

Intraconsult cc
Registration Number CK/86/12311/23

BIGEN AFRICA SERVICES
P.O. BOX 29
THE INNOVATION HUB
PRETORIA
0087

P.O. Box 604,
Fourways
2055
Gauteng

ATTENTION: MR P.J. NGOZO

Telephone : (011) 469 0854
Fax : (011) 469 0961

Email: intrac@mweb.co.za

Your reference

Our reference

Date

IR1325 PRELIM

12 NOVEMBER 2015

BAKUBANG LEDIG: PRELIMINARY GEOTECHNICAL SCAN

This limited, preliminary geotechnical report documents the findings of a desk study and a site inspection/walk-over survey undertaken on the Bakubang Ledig site identified on your Drawing 2734.00/ZA.01.S001.

1. LOCATION OF SITE

The site is located immediately east of the R565 Road between Phokeng and Tlhatlaganyane and north of the R556 Road to Rustenburg, at its intersection with the R565. The access road to Bakubang Camp and Sun City is located east of the site.

2. AVAILABLE INFORMATION

The following information sources were used for this preliminary overview:

- Geological Map 2526 Rustenburg at a scale of 1:250 000, produced by the Geological Survey (now Council for Geoscience), dated 1981.
- Council for Geoscience Seismic Hazard Map of Southern Africa (Fernandez and Guzman (1979) updated by Fernandez and du Plessis (1992), as well as Kijko et al. (2003))
- "Engineering Geology of Southern Africa" by A.B.A Brink, 1978, published by Building Publications.
- The Geology of South Africa. Edited by M.R. Johnson, C.R. Anhausser and R.J. Thomas. Published by the Council for Geoscience and the Geological Society of South Africa. 2006
- Generic Specification GFSH-2, National Department of Housing Specification. "Geotechnical site investigations for housing development." dated September 2002.

3. PROCEDURES USED IN THIS STUDY

This assessment consists of elements of the procedures outlined in Generic Specification GFSH-2 (2002).

3.1 Assimilation of Available Data - Information Sources

This investigation was initiated by gathering, assimilating and reviewing available geological and geotechnical data located on the Intraconsult data base pertaining to the site.

3.2 Geotechnical Characterisation of the Site and Development Potential

The procedures utilized in this report for the *broad* geotechnical zonation of the site are derived from the modification and integration of various classification systems and follow the SAIEG's "Guidelines for Urban Geological Investigations" with appropriate adaptations. Based on information gathered sites may be divided into three primary Geotechnical Categories. These categories broadly reflect the development potential of site. Categories 1, 2 or 3 indicate respectively most favourable, intermediate and least favourable geotechnical conditions as defined below:

Category	Definition	Potential land use based on geotechnical assumptions and subject to detailed geotechnical investigations
1	Most suitable	Potentially most suitable for any type of development including residential, commercial and light (dry) industrial.
2	Intermediate	Potentially suitable for any type of development including residential, commercial and light (dry) industrial, with precautionary and remedial measures.
3	Least favourable	Potentially only suitable for non-residential uses such as commercial and light (dry) industrial development with stringent precautionary and remedial measures.

Various combinations of Categories 1, 2 and/or 3 may be appropriate:

- The prefix describes the primary Category or the predominant characterisation of the zone and the suffix describes the characterisation of anticipated pockets or small sub-areas within the zone. As an example, a designation of Land Development Categories 1(2) indicates that the zone predominantly displays Category 1 conditions with smaller sub-areas of Category 2.
- A designation of Categories 2-3 indicates that the conditions in the zone range from Category 2 to Category 3 and are currently not distinguishable. The first designation (in this case Category 2) is anticipated to represent the predominant geotechnical conditions in the zone.

