obtained from commercial sources.
- *Layerworks for Paved or Segmental Block Paving* : Material for subbase and base construction must be obtained from commercial sources. It is recommended that a centerline investigation consisting of test pitting and soil sampling be conducted to allow the consulting engineer to produce suitable pavement designs for the project.
- *Wearing Course for Gravel Roads in Urban Areas* : Both the terrace gravels and calcrete can be stockpiled for the construction of a gravel wearing course for internal roads in the village.

13.3 Conditions of Excavation

Although manual excavation is possible through the terrace gravels, residual soil and to some extent through the calcrete, it is considered as not an economic proposition, mostly due to the consistency and composition of the soil. Excavation through these soils shall require the use of a TLB rated at 55kW minimum, or preferably a 30 ton excavator of the very dense pedocretes need to be removed. It is recommended that adequate provision be made for hard rock excavation.

13.5 Land Slope

Slope across the 10,5% of the land is less than 2%. This is regarded as being of intermediate suitability for urban development only. This has an influence on especially the stormwater disposal system but to a lesser extent on the waste water design. In theory the slope of 2% to 6% on 89,5% of the land can be regarded as favourable for urban development, but the combination of the slope and presence of rock outcrops result in conditions less desirable for development, reducing the suitability for residential development to intermediate.

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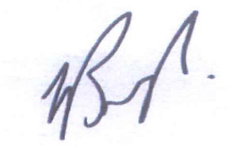

FJ Breytenbach, Pr Eng
For Cedar Land Geotechnical Consult (Pty) Ltd

2 September 2020

GEOTECHNICAL CONDITIONS ON PLOT 113, GARIEP SETTLEMENT: A REPORT FOR THE EXPANSION AND FORMALISATION OF GARIEP COMMUNITY

2020/J09/MCP_01

ADDENDUM A: TEST PIT PROFILES

TRIAL HOLE: 1

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'54,0" S 21°46'52,9" E*

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cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS* and *COBBLES* of banded ironstone, quartz, quartzite and calcrete in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. River terrace gravels.				1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20		Dirty white, very fine grained, very dense, hardpan *CALCRETE.* Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 1

FIGURE: A1

TRIAL HOLE: 2

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'51,4" S 21°46'58,3" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS* and *COBBLES* of banded ironstone, quartz, quartzite and calcrete in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. River terrace gravels.				1 Refusal of excavation at 600 mm on very dense hardpan calcrete.
0.20						
0.40						
		Dirty white, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.60						
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 2

FIGURE: A2

TRIAL HOLE: 3

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'56,7" S 21°46'45,1" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS* and *COBBLES* of banded ironstone and quartzite and medium coarse, angular *GRAVELS* of quartz in a matrix of light brown, fine sand. Overall consistency is medium dense. River terrace gravels. Foreign matter such as pieces of plastic, glass fragments and rubber are present in the horizon.				1 Refusal of excavation at 700 mm on very dense boulder calcrete.
0.20						
0.40						
0.60		Dirty white stained light yellow brown, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 3

FIGURE: A3

TRIAL HOLE: 4

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'48,3" S 21°47'04,3" E*

Cedar Land Geotechnical Consult (Pty) Ltd
P O Box 607
Ceres
6835
Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS* and *COBBLES* of banded ironstone, quartz, quartzite and calcrete in a matrix of dry, light brown, calcareous cemented fine sand. Overall consistency is medium dense becoming very dense at depth. River terrace gravels.				1 Refusal of excavation at 1100 mm on very dense gravels and cobbles.
0.20						
0.40						
			U9250	0-1,1	●	
0.60						
0.80						
1.00						
1.20						
1.40						

▽ Water encountered
▼ Water level
⏦ Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 4

FIGURE: A4

TRIAL HOLE: 5

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'45,3" S 21°47'00,6" E*

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Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS, COBBLES* and minor *BOULDERS* (±300 mm in diameter) of banded ironstone, quartz, quartzite and dolerite in a matrix of dry, light brown, sand. Overall consistency is dense. River terrace gravels.				1 Refusal of excavation at 400 mm on very dense hardpan calcrete.
0.20						
		Dirty white, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						
1.20						
1.40						

▽ Water encountered
▼ Water level
⌐ Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 5

FIGURE: A5

TRIAL HOLE: 6

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'44,3" S 21°47'05,3" E*

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Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS, COBBLES* and minor *BOULDERS* (±300 mm in diameter) of banded ironstone, quartz, quartzite and dolerite in a matrix of dry, light brown, sand. Overall consistency is dense. River terrace gravels.				1 Refusal of excavation at 500 mm on very dense hardpan calcrete.
0.20						
		Dirty white, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						
1.20						
1.40						

▽ Water encountered
▼ Water level
⌐ Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 6

FIGURE: A6

TRIAL HOLE: 7

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'41,7" S 21°47'03,7" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS, COBBLES* and minor *BOULDERS* (±300 mm in diameter) of banded ironstone, quartz, quartzite and dolerite in a matrix of dry, light brown, sand. Overall consistency is dense. River terrace gravels.				1 Refusal of excavation at 500 mm on very dense hardpan calcrete.
0.20			U9251	0-0,4	●	
0.40		Dirty white, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.60						
0.80						
1.00						
1.20						
1.40						

▽ Water encountered
▼ Water level
⏚ Bottom of hole
--- Approximate material change
• Disturbed sample
▪ Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 7

FIGURE: A7

TRIAL HOLE: 8

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'38,4" S 21°47'05,0" E*

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Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS, COBBLES* and minor *BOULDERS* (±300 mm in diameter) of banded ironstone, quartz, quartzite and dolerite in a matrix of dry, light brown, sand. Overall consistency is dense. River terrace gravels.				1 Refusal of excavation at 800 mm on very dense hardpan calcrete.
0.20						
0.40						
0.60						
0.80		Dirty white, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 8

FIGURE: A8

TRIAL HOLE: 9

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'53,3" S 21°46'48,1" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse to coarse, subrounded *GRAVELS* of banded ironstone and quartzite in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. River terrace gravels.				1 Refusal of excavation at 400 mm on hardpan calcrete.
0.20		Dirty white stained light yellow brown, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.		0,1-0,4	●	
0.40						
0.60						
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 9

FIGURE: A9

TRIAL HOLE: 10

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'53,3" S 21°46'43,6" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse to coarse, subrounded *GRAVELS* of banded ironstone and quartzite in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. River terrace gravels.				1 Refusal of excavation at 300 mm on hardpan calcrete.
0.20		Dirty white stained light yellow brown, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 10

FIGURE: A10

TRIAL HOLE: 11

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'49,0" S 21°46'41,5" E*

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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, angular *GRAVELS* of white calcrete in a matrix of dry, light grey brown, fine sand. Overall consistency is loose. Alluvium.				1 Refusal of excavation at 400 mm on very dense hardpan calcrete.
0.20		Dirty white stained light yellow brown, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.		0.1-0.4	●	
0.40						
0.60						
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 11

FIGURE: A11

TRIAL HOLE: 12

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'43,4" S 21°46'45,4" E*

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Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, medium coarse to coarse, subrounded *GRAVELS* of banded ironstone and quartzite in a matrix of dry, light brown, fine sand. Overall consistency is medium dense. River terrace gravels.				1 Refusal of excavation at 500 mm on hard rock, quartz-muscovite schist.
0.20						
0.40		Dirty white streaked light grey, very closely vertically jointed, intensely laminated, slightly weathered, hard rock, *quartz-muscovite SCHIST*. Discontinuities are open, smooth and filled with light red brown sand.				
0.60						
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 12

FIGURE: A12

TRIAL HOLE: 13

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'37,5" S 21°46'52,6" E*

Cedar Land Geotechnical Consult (Pty) Ltd
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Ceres
6835
Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS* and *COBBLES* of banded ironstone, quartz, quartzite and dolerite in a matrix of dry, light brown, fine sand. Overall consistency is dense. River terrace gravels. Foreign matter such as pieces of plastic, glass fragments and rubber are present in the horizon.				1 Refusal of excavation at 200 mm on very dense hardpan calcrete.
0.20		Dirty white, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 13

