Integrated Environmental Management | Waste Management Planning | Geotechnical Investigations

ruvimbo CONSULTING (Pty) Ltd

FINAL GEOTECHNICAL INVESTIGATION REPORT

GEOTECHNICAL INVESTIGATION FOR TOWNSHIP ESTABLISHMENT ON PORTION 22 OF THE FARM MOOIFONTEIN NO. 14 – IR, EKURHULENI METROPOLITAN MUNICIPALITY, GAUTENG PROVINCE.

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1. INTRODUCTION

Ruvimbo Consulting (Pty) Ltd has been appointed by GKM Consulting (Pty) Ltd to undertake a geotechnical investigation for the proposed township establishment on Portion 22 of the Farm Mooifontein No. 14 - IR, which previously called PTN8-LG1261/63. The proposed development consist of a residential of two storey buildings at a minimum density of 40 units per hectare.

This report deals with the geotechnical investigation which was conducted in accordance with the requirements of the National Department of Housing Generic Specification GFSH-2 (2002) [1].

The objectives of the geotechnical investigation were to:

- Identify potential hazards;
- Define the ground conditions and classify the conditions through detailed soil profile descriptions and groundwater occurrences within the zone of influence of foundations; and
- Provide the geotechnical basis for safe and appropriate land use planning, infrastructure and housing unit design as well as formulation of precautionary measures and risk management procedures.

The geotechnical properties of the various materials at the site were determined. This report documents the field and laboratory results of the investigation and provides recommendations for the appropriate foundation design of residential structures and precautionary measures to mitigate the identified risks. The reuse of the in-situ material on site for construction purposes is also discussed.

2. SITE DESCRIPTION

Portion 22 of the Farm MooifonteinNo.14 - IR, (hereafter referred to as “the site”) is located in Birch Acres, one of the northern suburbs of Kempton Park in the Ekurhuleni Metropolitan Municipality, Gauteng Province. It has a rectangular shape with an area of 1.3 hectares. The site is situated east of the Suikerbekkie Road and south-eastern of the Bergpatrys Street which is the access route to site. Overhead power lines occur on the northern boundary of the site. **Figure 1 and 2** depicts the Regional and Site Locality Maps.

The topography of the site is generally flat with a gentle slope in the east direction. Drainage occurs by sheet wash towards the east where a natural water pond of approximately 350m diameter is located.

The majority of the site is covered by grass and scattered shrubs. Disturbed areas comprising illegal dumping of rubbles occurs scatteredly across the site.