The Categories are defined as follows (after Partridge, Wood and Brink amended):

Constraint		Most favourable (1)	Intermediate (2)	Least favourable (3)
A	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

Constraint		Most favourable (1)	Intermediate (2)	Least favourable (3)
B	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
C	Active Soil	Low soil-heave potential anticipated*	Moderate soil heave potential anticipated	High soil-heave potential anticipated
D	Highly compressible soil	Low soil compressibility anticipated*	Moderate soil compressibility anticipated	High soil compressibility anticipated
E	Erodability of soil	Low	Intermediate	High
F	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
G	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 90-240 m below surface where slope closure has ceased	Mining within less than 90-240 m of surface or where total extraction mining has taken place
H	Stability: (Dolomite & Limestone)	Possibly stable. Areas of dolomite overlain by Karoo rocks or intruded by sills. Areas of Black Reef rocks. Anticipated Inherent Risk Class I	Potentially characterised by instability. Anticipated Inherent Risk Classes 2 – 5.	Known sinkholes and dolines. Anticipated Inherent Risk Classes 6 –8.
I	Steep slopes	Between 2 and 6 degrees (all regions)	Slopes between 6 and 18 degrees and less than 2 degrees (Natal and Western Cape) Slopes between 6 and 12 degrees and less than 2 degrees (all other regions)	More than 18 degrees (Natal and Western Cape) More than 12 degrees (all other regions)
J	Areas of unstable natural slopes	Low susceptibility	Intermediate susceptibility	High susceptibility (especially in areas subject to seismic activity)
K	Areas subject to seismic activity	10% probability of an event less than 100 cm/s ² within 50 years	Mining-induced seismic activity more 100 cm/s ²	Natural seismic activity more than 100 cm/s ²
L	Areas subject to flooding	A "most favourable" situation for this constraint does not occur	Areas adjacent to a know drainage channel or floodplain with slope less than 1%	Areas within a known drainage channel or floodplain

3.3 Seismic Activity

The level of amplification induced in structures by seismic events is primarily influenced by the nature and magnitude of the seismic impulse, e.g. magnitude and epicentre of an earthquake, but also by the dynamic stiffness properties of the rock mass and regolith and of the particular structures.

Early work on the seismicity of Southern Africa by Fernandez and Guzman (1979) which did not account for the effects of mining induced seismicity, has been considerably updated by Fernandez and du Plessis (1992), as well as Kijko et al. (2003) to include these influences.

Use is made of published information (seismic hazard maps) at regional scale. These maps indicate seismic intensity (Modified Mercalli Scale) with a 10 % probability of being exceeded at least once in a period of 50 years and peak horizontal ground acceleration (cm/s^2) with a 10% probability of being exceeded at least once in a period of 50 years.

The intensity designation and related description of the Modified Mercalli Scale is as follows:

Intensity	Description
I	Not felt. Marginal and long-period effects of large earthquakes.
II	Felt by persons at rest, on upper floors, or favourable places.
III	Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	Hanging objects swing. Vibrations like passing of heavy trucks, or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frame creak.
V	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
VI	Felt by all. Many frightened and run outdoors. People walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken visibly, or heard to rustle.
VII	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices, unbraced parapets and architectural ornaments. Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damage.
VIII	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B, none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers and elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

In the foregoing, each effect is named at the level of intensity at which it first appears frequently and characteristically. Each effect may be found less strongly, or in fewer instances, at the next lower grade of intensity; more strongly or more often at the next higher grade. A few effects are named at two successive levels to indicate a more gradual increase.

3.4 Geotechnical Categories

For the purposes of this report the broad geotechnical characteristics are described in terms of several 'geotechnical category designations' in terms of the NHBRC Guidelines as defined below :-

GEOTECHNICAL CATEGORY AND SITE CLASS DESIGNATION	GEOTECHNICAL CHARACTERISTICS
Inundated areas w	Wet area, drainage line, seepage zone.
Active soils (heave/shrink)	Expected range of total movement at surface:
H	<7.5 mm
H1	7.5 – 15 mm
H2	15 – 30 mm
H3	>30 mm
Collapsible soils	Expected range of total movement at surface:
C	<5 mm
C1	5 – 10 mm
C2	>10 mm
Compressible soils	Expected range of total movement at surface:
S	<10 mm
S1	10 – 20mm
S2	>20mm

3.5 Site inspection

Once the preliminary information was gathered, a field inspection or walk over survey was undertaken on site.