FIGURE: A13

TRIAL HOLE: 14

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'39,0" S 21°46'48,8" E*

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Cell: 082 570 2767
Email:
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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dirty white streaked light grey, very closely vertically jointed, intensely laminated, slightly weathered, hard rock, *quartz-muscovite SCHIST.* Discontinuiteis are open, smooth and filled with light red brown sand.				1 Refusal of excavation at 400 mm on hard rock, quartz-muscovite schist.
0.20			U9254	0-0,4	●	
0.40						
0.60						
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 14

FIGURE: A14

TRIAL HOLE: 15

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'36,0" S 21°46'55,7" E*

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6835
Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Dry, light brown, loose, fine *SAND* and matrix supported, medium coarse, subrounded and rounded gravels of quartz and banded ironstone. River terrace gravels.				1 Refusal of excavation at 200 mm on very dense hardpan calcrete.
0.20		Dirty white, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 15

FIGURE: A15

TRIAL HOLE: 16

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'38,0" S 21°46'58,4" E*

Cedar Land Geotechnical Consult (Pty) Ltd
P O Box 607
Ceres
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Cell: 082 570 2767
Email:
cedarland.frans@breede.co.za

Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS, COBBLES* and minor *BOULDERS* (±300 mm in diameter) of banded ironstone, quartz, quartzite and dolerite in a matrix of dry, light brown, sand. Overall consistency is dense. River terrace gravels.	U9255	0-0,2	●	1 Refusal of excavation at 300 mm on very dense hardpan calcrete.
0.20		Dirty white, very fine grained, very dense, hardpan *CALCRETE*. Pedogenic deposits.				
0.40						
0.60						
0.80						
1.00						
1.20						
1.40						

Water encountered
Water level
Bottom of hole
Approximate material change
Disturbed sample
Undisturbed sample

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 16

FIGURE: A16

TRIAL HOLE: 17

PROJECT: *EXPANSION AND FORMALISATION OF GARIEP COMMUNITY*

LOGGED BY: *FJB*

SITE: *PLOT 113, GARIEP SETTLEMENT*

DATE LOGGED: *7/7/2020*

CLIENT: *!KHEIS MUNICIPALITY*

LOCATION: *28°36'35,6" S 21°47'01,3" E*

Cedar Land Geotechnical Consult (Pty) Ltd
P O Box 607
Ceres
6835
Cell: 082 570 2767
Email:
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Depth (m)	Legend	PROFILE	SAMPLE Number	SAMPLE Type	SAMPLE Symbol	Remarks
0.00		Ground Surface				NOTES:
		Abundant, clast supported, coarse, rounded *GRAVELS, COBBLES* and minor *BOULDERS* (±300 mm in diameter) of banded ironstone, quartz, quartzite and dolerite in a matrix of dry, light brown, sand. Overall consistency is dense. River gerrace gravels.				1 Refusal of excavation at 600 mm on very dense cemented gravels and cobbles.
0.20						
0.40		Abundant, clast supported, coarse, rounded *GRAVELS* and *COBBLES* of banded ironstone and quarzite in a matrix of white, calcareous cemented sand. Overall consistency is very dense. Pedogenic deposit.				
0.60						
0.80						
1.00						
1.20						Water encountered Water level Bottom of hole Approximate material change Disturbed sample Undisturbed sample
1.40						

Contractor: Als Plant Hire
Date Drilled: 7/7/2020
Machine: Bell 315SK

Hole Diameter: 600 mm
Water Depth:
Sheet: 1 of 1

SOIL PROFILE: TEST PIT 17

FIGURE: A17

GEOTECHNICAL CONDITIONS ON PLOT 113, GARIEP SETTLEMENT: A REPORT FOR THE EXPANSION AND FORMALISATION OF GARIEP COMMUNITY

2020/J09/MCP_01

ADDENDUM B: RESULTS OF MATERIALS TESTING

ROADLAB

Roadlab Germiston
207 Rietfontein Road Germiston
1401
Tel: 011 828 0279 Fax: 011 828 0279
Email: info@roadlab.co.za
Web: www.roadlab.co.za

Date Reported : 2020-08-05

Job Request No.: RU3525
Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
Ceres
6835
Attention : Frans Breytenbach

Project : Gariep Infrastructure Upgrade

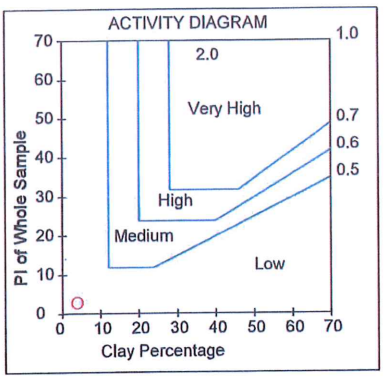
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

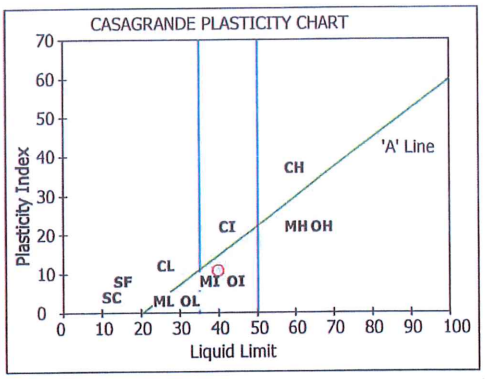
Sample No.	: U9250
Position	: TP 4
Layer Type	: 0-1100mm
Sample Colour	: Light Brown
Sample Type	: Calcrete Sand Mix

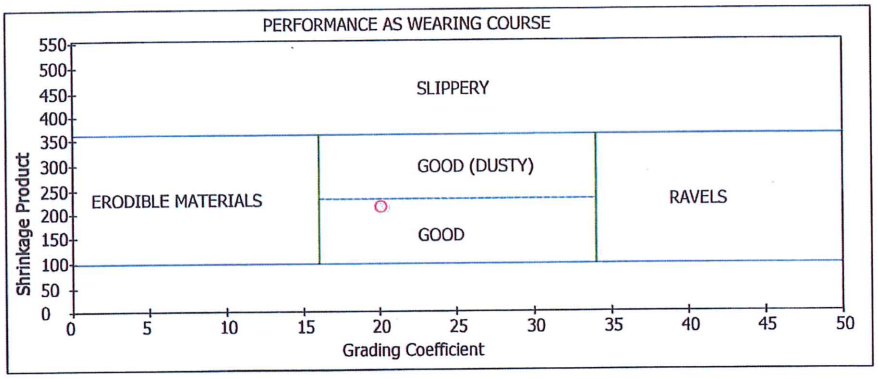
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	100
28.00	86
20.00	65
14.00	55
5.000	38
2.000	33
0.425	31
0.250	28
0.150	20
0.075	12
0.060	6,2
0.050	6,0
0.020	5,5
0.005	5,0
0.002	3,9