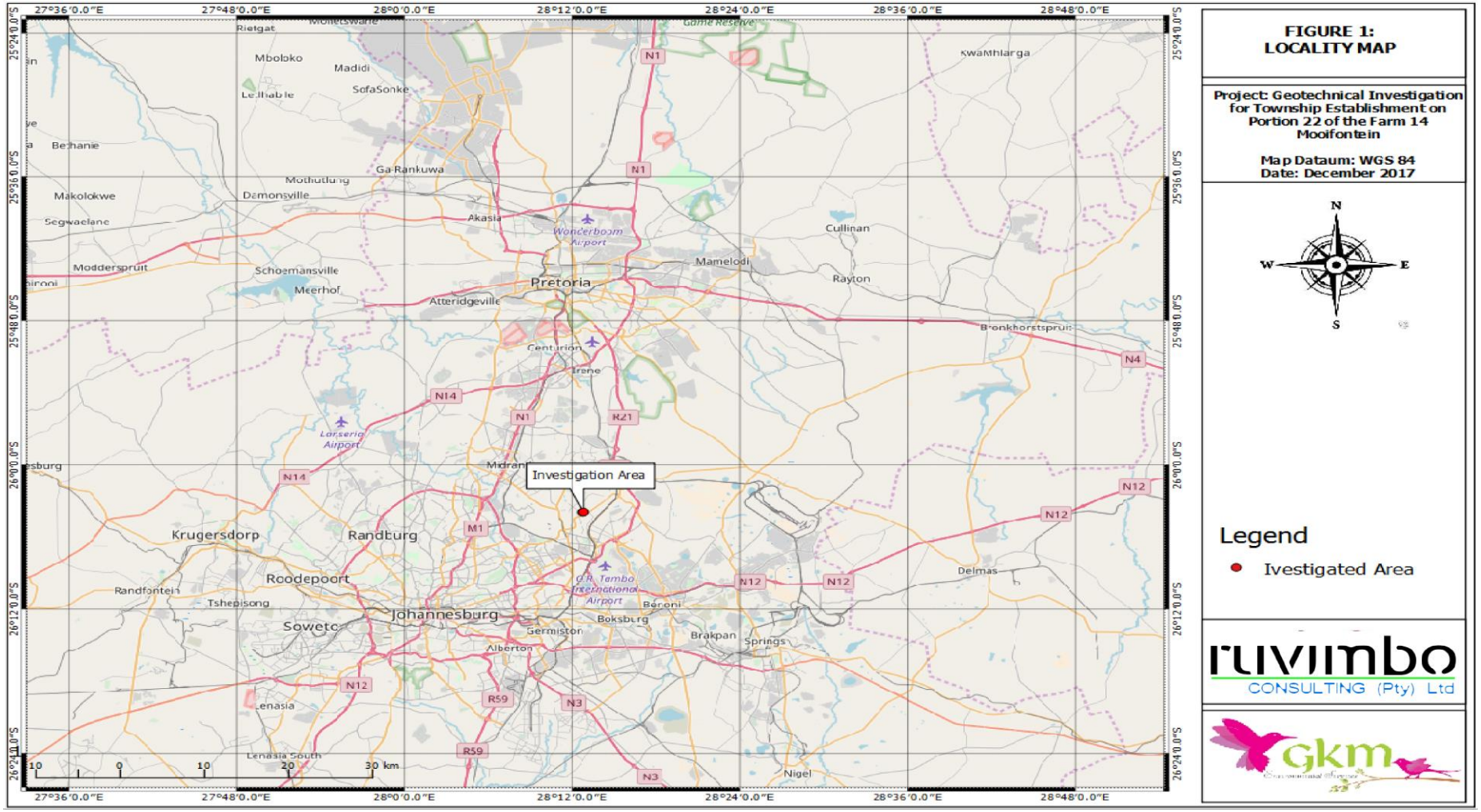

Figure 1: Regional Locality Map

Figure 2: Site Locality Map

3. GEOLOGY

According to the published 1:250 000 scale geological map of the area, 2628 East Rand, Portion 22 of the Farm MooifonteinNo.14-IR is underlain by grey medium grained granodiorite rock of Halfway House Granite Suite [2]. **Figure 3** depict a regional geological map of the site. The rock granodiorite is typical granite with medium to coarse-grained size that is among the most abundant intrusive igneous rocks; it contains quartz and is distinguished from other granitic rocks by its darker colour due to greater plagioclase mineral content than orthoclase feldspar [3].

According to Weinert's climatic N-value, the site falls in an area classified as N<3, indicating relatively humid climate conditions. The predominant weathering mode is therefore chemical decomposition and is usually associated with the formation of pedogenic ferricrete [4].

Ferricrete forms when iron oxides are mobilised in solution and deposited elsewhere in the soil profile. This occurs during the fluctuation of the groundwater table during the wet and dry seasons. These iron oxides cement to form ferricrete nodules, which may, given time, form a hard impermeable horizon referred to as honeycomb (when voided) or hardpan ferricrete. The pedogenic soils were not encountered during the geotechnical investigation.