4. OBSERVATIONS AND GEOTECHNICAL COMMENTS

4.1 Field observations

During the site inspection the following was noted:

- The site falls to the south with a well defined gully running from north to south through the central area. A poorly defined gully with a north west – south east orientation drains part of the eastern sector of the site. Flood lines will need to be determined (Photographs 3 and 5 in Appendix 1).
- Typical soil profiles observed on site are as follows (Photographs 1 and 3, Appendix 1):
 - Reddish orange and brown hillwash overlying
 - Ferricrete which varies from hardpan to slightly ferruginised materials, overlying
 - Residual norite grading into hard rock norite bedrock.

The norite bedrock head is typically undulating, with implication where outcropping or sub-outcropping for open works and excavations for services. The outcropping rock appears to be scattered. Hardpan ferricrete is noted across the site, especially along the fringes of the gully.

4.2 Geology (Figure 1)

The site is predominantly underlain by the Pyramid gabbro-norite of the Rustenburg Layered Suite of the Bushveld Igneous Complex.

The northern boundary of the site impinge onto high ground and ridges of Chakise Foyiate of the Pilasnsberg Complex

4.3 Soils

4.3.1 Residual soils

Red, grey and black soils are anticipated. Scattered outcrops of norite, that are typically of this geological setting are noted on the site. Sub-outcropping rock is also anticipated. A east-west striking ridge occupies the northern boundary area of the site. Soils will thin along the margins of this ridge.

Typically the norites weather to produce:

- Black clays which represent a reworked horizon and are typically highly active. Reworking is achieved by self-mulching (H2 to H3).
- Grey clays in depressions and drainage lines. These clays are typically highly active (H2 to H3).
- Reddish brown sandy clays, particularly on concave sideslopes or pediment crests. These residual soils are generally moderately active (H1 to H2). These soils are anticipated to predominate.

4.3.2 Transported soils

The site is anticipated to be covered in part by colluvium typically containing boulders of norite. The transported soils are typically active (H1 to H2).

Typical transported soil types anticipated on site are listed in the table below.

Origin of Transported Soils		
Fill material		Man-made: Variable composition
Transported Soils	Colluvium: Talus (Coarse Colluvium) Hillwash (Fine Colluvium)	Unsorted angular gravel and boulders within sandy soil matrix Soils of sandy, clayey, silty and gravelly composition
	Gulley wash	Boulders, cobbles, gravel Fine gravels and silts Clays (depressions and drainage lines)

4.3.3 Pedocretes

Hardpan ferricrete is noted to occur extensively on the site.

4.4 Surface drainage and geohydrology

Perched groundwater is anticipated on the norites and ferricretes. The central site area is drained by a well developed, north-south draining gully and the eastern sector by a northwest-southeast orientated, more poorly developed gully.

4.5 Seismic activity

The seismological data for the area is contained on the Seismic Hazard Maps provided by the Council for Geoscience (Section 3.4). The maps indicate

- 4.5.1** Seismic intensity (Modified Mercalli Scale) with a 10% probability of being exceeded at least once in a period of 50 years. The site falls within an area designated as Seismic Intensity V and is described as follows on the Modified Mercalli Scale as "Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate".
- 4.5.2** Peak horizontal acceleration of 50 to 100cm/s² with a 10% probability of being exceeded at least once in a period of 50 years.

4.6 Simplified topography

Based on estimated, simplified topography the ground falls from north to south, with an approximate elevation of 1096m AMSL on the ridge immediately north of the northern boundary to 1065m AMSL in the south western sector and 1062m AMSL in the south east.