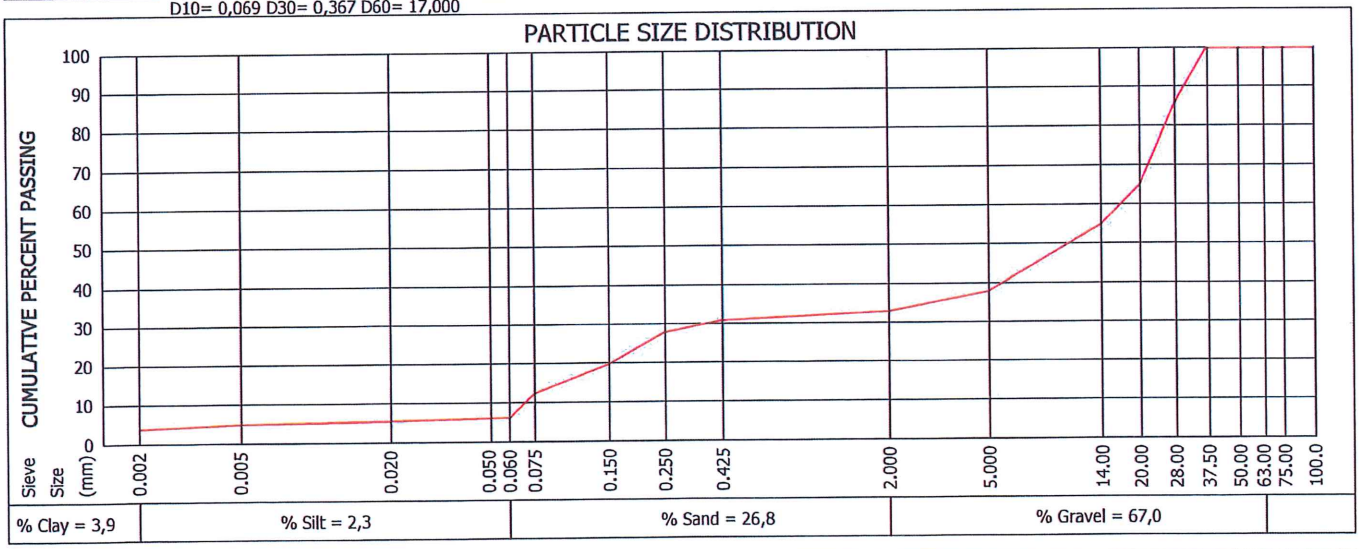
Soil Mortar	2.000 - 0.425	6
	0.425 - 0.250	9
	0.250 - 0.150	25
	0.150 - 0.075	24
	< 0.075	37
Effective Size		0,069
Uniformity Coefficient		246,4
Curvature Coefficient		0,1
Oversize Index		0,0
Shrinkage Product		217,0
Grading Coefficient		20,1
Grading Modulus		2,20
Atterberg Limits	Liquid Limit	40
	Plasticity Index	11
	Linear Shrinkage	7.0
	PI < 0.075	
Unified Soil Classification		GM
US Highway Classification		A-2-6(0)

D10= 0,069 D30= 0,367 D60= 17,000









Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 7.66 [SANS 5854] & Conductivity = 0.06 S/m [SANS 6240]

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Date Reported : 2020-07-17

Job Request No.: RU3525
Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
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6835
Attention : Frans Breytenbach

Project : Gariep Infrastructure Upgrade

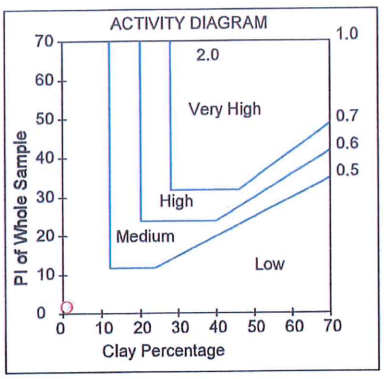
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

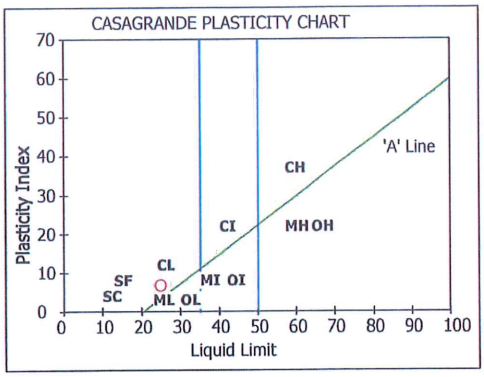
Sample No.	: U9251
Position	: TP 7
Layer Type	: 0-400mm
Sample Colour	: Dark Brown Gravel
Sample Type	: Mix Ironstone+OCC Ca

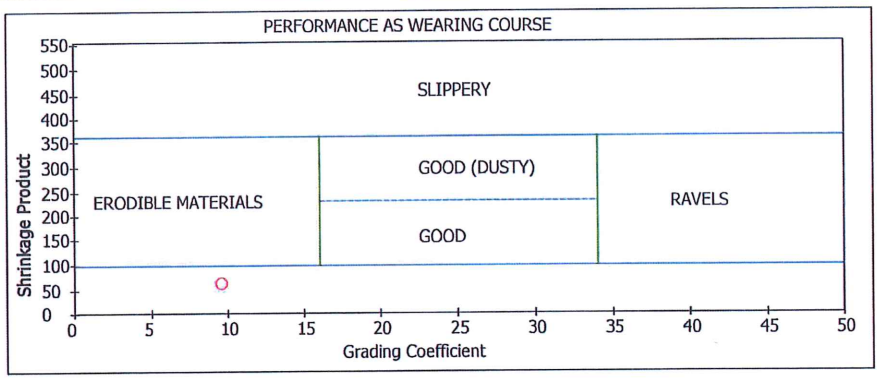
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	97
50.00	97
37.50	79
28.00	63
20.00	49
14.00	39
5.000	24
2.000	23
0.425	22
0.250	20
0.150	15
0.075	9,0
0.060	3,3
0.050	3,1
0.020	2,0
0.005	1,8
0.002	0,8

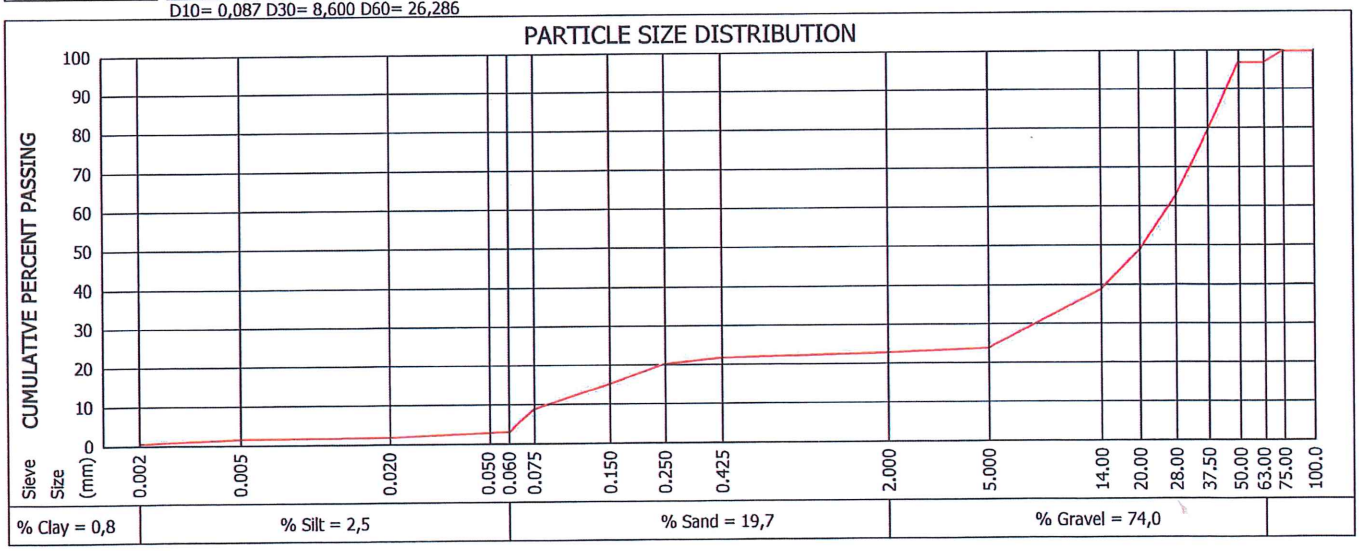
Soil Mortar	2.000 - 0.425	2
	0.425 - 0.250	8
	0.250 - 0.150	23
	0.150 - 0.075	28
	< 0.075	40
Effective Size		0,087
Uniformity Coefficient		302,1
Curvature Coefficient		32,3
Oversize Index		18,0
Shrinkage Product		66,0
Grading Coefficient		9,6
Grading Modulus		2,50
Atterberg Limits	Liquid Limit	25
	Plasticity Index	7
	Linear Shrinkage	3.0
	PI < 0.075	
Unified Soil Classification		GW-GM-GC
US Highway Classification		A-2-4(0)