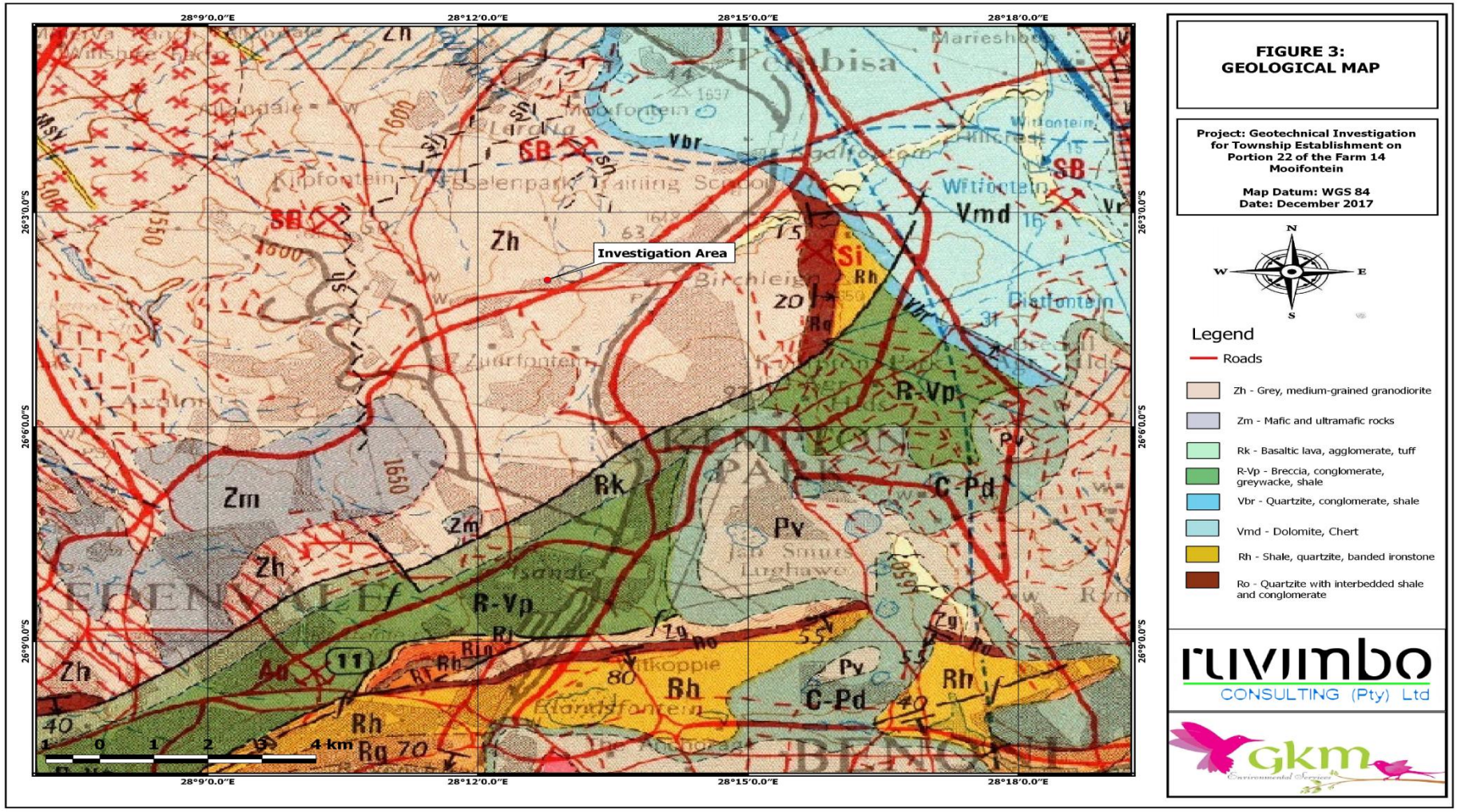

Figure 3: Geological Map of the Site

4. METHOD OF INVESTIGATION

A desktop study was conducted where Geological Map and Google Earth image were studied prior to the test pit investigation.

The geotechnical investigation comprised the excavation of nine test pits (TP1 to TP9) on the 19th of November 2017, using Tractor Loader Backhoes (TLB's). **Figure 4** shows the position of the test pits and geotechnical zonation of the site. The test pits were excavated to refusal depth or to the maximum reach of the machine. The test pits were logged by geologist according to standard practice [5]. The soil profiles are presented and attached as **Appendix A**.

The positions of the test pit positions were recorded with a hand-held Global Positioning System (GPS) with an accuracy of 3m. Co-ordinates are provided on the test pit logs in SA Grid (Lo29), WGS 84 Datum.

Soil samples were taken from representative soil horizons and submitted to LTD Civil Engineering Material Laboratory in Tshwane (Pretoria), Gauteng Province. The following tests were conducted:

- 6x Foundation Indicator tests (grading, Atterberg limits and clay content)
- 3x Modified AASHTO compaction tests to determine the maximum dry density and optimum moisture content.
- 3x California Bearing Ratio (CBR) tests
- 2x Double Oedometer tests

The laboratory test results are discussed in Section 7 of this report and the detailed results are provided and attached as **Appendix B**.

Figure 4: Test Pits Position and Geotechnical Zonation

5. TYPICAL SOIL PROFILE

The typical profiles consist of fill material and transported (colluviums) soil horizon that is underlain by residual granite. **Table 1** shows the summary of test pit profiles logs for geotechnical classification and assessment.

