- *Site Investigations*
- *Slope Stability*
- *Rock Mechanics*
- *Soil Mechanics*
- *Foundations*
- *Borrow Pits and Materials*
- *Roads*
- *Groundwater*
- *NHBRC*
- *Geotechnical Instrumentation*

Rapid Land Release Program: NHBRC Phase 1 Geotechnical Investigation for a Portion of the Remaining Extent of Portion 129 of the Farm Rietfontein 301 IQ, Gauteng: Final Report

Client: Glad Africa & GDHS

Reference: 19-0866.01R03

Dated: 29 October 2019

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Rapid Land Release Program: NHBRC Phase 1 Geotechnical Investigation for a Portion of the Remaining Extent of Portion 129 of the Farm Rietfontein 301 IQ, Gauteng: Final Report

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Rapid Land Release Program: NHBRC Phase 1 Geotechnical Investigation for a Portion of the Remaining Extent of Portion 129 of the Farm Rietfontein 301 IQ, Gauteng: Final Report

Reference: 19-0866.01R03 **Date: 29 October 2019**

EXECUTIVE SUMMARY

This report presents the findings of a NHBRC Phase 1 geotechnical investigation for the proposed housing development to be located on the remaining extent of portion 129 of the farm Rietfontein 301 IQ, Lenasia, and the conclusions and recommendations for excavations, foundations and earthworks.

The most important consideration in relation to the proposed development is the presence of dolomite within a depth of 60 m and chert outcrop in the northern portion of the site.

Based on the 1:250 000 Geological Map titled "2626 West Rand (1986)", the site is underlain by dolomite and chert of the Malmani Formation, Chuniespoort Group, Transvaal Supergroup. This results in the site being deemed as ***dolomitic land****. As a result, a dolomite stability investigation is required.*

All materials on site classify as SOFT excavation (SABS 1200 D) to depths ranging between 0.7 m and 2.8 m with an average depth of around 1.5 m. Below this depth, intermediate to hard excavation is to be anticipated due to well-cemented ferricrete layers. The northern portion of the site may classify as HARD excavation (SABS 1200 D).

The site has been classified as ***P(dolomite)/H/C/R*** *according to NHBRC guidelines. The following foundation recommendations are proposed for the site (but should be checked with the results and recommendations of the DSI):*

- *Stiffened strip foundations,*
- *Stiffened or cellular raft foundations,*
- *Modified normal soil raft,*
- *Compaction of in-situ soils below individual footings, and*
- *Normal foundations on well-cemented ferricrete or hard chert*

Finally, the ground conditions described in this report refer specifically to those encountered at the test positions advanced on site. It is therefore possible that conditions at variance with those discussed above may be encountered elsewhere on the site. In this regard it is critical that a dolomite stability investigation be commissioned and completed to facilitate the issue of a RoD from the CGS.

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Definitions and Abbreviations

Commercial:

GCS Geotechnical	GCS Geotechnical (Pty.) Ltd.

Technical:

CH	Chainage (metres)
mbgl	metres below ground level
masl	metres above sea level
NGL	Natural Ground Level
FL	Foundation Level
BH	Borehole
SPT	Standard Penetration Test
N	SPT N value (blows per 300 mm)
TLB	Tractor-mounted Loader Backhoe
TP	Test Pit
DCP	Dynamic Cone Penetrometer
EABC	Estimated Allowable Bearing Capacity
G1-G10	Standard classification of natural road building materials (TRH 14)
CBR	California Bearing Ratio
MDD	Maximum Dry Density (kg/m3)
MADD	Modified AASHTO Dry Density
OMC	Optimum moisture Content (%)
PI	Plasticity Index
LL	Liquid Limit
LS	Linear Shrinkage
RMR	Rock Mass Rating
GSI	Geological Strength Index
mi	Hoek-Brown Constant (origin & texture dependent)
RQD	Rock Quality Designation (%)
FF	Fracture frequency
UCS	Unconfined Compressive Strength (MPa)
C (c')	Cohesion (kPa) – total stress and (effective stress)
Φ (Φ')	Friction Angle (degrees) – total stress and (effective stress)
Kv	Modulus of Subgrade Reaction (MN/mm or kPa/mm)
CFA	Continuous Flight Auger (pile type)
DCI	Driven Cast In situ (pile type)
Cv	Coefficient of Consolidation (m2/yr)
Mv	Modulus of Compressibility (m2/MN)
MC1	Moisture Content Before Test (%)
MC2	Moisture Content After Test (%)
ρ	Dry Density (kg/m3)
VSR	Very soft rock
SR	Soft rock
MHR	Medium hard rock
HR	Hard rock
VHR	Very hard rock

