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SMEC INTERNAL REF. PA984/2024/04/2919

Geotechnical Desktop Study Report

Mogobe Battery Energy Storage System (BESS) Grid Corridor, Northern Cape

Client Reference No. PA984

Prepared for Mogobe EGI (Pty) Ltd.

26 April 2024

Document Control

Project Name	Mogobe Battery Energy Storage System (BESS) Grid Corridor, Northern Cape
Document Name	Geotechnical Desktop Study Report
Document Number	PA984/2024/04/2919
Revision Number	A

Revision History

Revision No.	Date	Prepared By	Reviewed By	Approved for Issue By
A	26/04/2024	B. Magwaza	A. Nxumalo	C. Warren-Codrington

Issue Register

Distribution List	Date Issued	Number of Copies
Mogobe EGI (Pty) Ltd.	26/04/2024	1 Electronic

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Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Background and Project Description

Mogobe EGI (Pty) Ltd. ("Client") is in the process of developing a Battery Energy Storage System (BESS) grid corridor near Kathu in the Northern Cape Province, South Africa. The proposed grid corridor extends for a distance of approximately 9 km north of the BESS site (Figure 1-1).

Figure 1-1: Site Layout Plan

1.2 Terms of Reference

SMEC South Africa (Pty) Ltd. ("SMEC") was appointed on 15 April 2024 to carry out a desktop study for the proposed grid corridor concerning geological and geotechnical aspects thereof.

1.3 Objectives and Methodology

This desktop study aims to provide high-level geological and geotechnical information for the Mogobe grid corridor so that the Client can provide stakeholders with baseline geological and geotechnical information for planning purposes. The tasks required to fulfil this objective are as follows:

- Identify and review existing geological and geotechnical information relevant to the project area;
- Review site topography and climate and their influence on rock decomposition and subsequent soil formation;
- Review geohydrological information at a desktop level (viz. groundwater levels, flow direction, etc.);

- Assess seismic data to determine the seismic hazard and earthquake-prone zones in the region;
- Provide a risk assessment related to geological and geotechnical factors;
- Provide insight into the perceived geotechnical conditions of the site (viz. foreseeable soil formations, depth, and quality of underlying rock masses);
- Comment on the geotechnical feasibility of the proposed development; and
- Indicate the anticipated timeframes to conduct geotechnical investigations.

1.4 Codes of Practices and Standards

SMEC used the following standard practice codes and guidelines in performing this study:

- Basis of structural design and actions for buildings and industrial buildings. Part 5: Basis for geotechnical design and actions. SANS 10160-5 (2010).
- Guidelines for Soil and Rock Logging in South Africa. 2nd Impression 2002. SAICE, SAIEG and AEGSA: South Africa. Brink, A. B., and Bruin R. M. H. (1990).
- Site Investigation Code of Practice, 1st Edition, South African Institute of Civil Engineering – Geotechnical Division, January 2010.
- Standard Specifications for Subsurface Investigations, SANRAL, 2010.
- The Safety of Persons Working in Small Diameter Shafts and Test Pits for Geotechnical Engineering Purposes – Codes of Practice, 2007.

In addition, the following sources were consulted:

- 2722 Kuruman, 1: 250 000 Geological Series.
- 2722 Kimberly, 1:500 000 Hydrogeological Map Series.
- Digital Elevation Model (DEM)-sourced elevation data.
- National Groundwater Archive (NGA)
- SMEC's geotechnical database of projects conducted near the project area and within similar geotechnical and geological zonation/ sequences.

1.5 Limitations of Assessment

The scope of this report is limited to providing geological and geotechnical information at a desktop level for the grid corridor and will culminate with recommendations for further geotechnical investigations.

The services performed by SMEC were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical profession practising under similar conditions for the requirements of a geotechnical feasibility study (SAICE, 2010). This geotechnical desktop study report is based on data obtained from a limited number of sources, including geological records, topographic maps, aerial imagery and geotechnical and geological literature available for the greater Kathu. The nature of geotechnical engineering is such that variations in soil and rock conditions may occur even where sites seem to be consistent. Variations in what is reported here will become evident during the site geotechnical investigations and construction.