4.7 Mine Infrastructure

A new mine is under development on the land immediately to the south of this site.

4.7.1 Anticipated development and potential geotechnical conditions

The preliminary summarized land use categories as described in Section 3 for the sites are outlined below together with comments on anticipated geotechnical conditions

a) Anticipated development category

Predominant anticipated Development Category: 2 (Sub-areas 3)
(Potential constraints A, B, C, D, F, G, K)

b) Anticipated geotechnical conditions

The following geotechnical conditions are anticipated on site:

- Collapsing soils: The colluvial cover material that typically blankets the residual profile, and in certain settings, the residual norite may have a collapsing fabric (A).
- Moderate to highly active transported, reworked and residual soils typically develop on the norites (C).
- Compressible clayey soils may develop on the norites (D).
- Intermediate to shallow or outcrop rock may occur in sub-areas of the site (F).
- Seasonal perched groundwater conditions may develop on the soil/bedrock interface and on the ferricrete (B).

- Where foundations straddle rock/collapsing or inert/active soil contacts, exacerbated differential movement may occur. Norite bedrock morphology is highly irregular and undulating. Large loose boulders may be present.
- Although no obvious signs of backfilled excavations or exploration pits were discernible during the desk study, such features may be present (G). In addition the impact of the adjoining mining related infrastructure should be assessed.
- Seismic activity is discussed above (K). A shock clause may be imposed by the DMR with respect to construction of housing units.

5. RECOMMENDATIONS AND CONCLUSIONS


The sites are largely anticipated to fall in **Development Category 2, i.e. potentially developable with constraints (e.g. active clays)**. The majority of development occurs on sites with this designation. Detailed geotechnical investigations are merited on the site. Such investigations should comply with the contents of Generic Specification GFSH-2.

The anticipated problematic soil conditions may be readily managed through the application of appropriate foundation solutions and precautionary measures on residential structures.

The nature of mining activities on the adjoining area must be considered. It is understood that the mine under development to the south of the site is to participate in the development process. For obvious reasons, mining companies typically do not divulge their proposed operational information. In view of this confidentiality, it is essential that the project managers formally request confirmation from the Mine, that mining will not occur at shallow depth (<240m) below the proposed township. It is accepted that the EIA process has or will address the matter of where rock dumps and tailing will be located during future operations.

We trust that these comments are of value. Please do not hesitate to contact us if you require additional information.