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Reference: 19-0866.01R03 **Date: 29 October 2019**

1. INTRODUCTION & TERMS OF REFERENCE

At the request of Nivendra Moodley of Glad Africa (and on behalf of the Gauteng Department of Human Settlements), ***GCS Geotechnical*** (hereafter referred to as GCS) was asked to provide a proposal and cost estimate quotation for the undertaking of a Phase 1 NHBRC geotechnical investigation for the proposed housing development to be located on the remaining extent of portion 129 of the farm Rietfontein 301 IQ, Lenasia, Gauteng.

2. AVAILABLE INFORMATION

The following information was drawn upon for the purposes of the investigation:

- The 1:250 000 Geological Map titled *"2626 West Rand*" as compiled by the South African Geological Survey, 1986,
- Google Earth Imagery,
- The 1:500 000 Hydrogeological Map titled "2628 Johannesburg" as compiled by DWAF, 1998,
- Anhaesseur, 1973: Geology of Johannesburg,
- SABS 1200 D – Earthworks, and
- Report titled *"RLRP: Desk Study Geotechnical Report for Rietfontein"*, referenced 19-0866.01R01, written by GCS in 2019.
- Report titled "*RLRP: Preliminary Geotechnical Report for Rietfontein*." Referenced 19-0866.01R02, written by GCS in 2019.

The table below shows the available published physiographical information on the site.

Table 2: Summary of Available Desk Study Information

Parameter	Value	Reference
Development	Residential	Glad Africa
Site coordinates	26°20'51.23"S / 27°51'49.25"E	Google Earth and Garmaps
Weinerts N-value	2-5	Weinert (1974)
Climatic Region	Moderate	TRH 2 (1978)
Rainfall	850-900 mm	
Temperature	5.8-26.2°C	After DWAF (1986)
Evaporation	1200 mm	Barnard (2000)
Water Balance	Deficit	Schulze (1985)
Weathering Type	Moderate decomposition with frost	Fookes et al (1971) & Embleton et al (1979)
General geology	Dolomite of Chuniespoort Group	1:250 000 Geological Map titled *"2626 – West Rand* (1986)
Soil cover	Fersiallitic sand, loam and clay, mainly red	Brink (1985)
Origin	Discontinuous sands of mixed origin	Brink (1985) Vol 4
Topography	Relatively flat at 1175masl	Google Earth
Drainage region	C22	DWAF (1999)
Hydrogeology	Karst 0.5 to 2.0 l/s	Hydrogeological Map – Johannesburg (1998)
Groundwater	20 to 40 mbgl	Barnard (2000)
Harvest potential	-	DWAF (2003)
Erodibility Index	9-15 (medium)	WRC (1992)
Seismic Intensity	VI (MMS)	Fernandez et al (1972)
Liquefaction	Likely (100-200 m2/s) <0.2g	Welland (2002)

3. SITE DESCRIPTION

The site is located on a vacant plot to the south of Ext 10 in Lenasia. The M10 is found on the western boundary. The Lehai Housing Project occurs on the eastern boundary with vacant land to the south.

The total site area is approximately 73 Ha in size.

Topographically, the site is fairly flat at 1:130 or less than 1% and is sparsely vegetated with small trees, shrubs and scattered grasses.

There is a gas pipeline that runs from west to east through the centre of the site as well as along the southern and eastern boundary.

No drainage paths were noted on site but what appears to be a wetland is located in the north-eastern corner.