On a conceptual basis, the current project phase may be considered a Category 1 geotechnical project (SANS 10160-5, 2010), requiring desktop study equivalent information to determine its feasibility.

It must be noted that the recommendations provided in this report are only conceptual. Referral to a design solution is conceptual, and the design process, as per the latest version of SANS 10160, specifically SANS 10160-5, must be undertaken under a separate appointment.

2 Site Dictates

2.1 Site Location

The site is located approximately 4 km south of Kathu in the Northern Cape Province. It can be accessed via the N14 and smaller internal roads joining from the N14 (Figure 2-1). Within the site boundary, numerous gravel tracks are discernible, most are probably easily accessible with a high clearance 4×4 vehicle.

The site is bounded about 2 km to the west by an active manganese open cast mine.

No drainage lines are anticipated near the site based on the assessment of satellite imagery.

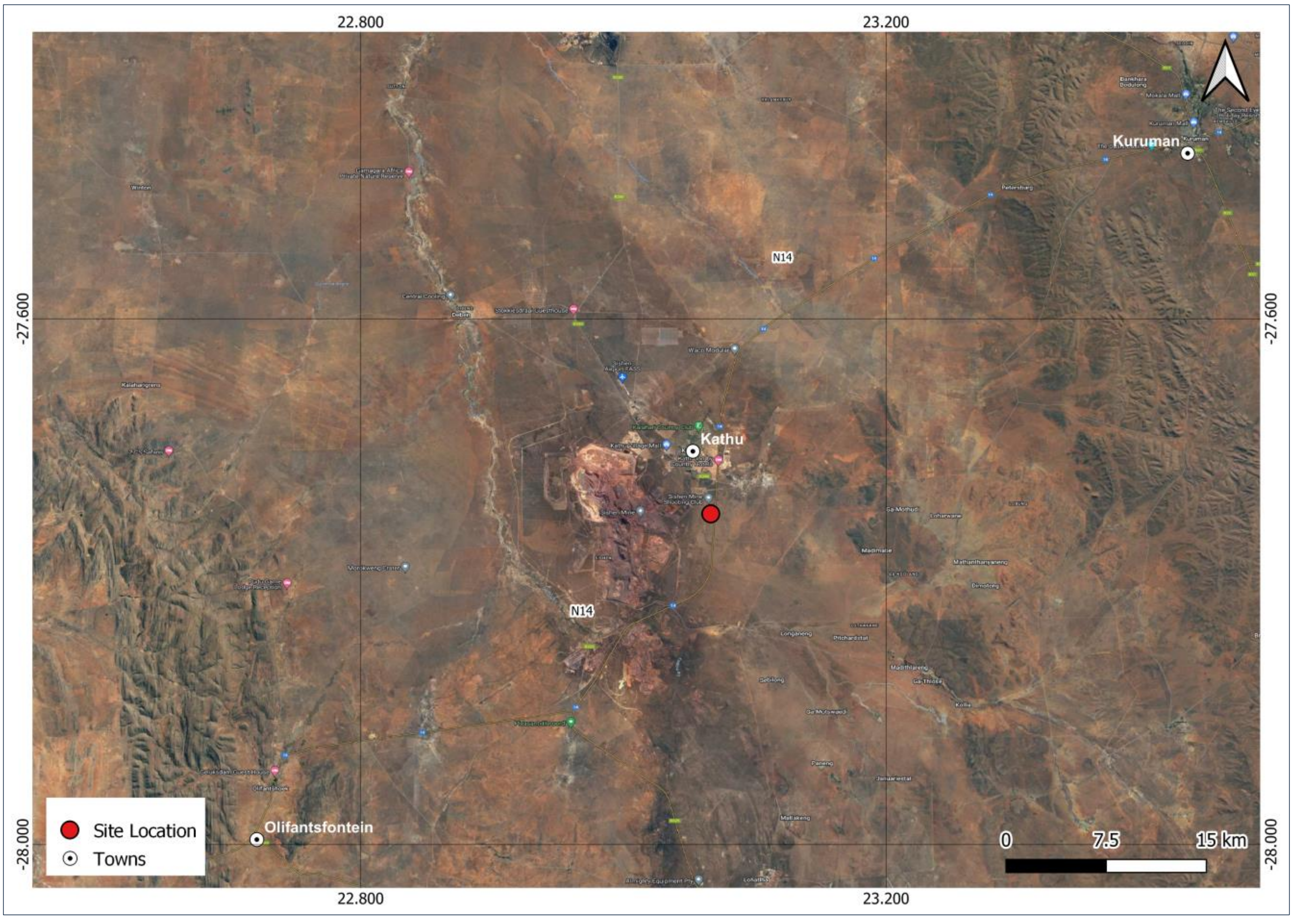

Figure 2-1: Site Location

2.2 Climate

This region experiences local steppe climates, with Thornthwaite's moisture index between -40 and -20. Climatic data (World Weather Online, 2024) indicates that the mean annual temperature in this region is 18.8°C. The average maximum daily temperatures vary from 32.2°C in December to 18.8°C in June-July. Corresponding minimum temperatures for these months are 16.4°C and 2.5°C, respectively. The mean annual precipitation is approximately 374 mm, falling mainly during summer. Precipitation is the lowest in July, with an average of 4 mm. The greatest amount of precipitation occurs in January, with an average of 75 mm. The average monthly temperature and rainfall distribution are illustrated in Figure 2-2.