D10= 0,087 D30= 8,600 D60= 26,286









% Clay = 0,8	% Silt = 2,5	% Sand = 19,7	% Gravel = 74,0

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

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Project : Gariep Infrastructure Upgrade

Attention : Frans Breytenbach

Determination of the California Bearing Ratio Test Report SANS 3001 - GR1 / GR2 / GR10 / GR20 / GR30 / GR40 / PR5

SAMPLE INFORMATION AND PROPERTIES

SAMPLE NO.	U9251			
HOLE NO./ Km / CHAINAGE	TP7			
ROAD NO./ NAME Line 1 ROAD NO./ NAME Line 2	S28° 36' 41,7" E21° 47' 03,7"			
LAYER TESTED/SAMPLED	0-400mm			
SAMPLE DEPTH	0-400mm			
DATE SAMPLED	2020-07-09			
COLOUR OF SAMPLE	Orange Brown			
TYPE OF SAMPLE	Iron Stone+Calcrete			

SIEVE ANALYSIS - % PASSING SIEVES *(SANS 3001-GR1:2010, SANS 3001-GR2:2010)

SIEVE ANALYSIS (GR 1) % PASSING	100.0 mm				
	75.0 mm	100			
	63.0 mm	97			
	50.0 mm	97			
	37.5 mm	79			
	28.0 mm	63			
	20.0 mm	49			
	14.0 mm	39			
	5.0 mm	24			
	2.0 mm	23			
	0.425 mm	22			
	0.075 mm	9			
GM %		2,5			

SOIL MORTAR ANALYSIS (SANS 3001-PR5:2011)

COARSE SAND	2.000 - 0.425	2			
COARSE FINE SAND	0.425 - 0.250	8			
MEDIUM FINE SAND	0.250 - 0.150	23			
FINE FINE SAND	0.150 - 0.075	28			
SILT CLAY	0.075	40			

ATTERBERG LIMITS ANALYSIS - *(SANS 3001-GR10:2010)

ATTERBERG LIMITS (%) SANS GR10,GR11	LIQUID LIMIT	25			
	PLASTICITY INDEX	7			
	LINEAR SHRINKAGE	3.0			
CLASSIFICATION	H.R.B.	A-2-4(0)			
	COLTO	G6			
	TRH 14	G7			

CALIFORNIA BEARING RATIO - *(SANS 3001-GR30:2010, SANS 3001-GR40:2010)

SANS GR30 MAX. DRY DENSITY	OMC %	6,1			
	MDD (kg/m³)	2283			
	COMP MC %	6,0			
SWELL % @	MOD | NRB | PRO	0,01 | 0,03 | 0,06			
C.B.R. SANS GR40	100 %	97			
	98 %	58			
	97 %	45			
	95 %	27			
	93 %	16			
	90 %	8			

STABILISER IN LAB	Not Applicable			
TEST TYPE	CBR			
SAMPLING METHOD	TMH 5			
WEATHER WHEN SAMPLED	Cold			

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
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Report compiled by : Juraine Okkies

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Project : Gariep Infrastructure Upgrade

Attention : Frans Breytenbach

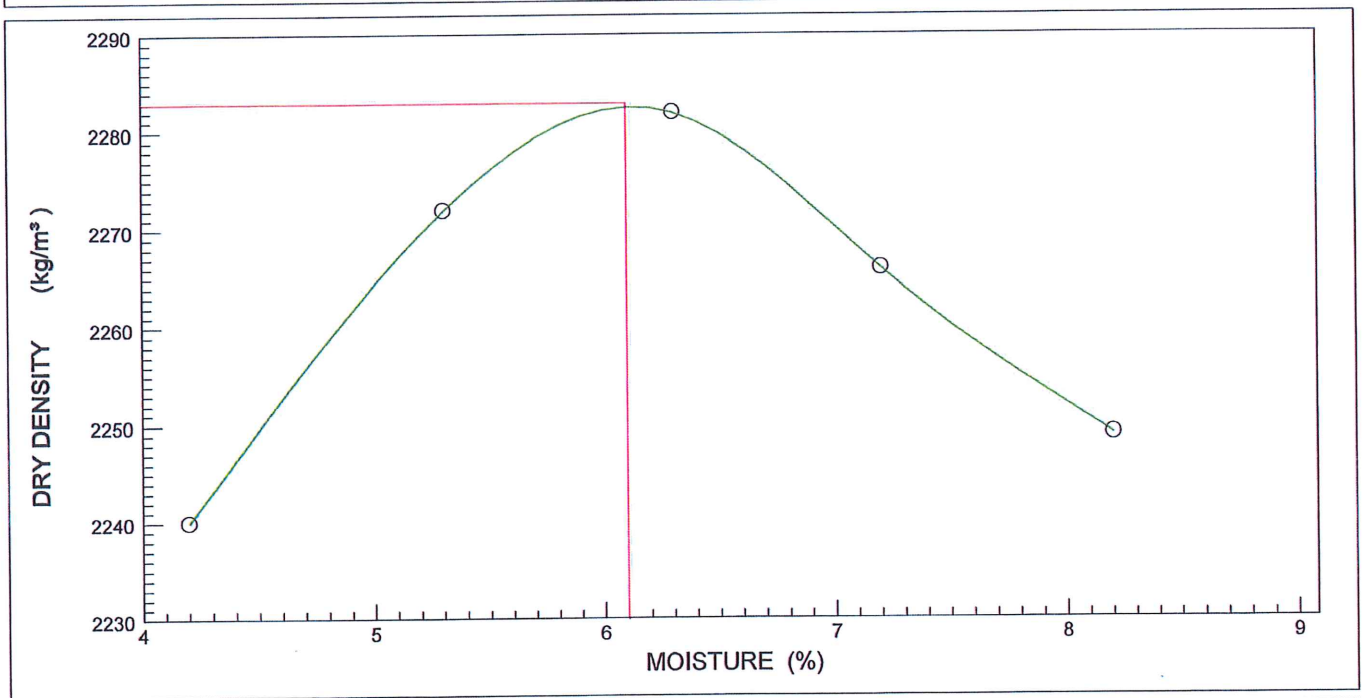
Determination Maximum Dry Density & Optimum Moisture Content Test Report

SANS 3001 - GR20/GR30

SAMPLE NO.	U9251
CONTAINER FOR SAMPLING	Black Bags
SIZE / APPROX. MASS OF SAMPLE	95kg
MOISTURE CONDITION OF SAMPLE	Moist
LAYER TESTED / SAMPLED FROM	0-400mm
MATERIAL DESCRIPTION	Mix Calcrete + Ironstone
HOLE NO./ km / CHAINAGE	TP7
ROAD NO.	Not Specified
DATE RECEIVED	2020-07-09
DATE SAMPLED	2020-07-08
CLIENT MARKING	S28° 36' 41,7"; E21° 47' 03,7"
COLOUR AND TYPE	Dark Brown Gravel

POINT NO.	1	2	3	4	5			
DRY DENSITY (kg/m³)	2240	2272	2282	2266	2249			
MOISTURE (%)	4,2	5,3	6,3	7,2	8,2			

MAXIMUM DRY DENSITY (kg/m³) : 2283	OPTIMUM MOISTURE CONTENT (%) : 6,1



Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

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Attention : Frans Breytenbach

Project : Gariep Infrastructure Upgrade

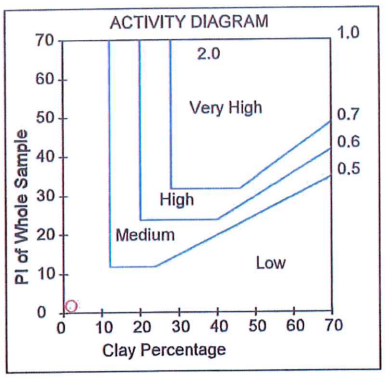
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