Portions of the site have been used as an informal dump with piles of domestic waste and builder's rubble.

4. GEOLOGY

Based on the 1:250 000 Geological Map titled *"2626 West Rand* (1986)", the site is underlain by dolomite and chert of the Malmani Formation, Chuniespoort Group, Transvaal Supergroup.

Only the dolomite and chert of the Malmani Formation was identified on site and therefore the site is deemed to be **dolomitic land**. As a result, a dolomite stability investigation is required.

5. PREVIOUS WORK

A search of the data base at the Council for Geoscience revealed that a high-level dolomite stability investigation (DSI) had been undertaken on the site by R.F Loxton, Hunting, and Associates in 1978 as part of the DSI for the greater Lenasia Extension 10 area. The investigation included the drilling of 32No percussion boreholes (but no gravity survey) and eight of these boreholes fall within the remaining extent of portion 129 of Rietfontein 301 IQ. The results of this investigation shall be reported upon in the detailed DSI investigation and report for the site (which has yet to be commissioned).

6. FIELDWORK

TLB-excavated test pits were conducted on site, in order to ascertain and better understand the general engineering properties and parameters of the subsurface materials. Existing exposures were logged in order to obtain more information across the site.

6.1 TLB-Excavated Trial Pits

Twenty-nine test pits were excavated over the 73 Ha site (according to guidelines of GFSH-2 of 2002), in order to better understand the engineering properties of the subsurface soil / rock conditions.

The results of the test pits indicated refusal depths ranging between 0.7 m and 2.8 m below existing ground level, refusing at an average depth of 1.5 m. Typically the ground conditions comprised a thin veneer of colluvium, underlain by residual chert or residual ferriginised chert, underlain by weathered chert bedrock. Detailed soil profiles can be found in Appendix A of this report.

A summary of the soil profiles across the site are given below in Table 6.1a to 6.1b:

Table 6.1a: Summary of Soil Layers in Test Pits

TP No.	Fill	Colluvium	Residual Chert	Residual Fe Chert	Chert
1		0.0-0.2	0.2-0.6		0.6-0.7
2			0.0-0.7	0.7-2.7	
3			0.0-0.3	0.3-2.7	
4			0.0-0.2	0.2-2.8	
5			0.0-0.15	0.15-2.7	
6		0.0-0.2	0.2-1.0		1.0-1.1
7		0.0-0.4	0.4-1.2		1.2-1.3
8		0.0-0.3		0.3-2.7	
9				0.0-2.0	2.0-2.1
10			0.0-2.1		2.1-2.2
11			0.0-2.2		2.2-2.3
12			0.0-0.4-		0.4-0.5
13			0.0-1.8		1.8-1.9
14		0.0-0.15	0.15-0.6		0.6-0.7
15		0.0-0.4	0.4-1.2		1.2-1.3
16		0.0-0.3	0.3-1.9		1.9-2.0
17		0.0-0.2		0.0-2.0	
18		0.0-0.3	0.3-1.5		1.5-1.6
19		0.0-0.5	0.5-2.1		2.1-2.2
20		0.0-0.3		0.3-1.2	1.2-1.3
21		0.0-0.4		0.4-1.5	1.5-1.6
22		0.0-0.4	0.4-1.2		1.2-1.3
23		0.0-0.5	0.5-1.5		1.5-1.6
24		0.0-0.3		0.3-2.8	
25	0.0-0.3	0.3-0.5	0.5-1.2		1.2-1.3
26		0.0-0.4	0.4-1.1	1.1-2.8	
27		0.0-0.2	0.2-0.5	0.5-1.9	1.9-2.0
28		0.0-0.4		0.4-1.3	1.3-14
29			0.0-0.5	0.5-2.2	2.2-2.3
Ave Depth	**0.3**	**0.3**	**1.1**	**2.2**	**1.5**