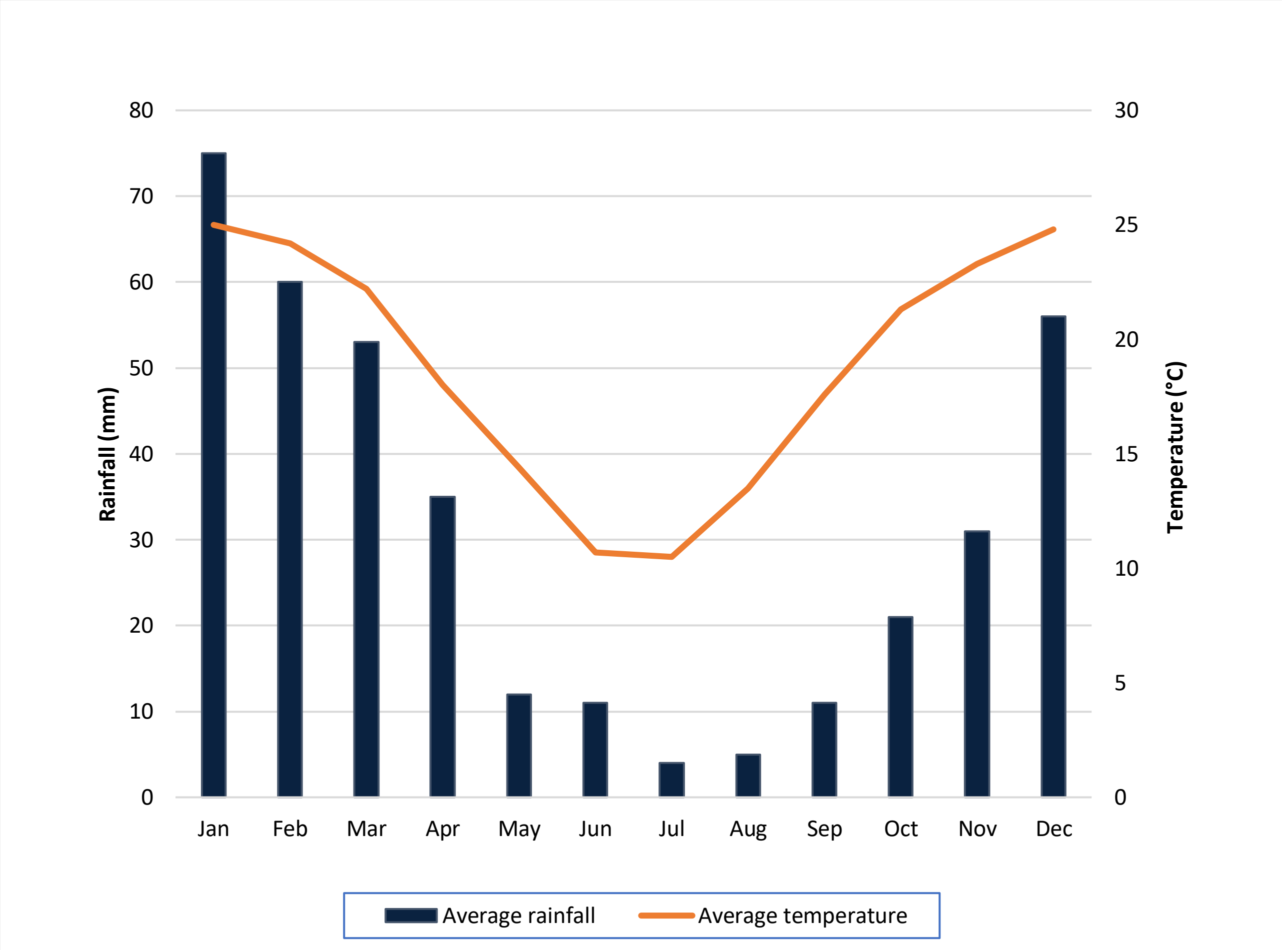

Figure 2-2: Summary of Climatic Data in the Site Region (after World Weather Online, 2024)

The climate is a pivotal factor for geotechnical considerations as it determines the mode and rate of rock mass weathering and, thus, the formation of soils. Weinert (1980) developed the N-Value to differentiate between regions of similar weathering characteristics. The N-value for this region is around 9, indicating that mechanical disintegration will be the dominant type of weathering, resulting in thin residual soils and weathered profiles.

2.1 Topography, Drainage and Vegetation

The proposed grid corridor is located at an average level of 1 221 masl in a relatively flat topography with a maximum gradient of 3.3%. The site is regionally surrounded by an undulating topography, with ironstone ridges reaching up to 1 795 masl and valleys reaching 944 masl (Figure 2-3). Elevation profiles indicate an elevation gain / loss of less than 50 m in the N-S direction.

There are no drainage lines locally bounding the site except the Ga-mogara River located about 8 km to the south by. Localised water ponding is possible at the site after heavy rainfall due to a relatively flat topography where impermeable layers are encountered.

According to 1:1 000 000 SANBI vegetation map (2018), the study area is regionally characterised by the Kalahari Plains Thorn Bushveld vegetation comprising mainly grass with low shrubs.