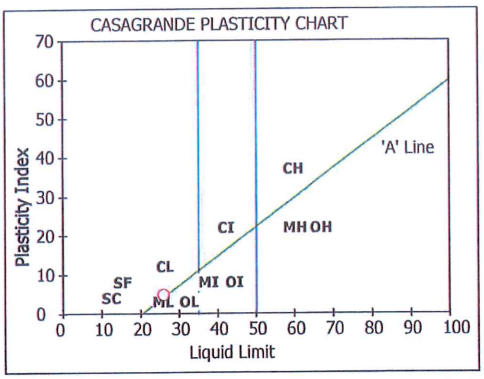
Sample No.	: U9252
Position	: TP 9
Layer Type	: 100-400mm
Sample Colour	: Dark Brown Gravel
Sample Type	: Mix Calcrete+Ironsto

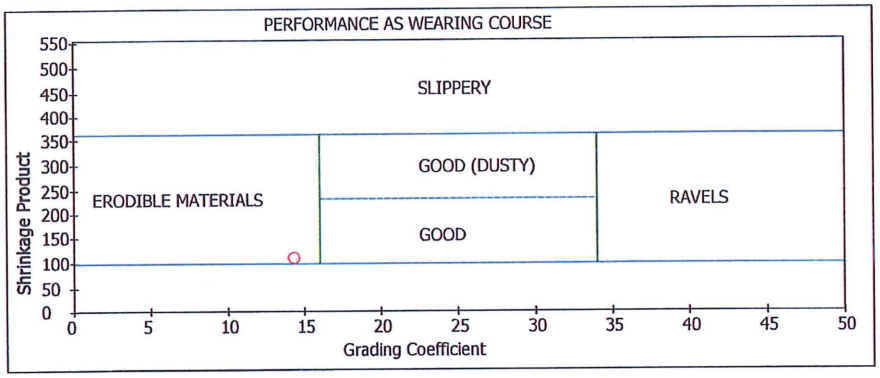
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	81
28.00	72
20.00	63
14.00	55
5.000	37
2.000	33
0.425	32
0.250	31
0.150	26
0.075	18
0.060	5,8
0.050	5,2
0.020	3,2
0.005	2,5
0.002	1,8

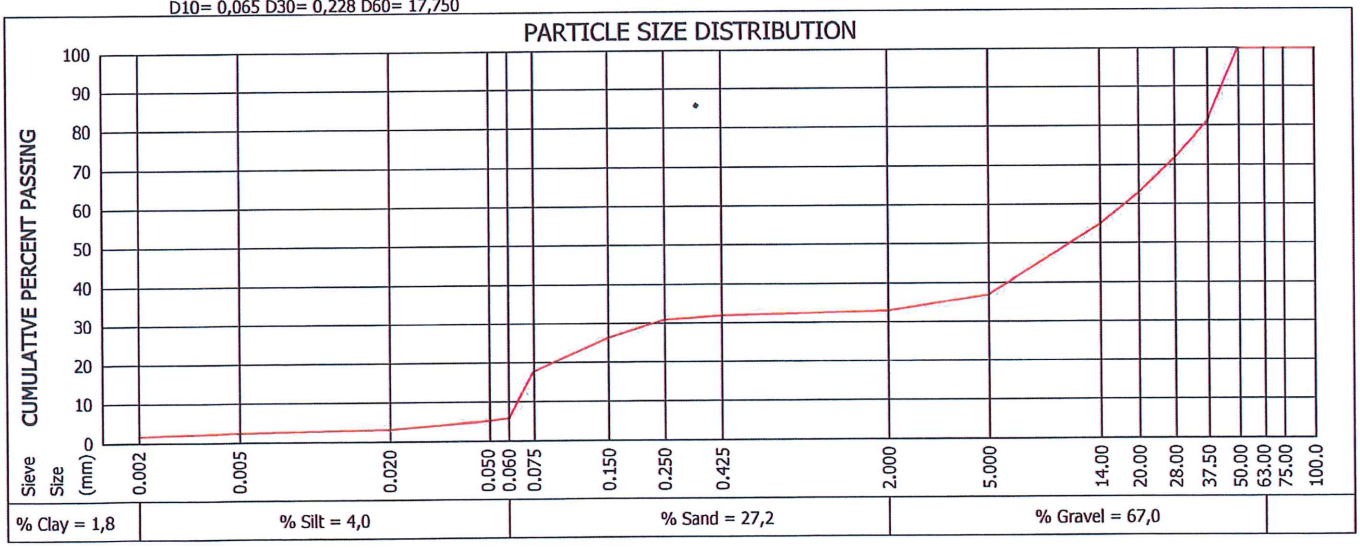
Soil Mortar	2.000 - 0.425	3
	0.425 - 0.250	3
	0.250 - 0.150	14
	0.150 - 0.075	25
	< 0.075	54
Effective Size		0,065
Uniformity Coefficient		273,1
Curvature Coefficient		0,0
Oversize Index		19,0
Shrinkage Product		112,0
Grading Coefficient		14,4
Grading Modulus		2,20
Atterberg Limits	Liquid Limit	26
	Plasticity Index	5
	Linear Shrinkage	3,5
	PI < 0.075	
Unified Soil Classification		GM-GC
US Highway Classification		A-1-b(0)

D10= 0,065 D30= 0,228 D60= 17,750









% Clay = 1,8	% Silt = 4,0	% Sand = 27,2	% Gravel = 67,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 7.80 [SANS 5854] & Conductivity = 0.09 S/m [SANS 6240]

Report compiled by : Juraine Okkies

sanas Testing Laboratory
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Date Reported : 2020-08-12

Job Request No.: RU3525
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Attention : Frans Breytenbach

Project : Gariep Infrastructure Upgrade

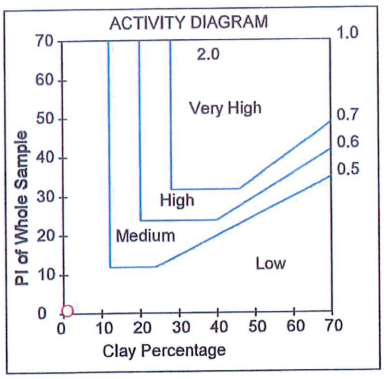
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

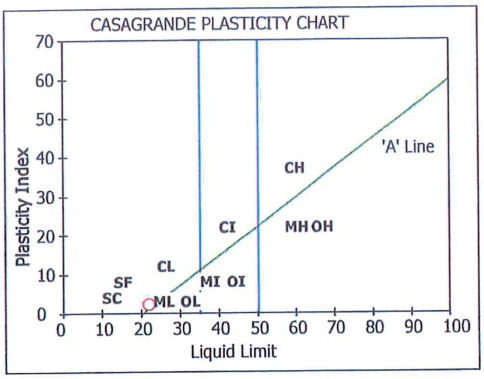
Sample No.	: U9253
Position	: TP 11
Layer Type	: 100-400mm
Sample Colour	: Brown Gravel
Sample Type	: Mix Calcrete+Ironsto

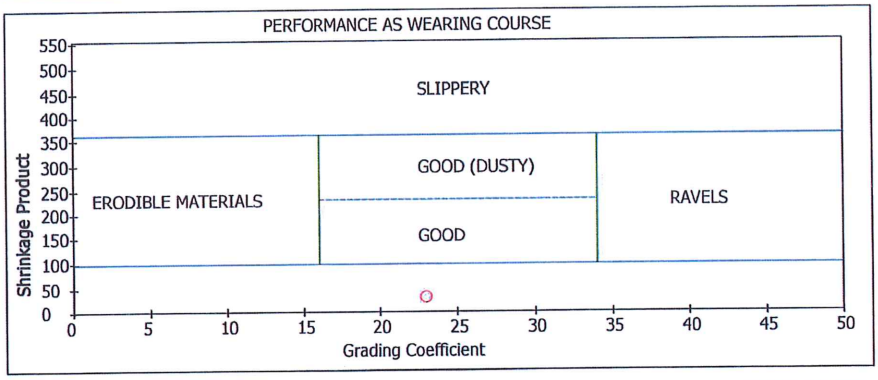
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	100
28.00	88
20.00	78
14.00	70
5.000	47
2.000	39
0.425	34
0.250	33
0.150	26
0.075	15
0.060	3,7
0.050	3,3
0.020	2,1
0.005	1,7
0.002	1,0