Table 6.1b: Summary of Soil Profile

Depth From (m)	Depth To (m)	Description	EABC (kPa)	Kv (kPa/mm)	E (MPa)	c (kPa)
Fill						
0.0	0.3	Dry to slightly moist, dark brown, LOOSE, sandy **CLAY** with domestic waste.	N/A	N/A	N/A	N/A
Colluvium						
0.0	0.3	Dry to slightly moist, light reddish brown, SOFT to FIRM, sandy gravelly **CLAY** with roots.	50-250	25-80	-	18-72
Residual Chert						
0.3	1.1	Dry to slightly moist, light reddish brown mottled light grey, FIRM and MEDIUM DENSE to DENSE, slightly gravelly sandy **CLAY** to clayey sandy **GRAVEL**.	150-500	55-200	15-35	30-55
Residual Ferruginised Chert						
1.1	2.2	Dry to slightly moist, light reddish brown blotched dark and light grey, FIRM and MEDIUM DENSE to DENSE, slightly gravelly sandy **CLAY** to clayey sandy **GRAVEL**.	150-500	55-200	15-35	30-55
Weathered Chert Bedrock						
1.5+		Light grey stained red, moderately weathered, very fine to fine grained, highly fractured, very soft rock.	500+	200+	-	-

EABC = estimated allowable bearing capacity (ignoring collapse potential)
Kv = modulus of subgrade reaction
E = elastic modulus

6.2 Exposures

Thirty-five exposures were logged across the 73 Ha site (according to guidelines of GFSH-2 of 2002), in order to better understand the engineering properties of the subsurface soil / rock conditions.

The results of the exposures highlighted areas of outcropping and shallow chert along the northern portions of site and all consisted of weathered chert bedrock exposed at surface. The rock profiles can be found in Appendix A of this report.

7. GROUNDWATER

No groundwater seepage occurred on site in any of the test pits, although during summer months and during times of prolonged or heavy rainfall, it may be assumed that a perched groundwater table may be present at relatively shallow depths over the site.

Existing borehole information across the site places the groundwater level at about 30 mbgl.

8. LABORATORY TESTING

Laboratory tests have been conducted on soil samples recovered from the site. The following tests have been carried out:

- Sixteen foundation indicator tests (particle size distribution, hydrometer, moisture content, and Atterberg Limits);
- Five Mod AASHTO compaction tests; and
- Ten chemical tests (pH and conductivity).

The detailed laboratory test results will be provided in the final report in Appendix B, while summaries of these results are presented below as in Tables 8a to 8c:

Table 8a: Summary of Foundation Indicators

TP No.	Depth (m-m)	LL	PI	GM	PE*	CBR* (%)	Classifications		
							TRH14	PRA	USCS
Residual Chert									
1	0.2-0.6	NP	NP	2.26	-	>60*	G5	A.1.a	SP-SC
2	0.4-0.6	37	7	0.67	Low	17	G10	A.4	SC
6	0.2-1.0	NP	NP	2.00	-	>60*	G5	A.1.b	SM
10	0.0-1.1	NP	NP	0.93	-	25-30*	G7	A.4	SM
13	0.5-1.8	NP	NP	1.07	-	30-31*	G7	A.4	SM
14	0.15-0.6	NP	NP	2.70	-	>60*	G5	A.1.a	GW
15	0.4-1.2	NP	NP	0.84	-	25-30*	G7	A.4	SM
19	0.5-2.1	NP	NP	1.36	-	36-40*	G6	A.2.4	SM
25	0.5-1.2	29	5	1.26	Low	28	G6	A.2.4	SM-SC
26	0.4-1.1	NP	NP	0.59	-	14*	G10	A.4	SM
Residual Ferruginised Chert									
2	0.7-2.7	NP	NP	1.23	-	35*	G6	A.4	SM
8	0.3-2.7	NP	NP	1.64	-	46-49*	G5	A.1.b	SM
17	0.2-2.0	NP	NP	2.22	-	>60*	G5	A.1.a	SP-SC
21	0.4-1.5	28	6	1.25	Low	27	G6	A.4	SM-SC
24	0.3-0.8	22	11	1.31	Low	21	G6	A.2.6	SC
28	0.4-1.3	NP	NP	2.02	-	>60*	G5	A.1.b	SM