Table 1: Summary of Test Pit Profile Logs

Test Pit No.	Total depth (m)	Depths of Layers (m) – (m)			Depth of Groundwater Seepage (m)	Zone
		Fill	Transported Soils	Residual Soils		
			Colluvium	Granite		
P1	3,5	-	0 – 0,3	0,3 – 3,5+	-	1
P2	3,4	-	0 – 0,3	0,3 – 3,4+	-	1
P3	3,5	-	0 – 0,3	0,3 – 3,5+	3,4	1
P4	3,4	0 – 0,4	-	0,4 – 3,4+	-	1
P5	3,4	0 – 0,2	-	0,2 – 3,4+	2,8	1
P6	3,4	0 – 0,4	-	0,4 – 3,4+	-	1
P7	3,3	0 – 0,5	-	0,5 – 3,3+	-	1
P8	3,3	0 – 1,5	-	1,5 – 3,3+	3,0	2
P9	3,3	0 – 0,9	-	0,9 – 3,3+	2,5	2

Table 2 shows the geotechnical classification for urban development zones.

Table 2: Urban Development Zone Descriptions

Constraint		Zone 1	Zone 2
A	Collapsible soil	2	2
B	Seepage	1	1
C	Active soil	-	-
D	Highly compressible soil	2	2
E	Erodibility of soil	-	-
F	Difficulty of excavation	-	-
G	Undermined ground	-	-
H	Stability (Dolomite and limestone)	-	-
I	Steep slopes	1	1
J	Areas of unstable natural slopes	1	1
K	Areas subject to seismic activity	1	1
L	Areas subject to flooding	1	2
Summary		2A, 1B, 2D, 1I, 1J, 1K, 1L	2A, 1B, 2D, 1I, 1J, 1K, 2L

***1- Most favourable, 2- Intermediate, 3- Least favourable**

The site is defined by two broad zones (Zone 1 and Zone 2), based on the materials encountered and typical soil profile as follows:

5.1 Zone 1 (TP1 - TP7)

This is characterised by thin layers of fill and colluvium overlying a thick layer of residual granite soil. The typical soil profile for this zone is as follows:

- Fill comprising medium dense, intact silty fine sand with plastics and building rubbles covers most part of the site and occurs to a maximum depth that varies from 0,2m to 0,5m.
- A thin layer of colluvium covers the western portion of the site to 0,3m depth. Medium dense, intact, silty fine sand with minor roots found in this horizon.
- Thick layer of residual granite occurs either below fill material or colluvium with an unknown layer thickness. This soil horizon comprises clayey silty sand with occasionally silty gravelly sand and has a medium dense consistency with an intact soil structure.

5.2 Zone 2 (P8 – P9)

This zone is characterised by generally thick layers of fill overlying the residual granite. The typical soil profile is as follows:

- Thick layer of fill covers the area of TP8 and TP9 to maximum depth of 1,5m and 0,9m, respectively. It comprises silty fine sand with scattered building rubbles and plastic. The fill material has medium dense to occasionally dense consistency with an intact soil structure.
- A thick medium dense to occasionally dense, intact, clayey silty sand to silty gravelly sand residual granite horizon occurs below the fill an unknown layer thickness.

6. GROUNDWATER

Groundwater seepage was encountered at P3, P5, P8 and P9 at depth between 2,5m and 3,4m below the ground surface. Natural water pond occurs towards the eastern vicinity of the site. The test pits were excavated at the beginning of the wet season. However, seasonal perched groundwater is anticipated to rise at the site. These perched water tables are likely to be realised during the rainy season.

7. LABORATORY TEST RESULTS

The detailed results of the geotechnical laboratory tests are provided in **Appendix B** and are summarised in **Table 3**. The test results include Foundation Indicator, CBR and Modified AASHTO compaction including the Oedometer.

Table 3: Summary of Laboratory Results

SAMPLE		GRADING (%)				ATTERBERG LIMITS (%)			GM	PE	USC	MOD. AASHTO COMPACTION		CBR (%)			COLTO	DESCRIPTION
No.	Depth (m)	Gravel	Sand	Silt	Clay	LL	PI	LS				MDD (kg/m³)	OMC (%)	93	95	98		
P2/1	1,2 - 3,4	21	49	18	12	39	13	7,0	1,5	Low	SC	1976	12	17	24	34	G7	Residual Granite
P2/2	1,56 - 1,61	9	50	23	17	43	15	8,5	1,1	Low	SC	-	-	-	-	-	-	Residual Granite
P5/1	1,11 - 1,20	18	51	20	11	30	12	5,9	1,4	Low	SC	-	-	-	-	-	-	Residual Granite
P5/2	0,2 - 3,4	17	59	14	10	34	11	6,0	1,5	Low	SC	1982	10	10	12	18	G8	Residual Granite
P7/1	0,5 - 3,3	41	46	8	5	35	10	5,0	2,0	Low	SC	-	-	-	-	-	-	Residual Granite
P9/1	0,9 – 3,3	27	61	7	5	22	5	2,3	1,8	Low	SM-SC	2112	5	19	26	40	G6	Residual Granite