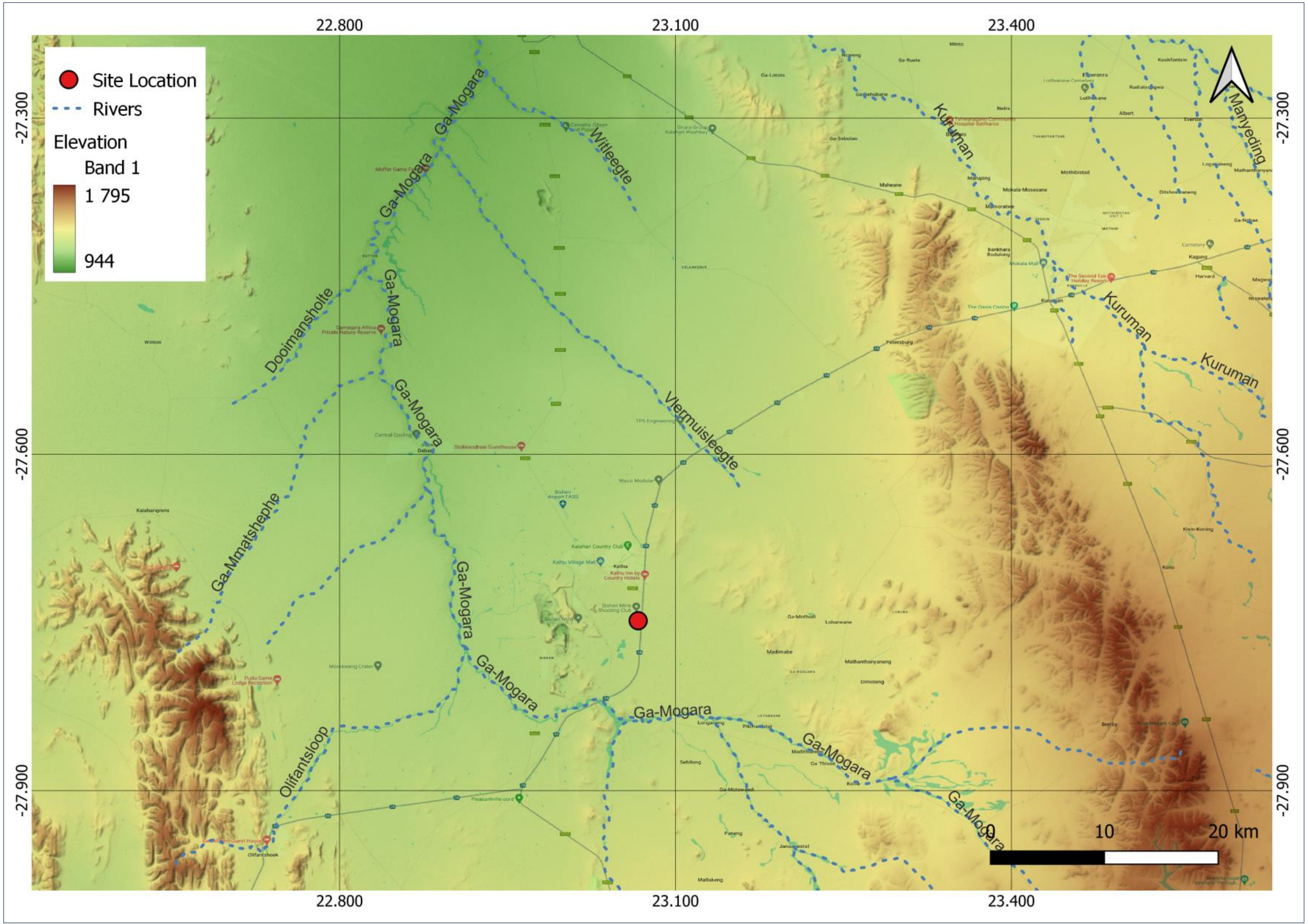

Figure 2-3: Topography and Drainage of the Study Area

2.2 Regional Geology

A review of 2722 Kuruman, 1:250 000 Geological Series (Figure 2-4) indicates that the grid corridor is underlain by sedimentary and meta-sedimentary rocks belonging to the Daniëlskuil (Vad) and Kuruman (Vak) formations of the Asbestos Hill Subgroup. The Danièlskuil Formation comprises banded iron formation (BIF) clasts in mudstone and shale layers with amphibolite, jaspilite and chert beds or lenses. The older Kuruman Formation comprises BIF with bands of amphibolite lenses and flat-pebble conglomerates in places.

Along the grid corridor, these rocks are covered by Quaternary Aeolian deposits (Qs) and, to a lesser extent, by Tertiary surface limestone (Tl) outcropping in the northern portion of the corridor.

The Asbestos Hill Subgroup is underlain by the dolomitic rocks of Ghaap Group, outcropping further south of the study area, but may occur at depth in the BESS corridor.

A series of NE-SW trending faults occur to the northeast of the site and are expected to be continuous throughout the Asbestos Hill sequence.