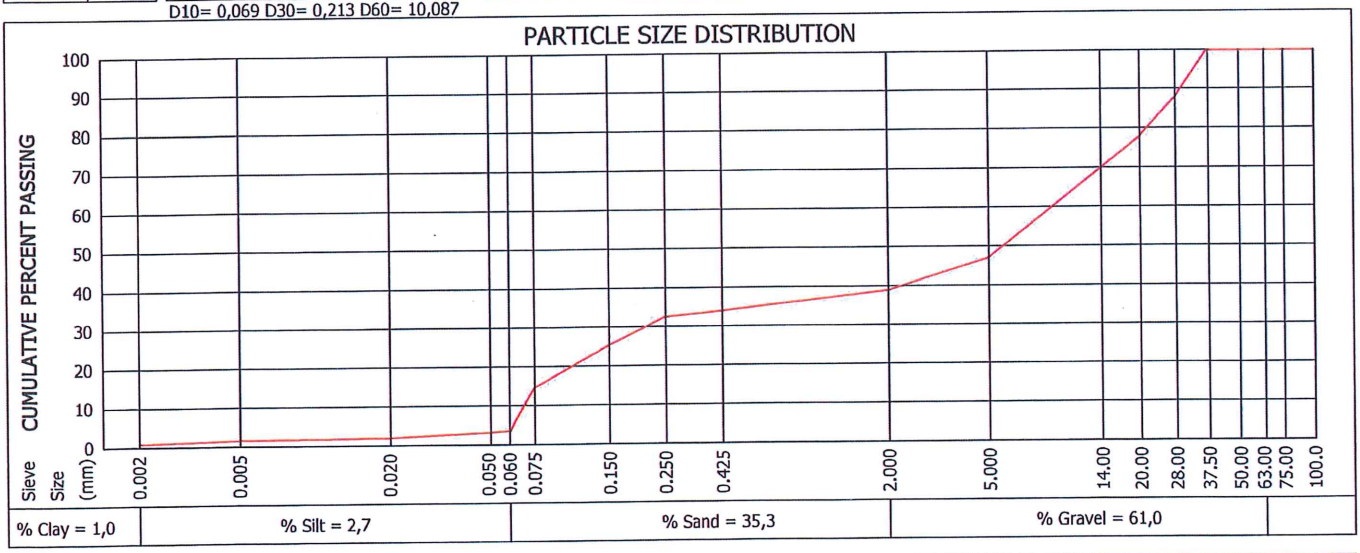
Soil Mortar	2.000 - 0.425	11
	0.425 - 0.250	5
	0.250 - 0.150	18
	0.150 - 0.075	27
	< 0.075	39
Effective Size		0,069
Uniformity Coefficient		146,2
Curvature Coefficient		0,1
Oversize Index		0,0
Shrinkage Product		34,0
Grading Coefficient		23,0
Grading Modulus		2,10
Atterberg Limits	Liquid Limit	22
	Plasticity Index	3.0
	Linear Shrinkage	1.0
	PI < 0.075	
Unified Soil Classification		GC
US Highway Classification		A-1-b(0)

D10= 0,069 D30= 0,213 D60= 10,087









% Clay = 1,0	% Silt = 2,7	% Sand = 35,3	% Gravel = 61,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 8.19 [SANS 5854] & Conductivity = 0.08 S/m [SANS 6240]

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

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Date Reported : 2020-08-05

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Attention : Frans Breytenbach

Project : Gariep

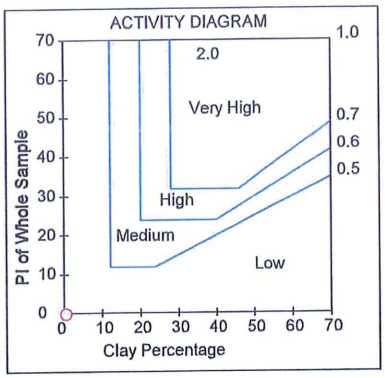
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

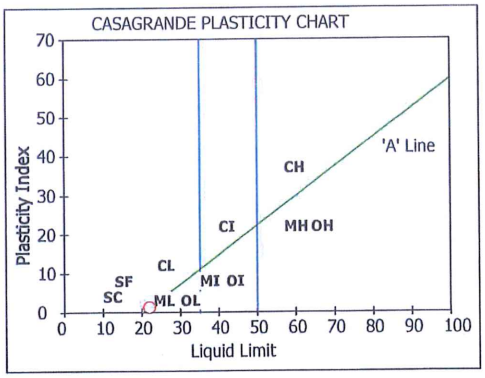
Sample No.	: U9254
Position	: TP 14
Layer Type	: 0-400mm
Sample Colour	: Dark Brown Gravel
Sample Type	: Mix Ironstone+OCC Ca

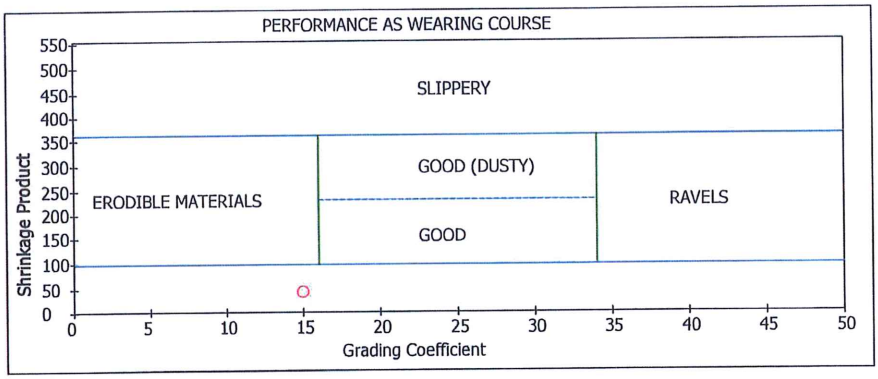
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	97
37.50	89
28.00	75
20.00	64
14.00	56
5.000	34
2.000	31
0.425	29
0.250	28
0.150	24
0.075	16
0.060	3,6
0.050	3,1
0.020	1,7
0.005	1,5
0.002	0,6