ABBREVIATIONS					
LL	:	Liquid Limit	OMC	:	Optimum Moisture Content
PI	:	Plasticity Index	NP	:	Non-Plastic
LS	:	Linear Shrinkage	CBR	:	California Bearing Ratio
USC	:	Unified Soil Classification	SC	:	Clayey silty sand with gravel
GM	:	Grading Modulus	SM	:	Silty sand with gravel
PE	:	Potential Expansiveness			
MDD	:	Maximum Dry Density			

The results of the different material types are discussed below:

- The foundation indicator test results indicate that the residual granite on site is fairly consistent with high sand content of between 46% and 61% with a corresponding high Grading Modulus of between 1,1 and 2,0; which is indicative of coarse grained material. The Plasticity Index varies from 5% to 15% and the Potential for Expansiveness is low, according to Van Der Merwe's Activity Chart. The material classifies as SC (clayey silty sand with gravel) or SM-SC (silty sand with gravel) according to the Unified Soil Classification (USC).
- The compaction tests on the residual granite yielded a Modified AASHTO maximum dry density maximum dry density (MDD) of between 1976kg/m³ and 2112kg/m³ with optimum moisture content (OMC) of between 5% and 12%. The CBR test results indicate low strengths of 17% (P2) and 10% (P5) at 93% MDD and the soil is subsequently classified as G7 to G8 quality material according to COLTO [6]. However, the soil sample from P9 indicates high strengths of 26% at 95% MDD and classifies as G6.

8. GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

8.1 Engineering and Material Characteristics

Fill material and transported soils comprising silty fine sand with, plastics and building rubbles should be cut to stockpile for landscaping purposes.

The residual granite comprises clayey silty sand with zones of silty gravelly sand classifies as G6 to G8 quality. Due to the low frequency of testing required in this level investigation, additional testing should be carried out during construction to confirm the material results.

Backfilling should be done using a 10 ton smooth drum roller to compact the material to the specified densities. Troxler Density Testing should be done to verify the compaction densities achieved by the contractor.

It is recommended that a competent person should inspect the foundation excavations prior to commencing with backfilling.

8.2 Slope Stability

Natural slope stability problems are not anticipated for this site due to the gentle gradient encountered across the site.

8.3 Erosion

Indications for highly erosive soils are not evident on site. However, a natural water pond occurs along the eastern boundary of the site and is anticipated that during high rainfall, erosion may

occur from surface run-off water from overflowing water pond. It is recommended that proper drainage is implemented during the construction.

8.4 Excavatability

The excavatability of soil on site categorized as soft conditions to 3,5m depth, Intermediate conditions can be expected below 3,5m.

8.5 Drainage

Proper site drainage will be required due to perched water tables and surface seepage which is expected to be realised in the rainy season. Problems relating to the seepage include dampness in surface structures as well as during the installation of underground services. It is recommended that the installation of underground services and surface drainage is undertaken in accordance with SANS 1200 LF-1983 [7].

8.6 Site Stability

The site does not classify as dolomite land and no instability caused by dolomite will therefore occur. No mining activities that led to any undermining of the site are present.

8.7 Site Classification and Foundation Recommendations

8.7.1 General

The proposed township development requires the construction of sound foundations to limit settlements. Based on the available information obtained for this investigation, it is clear that a similarity of the in-situ materials exists at the site. The site, which has been divided into two geotechnical zones, based on the material types and typical soil profiles were classified for Residential Site Class Designations according to NHBRC GFSH-2 document. The results of this classification are dealt with in the subsequent paragraphs.

8.7.2 Zone 1 (NHBRC Site Class Designation: C1 – C2)

Zone 1 is characterised by thin layer of silty fine sand with plastics and building rubbles fill and silty fine sand with fine roots colluvium. The fill material and colluvium soil structure is intact. The fill material and colluvium occurs to depths of between 0,2m and 0,5m below the surface and the soil consistency is medium dense indicating the expected allowable bearing capacity varying from 80kPa to 120kPa. The general consistency of residual granite soil horizon below fill and colluvium is medium dense to occasionally dense at TP4 and TP7.The layer thickness of residual granite is unknown. The expected allowable bearing capacity is limited to no more than 120kPa.

The following foundation options as defined by the GFHS-2 are recommended for single and double story masonry house structures to be erected at Zone 1:

- Stiffened strip footings;
- Stiffened or cellular raft foundation;
- Compaction of in-situ soils below individual footing; and
- Soil raft.