*CBR estimated from PI-GM relationship.
*PE – Potential Expansiveness

Table 8b: Summary of Corrosivity Tests

TP No.	Depth (m-m)	pH	EC (µS/cm)	TDS (ppm)	Resistivity (Ohm/cm)	Degree of Corrosivity
Colluvium						
22	0.0-0.4	4.3	71	36	14065	Not Generally Corrosive
Residual Chert						
6	0.2-1.0	3.8	169	84	5924	Mildly Corrosive
13	0.5-1.8	4.4	37	19	27027	Not Generally Corrosive
16	1.0-1.9	4.8	42	21	23866	Not Generally Corrosive
19	0.5-2.1	4.9	22	11	45455	Not Generally Corrosive
Residual Ferriginised Chert						
2	0.7-2.7	6.2	293	147	3413	Very Corrosive
8	0.3-2.7	4.6	36	18	28090	Not Generally Corrosive
17	0.2-2.0	4.0	200	100	5003	Mildly Corrosive
21	0.4-1.5	5.0	39	20	25641	Not Generally Corrosive
28	0.4-1.3	4.5	39	20	25907	Not Generally Corrosive

Table 8c: Summary of Compaction Test Result

TP No.	Depth (m-m)	MDD (kg/m3)	OMC (%)	Swell (%)	CBR (%)				
					90	93	95	98	100
Residual Chert									
13	0.5-1.8	2164	8.2	0.08	31	46	61	92	121
Residual Ferriginised Chert									
2	0.7-2.7	2026	13.1	0.17	22	33	44	67	89
17	0.2-2.0	2196	8.2	0.21	30	45	59	89	116
21	0.4-1.5	2083	9.9	0.08	22	33	43	63	82
28	0.4-1.3	2214	8.2	0.17	19	29	38	58	77

Table 8d: Materials Classification and Recommended Usage

Material Description	Classification	Anticipated Recommended Usage
Fill	PI = - GM = - Classification: -	G10->G10 (subgrade layers and general fill)
Colluvium	PI = - GM = - Classification: -	G7-G9 (select layers and general fill)
Residual Chert	PI = NP-7 GM = 0.59-2.70 Classification: G10-G5|A.1.a-A.4| GW-SM	G5-G10 (upper subbase layers to general fill)
Residual Ferriginised Chert	PI = NP-11 GM = 1.23-2.22 Classification: G5-G6|A.1.a-A.4| SP-SM	G5-G6 (upper to lower subbase layers)
Weathered Chert	PI = - GM = - Classification: -	G5-G6 (upper to lower subbase layers)

9. DEVELOPMENT RECOMMENDATIONS

9.1 Materials Usage

The soils include a thin fill layer underlain by colluvium, residual chert and ferriginised chert, underlain by weathered chert.

Based on visual and tactile means and prior to laboratory results, the materials on site may be assumed to be used as follows (based on previous investigation):

- ***Fill***

This layer is assumed to qualify as between G10 to >G10 and should be cut and carted off site.

- ***Colluvium***

This layer is assumed to qualify as between G7-G9 (select layers and general fill) and the more gravely layers can potentially be used in select layers and as select and general fill across the site.

- ***Residual Chert***

This layer qualifies as G5-G10 and the more gravely layers can be used as upper subbase layers to general fill and may be re-used as such.

- ***Residual Ferriginised Chert***

This layer qualifies as G5-G6 and the more gravely layers may be used as upper to lower subbase layers.

9.2 NHBRC Classification

The site is underlain by shallow hard chert with frequent outcrops in the northern portion of the site. The remainder of the site is underlain by soils with a low potential expansiveness and a low potential for collapsible. There are portions of fill across the site as it has been used as a dump site. These observations coupled with the layer thickness and laboratory results have led to the suggestion that this site can be represented by NHBRC classification: **P(dolomite)/H/C/R**. This signifies a cumulative potential collapse of <5 mm, a cumulative potential heave of less than <7.5 mm and possible difficult excavation to 1 m in the northern portion of the site. A summary of the NHBRC classification can be seen in Table 9.2 below:

Table 9.2: Residential Site Class Designations (from NHBRC, Part 1, Section 2, Table 1)

Typical founding material	Character of founding material	Expected range of total soil movements	Assumed differential movement (% of total)	Site class
Rock	STABLE	NEGLIGBLE	-	**R**
Silty sands, sands, sandy and gravelly soils	COMPRESSIBLE AND POTENTIALLY COLLAPSIBLE SOILS	<5mm	75%	**C**
Fine grained soils with moderate to very high plasticity (clays, silty clays, clayey silts, and sandy clays)	EXPANSIVE SOILS	<7.5	50%	**H**
Contaminated soils, controlled fill, dolomite land, landfill, uncontrolled fill	VARIABLE	VARIABLE	-	**P**

9.3 Foundations

The NHBRC Site Classification based on test pit logs excavated over the site can be mitigated by the following foundation options (subject to the requirements set out by the DSI report):

- Stiffened strip foundations,
- Stiffened or cellular raft foundations,
- Modified normal soil raft,
- Compaction of in-situ soils below individual footings, and
- Normal foundations on shallow, well-cemented residual ferriginised chert.

All foundation options will be superseded by the recommendations contained in the dolomite stability investigation report.

9.4 Excavatability & Earthworks

All materials on site classify as SOFT excavation (SABS 1200 D) to depths ranging between 0.7 m and 2.8 m with an average depth of around 1.5 m. Below this depth, intermediate to hard excavation is to be anticipated due to well-cemented ferricrete layers. The northern portion of the site may classify as HARD excavation (SABS 1200 D).

9.5 Drainage

For the promotion of a stable site, with no soil movement-related issues (settlement and/or heave), it is extremely important that adequate drainage, both surface and subsurface, be constructed so that no water ingress into the subsurface soils in and around foundation bases is possible. Drainage should be such that any rainfall is diverted to the nearest stormwater drainage system. Areas of potential pooling or damming of rainfall on site should be carefully designed and sloped so as the remove this water away from the foundations.

10. CONCLUSIONS & RECOMMENDATIONS

General

- This report presents the findings of a NHBRC Phase 1 geotechnical investigation for the proposed housing development to be located on the remaining extent of portion 129 of the farm Rietfontein 301 IQ, Lenasia, and the conclusions and recommendations for excavations, foundations and earthworks.

- The most important consideration in relation to the proposed development is the presence of dolomite within a depth of 60 m and shallow and outcropping chert in the northern portion of the site.

Geology & Ground Conditions

- Based on the 1:250 000 Geological Map titled "*2626 West Rand* (1986)", the site is underlain by dolomite and chert of the Chuniespoort Group, Transvaal Supergroup. This results in the site being classified as **dolomitic land**. As a result, a dolomite stability investigation is required.

Excavatability

- All materials on site classify as SOFT excavation (SABS 1200 D) to depths ranging between 0.7 m and 2.8 m with an average depth of around 1.5 m. Below this depth, intermediate to hard excavation is to be anticipated due to well-cemented ferricrete layers. The northern portion of the site may classify as HARD excavation (SABS 1200 D).

Foundations

- The site has been classified as **P(dolomite)/H/C/R** according to NHBRC guidelines. The following foundation recommendations are proposed for the site (but should be checked with the results and recommendations of the DSI):

    - Stiffened strip foundations,
    - Stiffened or cellular raft foundations,
    - Modified normal soil raft,
    - Compaction of in-situ soils below individual footings, and
    - Normal foundations on well-cemented ferricrete.

Further Investigations

- Finally, the ground conditions described in this report refer specifically to those encountered at the test positions advanced on site. It is therefore possible that conditions at variance with those discussed above may be encountered elsewhere on the site. In this regard it is critical that a dolomite stability investigation (DSI) be commissioned and completed to facilitate the issue of a RoD from the CGS.

N Welland: Pr.Eng. / Pr.Sci.Nat

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29 October 2019

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APPENDIX A
TLB-Excavated Trial Pit Profiles

APPENDIX B
Laboratory Test Results

FIGURE 1
Site Plan

FIGURE 2
Geological Plan