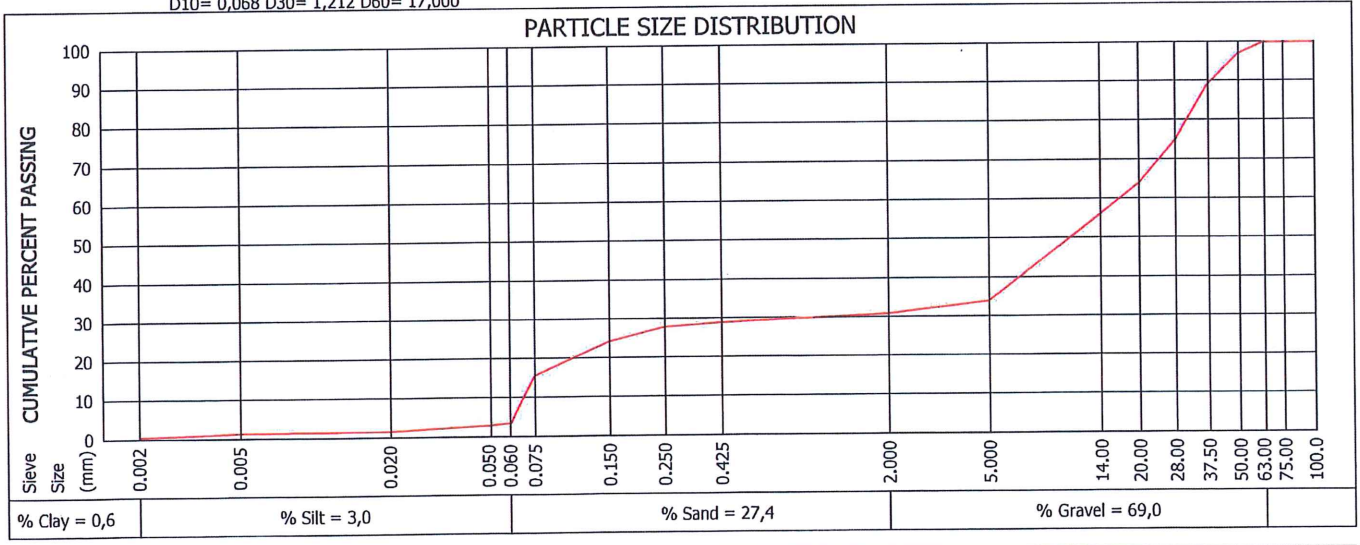
Soil Mortar	2.000 - 0.425	6
	0.425 - 0.250	4
	0.250 - 0.150	12
	0.150 - 0.075	27
	< 0.075	52
Effective Size		0,068
Uniformity Coefficient		250,0
Curvature Coefficient		1,3
Oversize Index		8,0
Shrinkage Product		43,5
Grading Coefficient		15,0
Grading Modulus		2,20
Atterberg Limits	Liquid Limit	22
	Plasticity Index	1,0
	Linear Shrinkage	1,5
	PI < 0.075	
Unified Soil Classification		GM
US Highway Classification		A-1-b(0)

D10= 0,068 D30= 1,212 D60= 17,000









% Clay = 0,6	% Silt = 3,0	% Sand = 27,4	% Gravel = 69,0

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Job Request No.: RU3525

Date Reported : 2020-08-05

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Project : Gariep Infrastructure Upgrade

Attention : Frans Breytenbach

Determination of the California Bearing Ratio Test Report SANS 3001 - GR1 / GR2 / GR10 / GR20 / GR30 / GR40 / PR5

SAMPLE INFORMATION AND PROPERTIES

SAMPLE NO.		U9254			
HOLE NO./ Km / CHAINAGE		TP14			
ROAD NO./ NAME Line 1 ROAD NO./ NAME Line 2		S28° 36' 39,0" E21° 46' 48,8"			
LAYER TESTED/SAMPLED		0-400mm			
SAMPLE DEPTH		0-400mm			
DATE SAMPLED		2020-07-08			
COLOUR OF SAMPLE		Dark Brown			
TYPE OF SAMPLE		Mix Ironst+Calcrete			

SIEVE ANALYSIS - % PASSING SIEVES *(SANS 3001-GR1:2010, SANS 3001-GR2:2010)

SIEVE ANALYSIS (GR 1) % PASSING	100.0 mm				
	75.0 mm				
	63.0 mm	100			
	50.0 mm	97			
	37.5 mm	89			
	28.0 mm	75			
	20.0 mm	64			
	14.0 mm	56			
	5.0 mm	34			
	2.0 mm	31			
	0.425 mm	29			
	0.075 mm	16			
GM %		2,2			

SOIL MORTAR ANALYSIS (SANS 3001-PR5:2011)

COARSE SAND	2.000 - 0.425	6			
COARSE FINE SAND	0.425 - 0.250	4			
MEDIUM FINE SAND	0.250 - 0.150	12			
FINE FINE SAND	0.150 - 0.075	27			
SILT CLAY	0.075	52			

ATTERBERG LIMITS ANALYSIS - *(SANS 3001-GR10:2010)

ATTERBERG LIMITS (%) SANS GR10,GR11	LIQUID LIMIT	22			
	PLASTICITY INDEX	2			
	LINEAR SHRINKAGE	1,5			
CLASSIFICATION	H.R.B.	A-1-b(0)			
	COLTO	G6			
	TRH 14	G6			

CALIFORNIA BEARING RATIO - *(SANS 3001-GR30:2010, SANS 3001-GR40:2010)

SANS GR30 MAX. DRY DENSITY	OMC %	6,9			
	MDD (kg/m³)	2254			
	COMP MC %	6,9			
SWELL % @	MOD | NRB | PRO	0,01 | 0,03 | 0,06			
C.B.R. SANS GR40	100 %	53			
	98 %	46			
	97 %	43			
	95 %	38			
	93 %	33			
	90 %	27			

STABILISER IN LAB	Not Applicable			
TEST TYPE	CBR			
SAMPLING METHOD	TMH 5			
WEATHER WHEN SAMPLED	Cold			

Deviation from Test Method :
Remarks and Notes :

Opinions and interpretations are not included in our scope of works. (T0296)
The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM).
The test results reported relate to the samples tested.
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Report compiled by : Juraine Okkies

sanas Testing Laboratory
Accreditation No. T0296
Prog.ver 10.7 (2019/11/07)

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Date Reported : 2020-07-17

Job Request No.: RU3525
Ceder Land Geotechnical Consult (Pty) Ltd
PO Box 607
Ceres
6835

Project : Gariep Infrastructure Upgrade

Attention : Frans Breytenbach

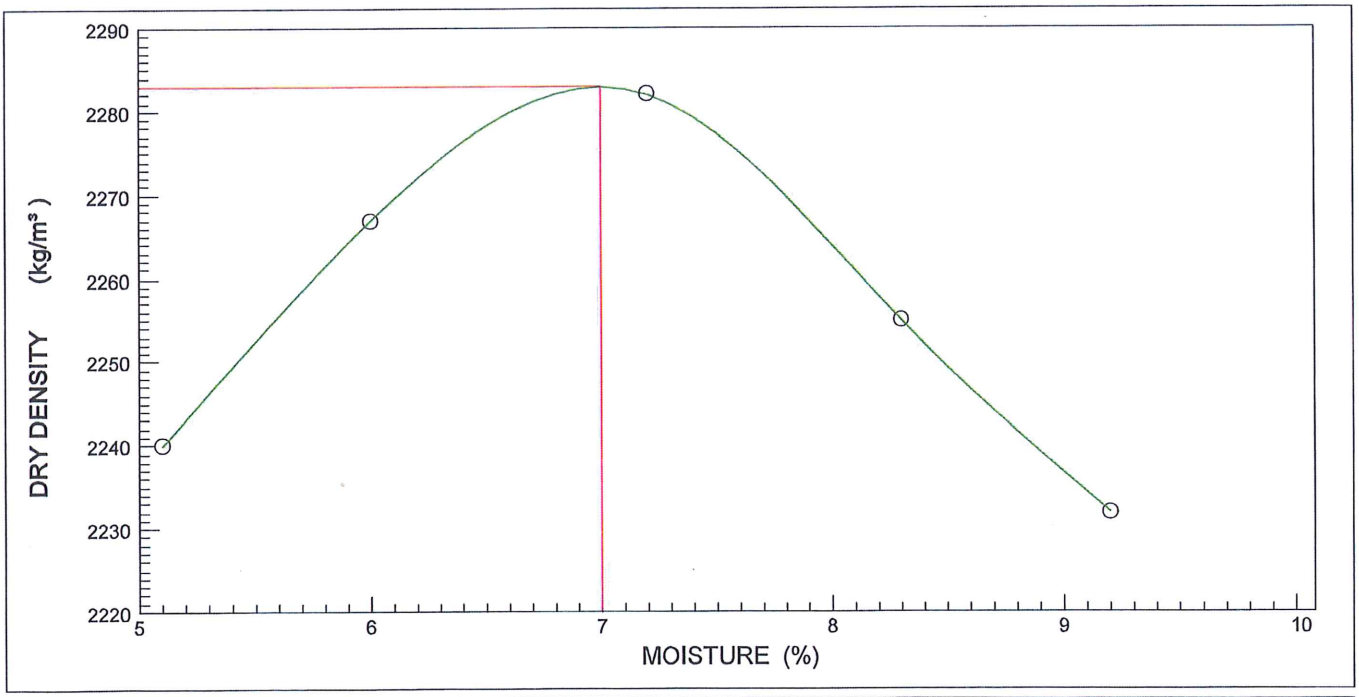
Determination Maximum Dry Density & Optimum Moisture Content Test Report