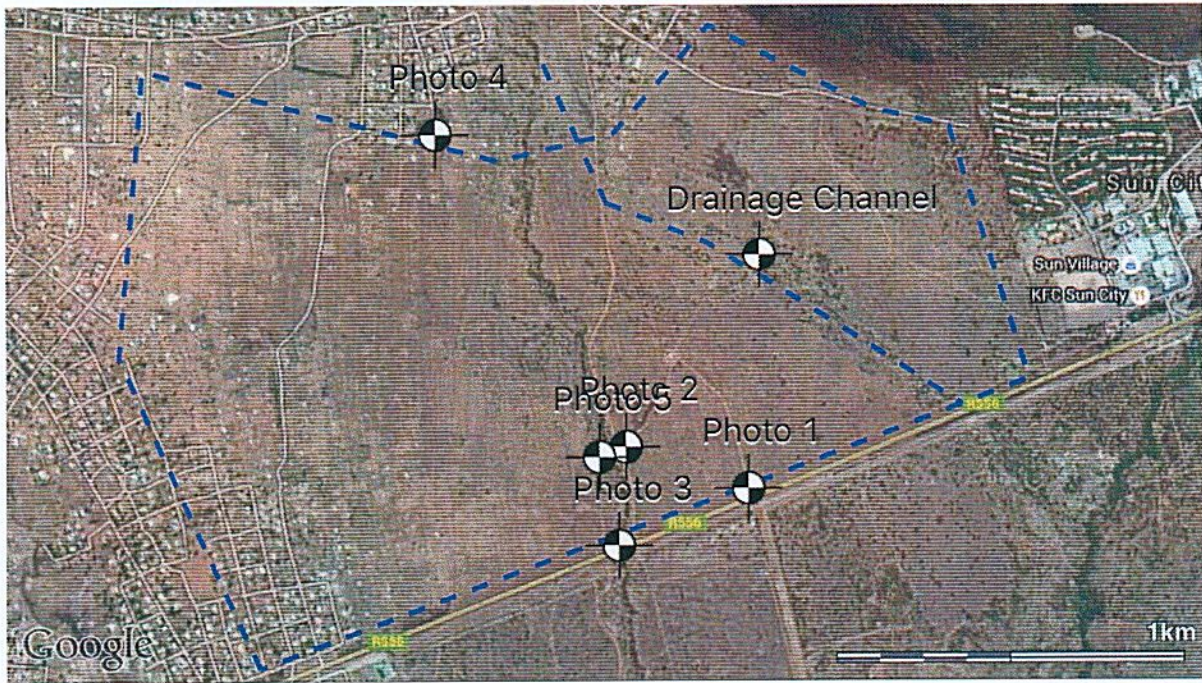
Yours faithfully



Dr D. Buttrick
For Intraconsult cc

FIGURE 1

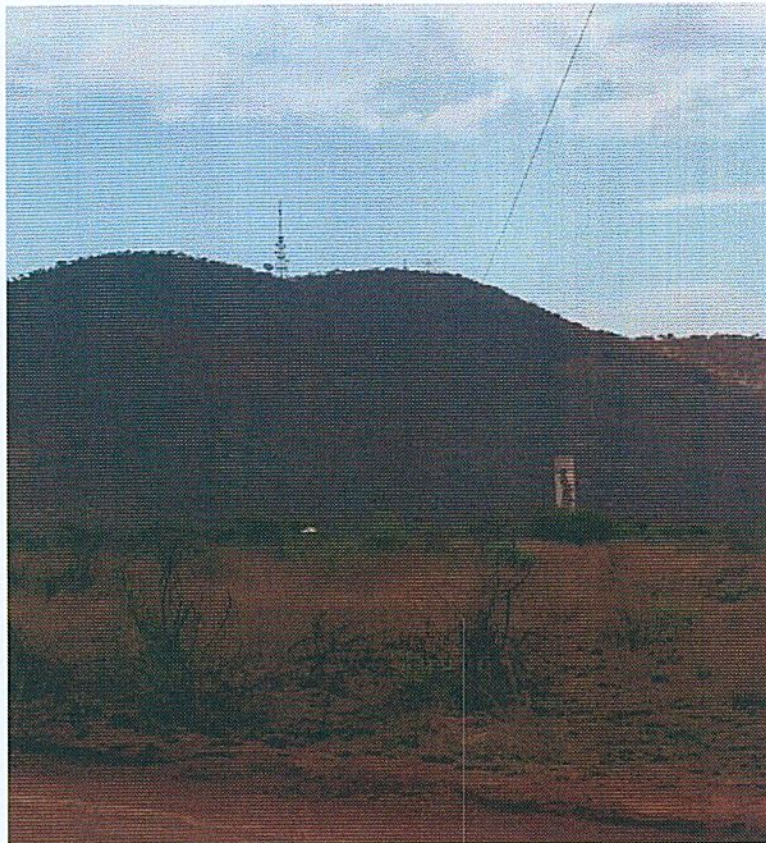
APPENDIX 1



Photograph Positions



Photograph 1
Typical Soil Profile



Photograph 2
View north towards Chakise Foyaite outcrop



Photograph 3

Gully profile in southern sector



Photograph 4

View south with mine shaft in the distance



Photograph 5
Gulley - view north
(Note: Ferricrete horizon)