8.7.3 Zone 2 (NHBRC Site Class Designation: P (uncontrolled Fill)

This zone contains prominent and less prominent areas of fill, which originates mostly from construction activities in the nearby area. This zone is generally found in the eastern boundary of the site where the dam is located. TP8 and TP9 are characterised by thick fine sand with plastics and building rubbles fill. This fill has an intact soil structure and a medium dense with occasionally dense soil consistency with an expected allowable bearing capacity of 120kPa or less. Medium dense to occasionally dense residual granite has an allowable bearing capacity of 80kPa to 120kPa.

Zone 2 to be excluded from development. However, should recommendations be required the following foundation options are recommended:

- Remove the fill; and
- Leveling and compaction by means of dynamic compaction to the required density of 93% Mod. AASHTO at -2% to +2% of OMC through the entire thickness of the fill.

One of the following foundation options were recommended for structures to be erected on the compacted fill:

- Stiffened or cellular raft foundation;
- Piled or pier foundation; and
- Soil raft.

8.8 Special Precautionary Measures

Localised uncontrolled fill is noted on the eastern portion of the site causing localised variations to the anticipate soil profile and recommendations described above.

9. CONCLUSION

A geotechnical investigation was conducted for the proposed township establishment in November 2017. The proposed site is situated on Portion 22 of the Farm MooifonteinNo.14 - IR, which previously calledPTN8-LG1261/63.This geotechnical investigation aimed to identify potential hazards for the development, determine the ground conditions at the site provide the recommendations for safe and appropriate land use planning, infrastructure and housing unit design, including the formulation of precautionary measures and risk management procedures.

The site is underlain by grey medium grained granodiorite (grey medium to coarse-grained granite) of Halfway House Granite Suite. The typical profiles consist of the fill material and transported (colluviums) soil horizon that is underlain by residual granite.

The site is classified as non-dolomitic and is characterised by two geotechnical zones according to NHBRC site classification, viz. Zone 1 and Zone 2.

Zone 1 is characterised by thin layers of silty fine sand fill and colluvium overlying clayey silty fine sand with occasionally silty gravelly sand residual granite. NHBRC Site Class Designation: C1-C2.

Zone 2 is characterised by thick layer of silty fine sand fill overlying clayey silty sand to silty gravelly sand residual granite towards the eastern boundary of the site. NHBRC Site Class Designation: P (uncontrolled fill).

Foundation recommendations for the development are given in Section 8.7 of this report for the two identified zones.

Results indicate that the residual granite is potentially suitable for reuse on site. However, further laboratory tests will required to confirm the quantity and suitability of bulk soils for specified backfilling.

The field work was carried out at the beginning of the wet season where groundwater seepage was only encountered in P3, P5, P8 and P9 at depth between 2,5m and 3,4m below the ground surface. The effect of this seasonal water table should be taken into consideration for the design of the development.

It is recommended that a competent person should inspect the foundation excavations prior to commencing with backfilling.

It is recommended that additional geotechnical investigation be carried out at the site in accordance with the NHBRC requirements should additional load applied on two storey residential. The investigation will typically include the following:

- Conduct a geotechnical investigation by excavating test pits with a TLB to a minimum depth of 3,0m, or excavation refusal of a TLB machine.
- Conduct the Dynamic Probe Super Heavy (DPSH) to determine the consistency of deeper soils.
- Collect representative soil samples for laboratory testing as required for a supplementary geotechnical investigation.
- Prepare a comprehensive geotechnical report with all data analysis and recommendations for construction.

REFERENCE

[1] Generic Specification GFSH-2 (September 2002) of the National Department of Housing.

[2] 2628 EastRand Geological Map 1:250 000, 1978, Compiled by Walraven, F., from mapping by Teichmann, R.F.H., Glatthaar, C.W., Manaczynski, W.M., Clubley-Armstrong, A.R., Von Gruenewald, G., Schwellnus, J.S.I., Gaigher, J.S., Wolhuter, L.E., de Bruiyn, H., MacCaskie, D.R., Snyman, C.P., Groeneveld, D., Marlow, A.G., Behr, S.H, Molyneux, T.G., Hammerbeck, E.C.I. & Van Graan, J.A. Landsat interpretation by Walraven, F. Aeromagnetic interpretation by Richards, D.J.

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APPENDICES

APPENDIX A: TEST PIT PROFILES

APPENDIX B: LABORATORY TEST RESULTS