SANS 3001 - GR20/GR30

SAMPLE NO.	U9254
CONTAINER FOR SAMPLING	Black Bags
SIZE / APPROX. MASS OF SAMPLE	98kg
MOISTURE CONDITION OF SAMPLE	Moist
LAYER TESTED / SAMPLED FROM	0-400mm
MATERIAL DESCRIPTION	Mix OCC Calcrete + Ironstone
HOLE NO./ km / CHAINAGE	TP14
ROAD NO.	Not Specified
DATE RECEIVED	2020-07-08
DATE SAMPLED	2020-07-09
CLIENT MARKING	S28° 36' 39,0"; E21° 46' 48,8"
COLOUR AND TYPE	Dark Brown Gravel

POINT NO.	1	2	3	4	5			
DRY DENSITY (kg/m³)	2240	2267	2282	2255	2232			
MOISTURE (%)	5,1	6,0	7,2	8,3	9,2			

MAXIMUM DRY DENSITY (kg/m³) : 2283	OPTIMUM MOISTURE CONTENT (%) : 7,0



Deviation from Test Method :
Remarks and Notes :

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Date Reported : 2020-08-05

Project : Gariep Infrastructure Upgrade

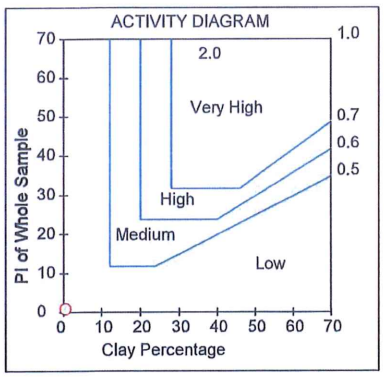
Foundation Indicator Test Report SANS 3001 - GR1 / GR3 / GR10

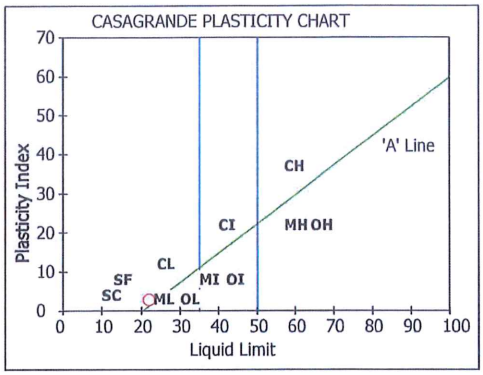
Sample No.	: U9255
Position	: TP 16
Layer Type	: 0-200mm
Sample Colour	: Dark Brown
Sample Type	: Granite Iron Stone G

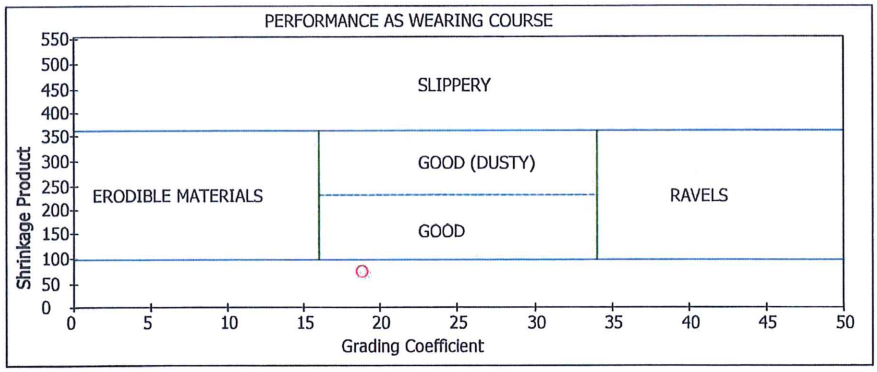
Sieve Size(mm)	% Passing
100.0	100
75.00	100
63.00	100
50.00	100
37.50	97
28.00	84
20.00	76
14.00	66
5.000	41
2.000	38
0.425	38
0.250	36
0.150	29
0.075	17
0.060	4,5
0.050	4,0
0.020	2,2
0.005	1,4
0.002	0,7

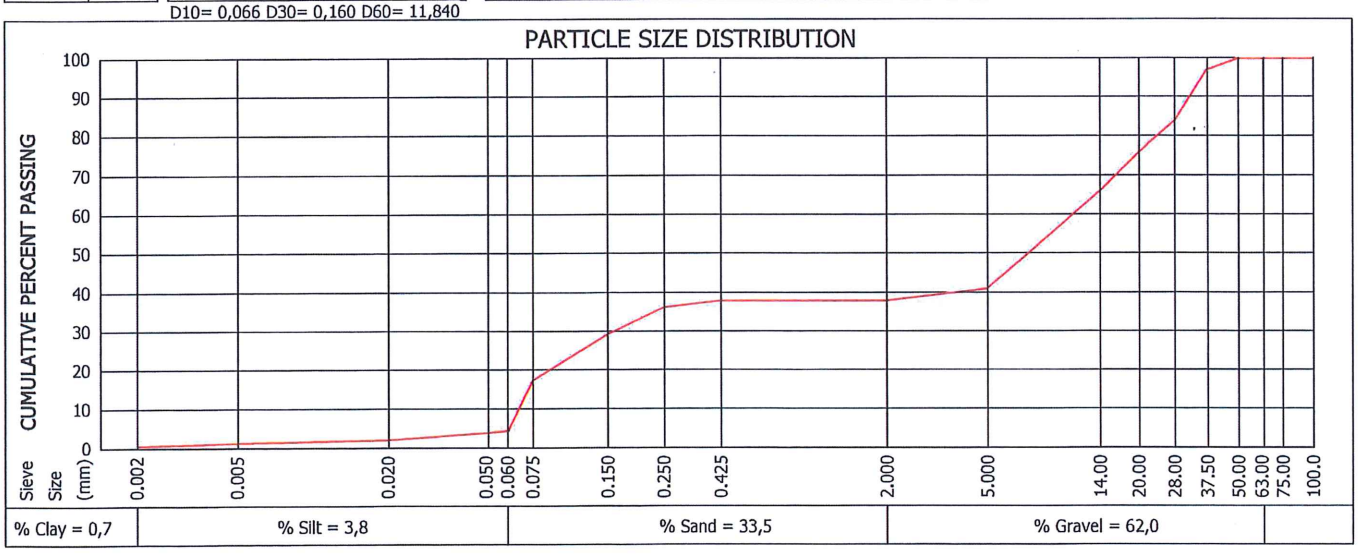
Soil Mortar	2.000 - 0.425	2
	0.425 - 0.250	4
	0.250 - 0.150	18
	0.150 - 0.075	32
	< 0.075	44
Effective Size		0,066
Uniformity Coefficient		179,4
Curvature Coefficient		0,0
Oversize Index		3,0
Shrinkage Product		76,0
Grading Coefficient		18,9
Grading Modulus		2,10
Atterberg Limits	Liquid Limit	22
	Plasticity Index	3,0
	Linear Shrinkage	2,0
	PI < 0.075	
Unified Soil Classification		GC
US Highway Classification		A-1-b(0)

D10= 0,066 D30= 0,160 D60= 11,840









% Clay = 0,7	% Silt = 3,8	% Sand = 33,5	% Gravel = 62,0

Deviation from Test Method :
Remarks and Notes : Chemistry: pH = 7.55 [SANS 5854] & Conductivity = 0.08 S/m [SANS 6240]

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