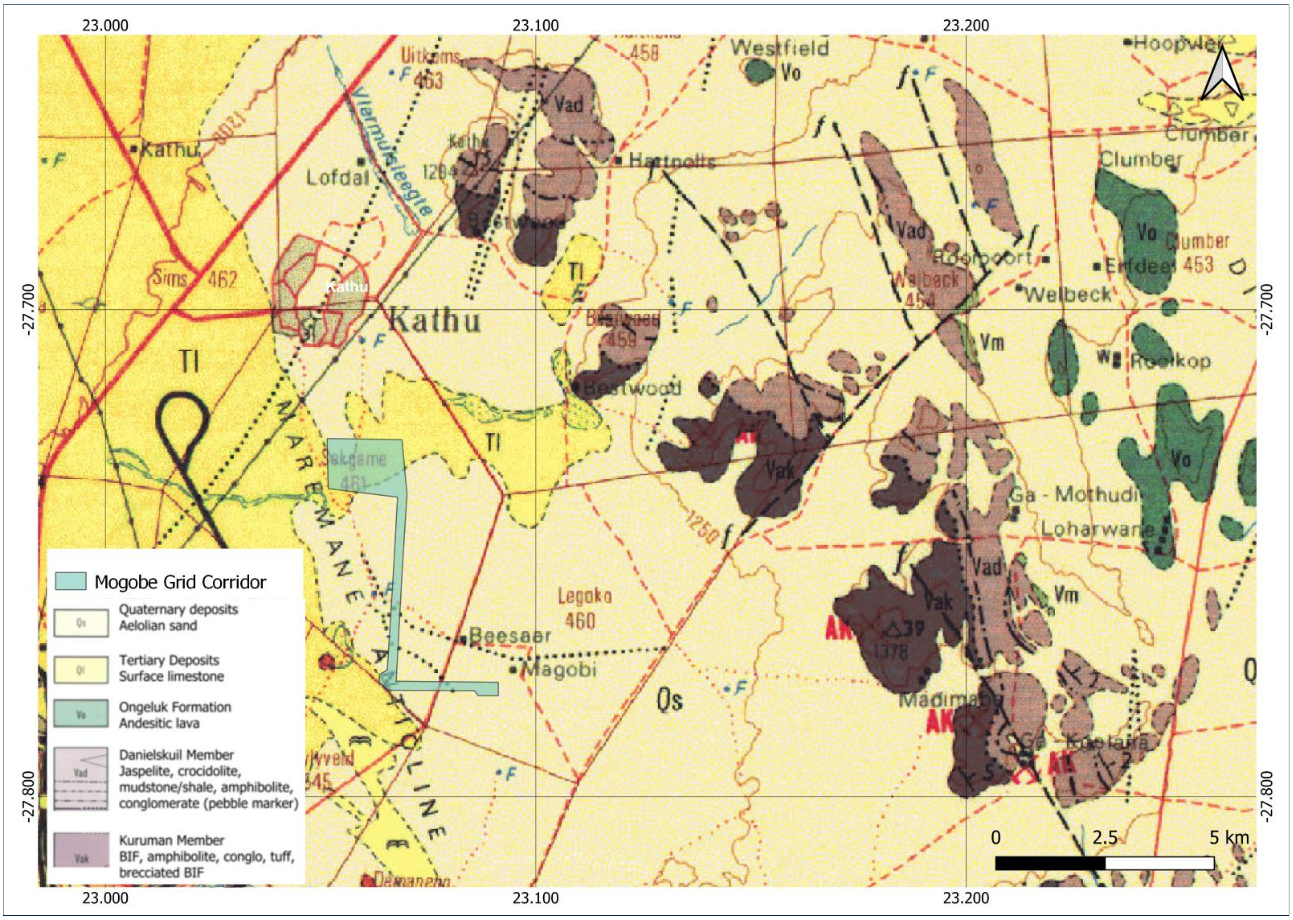

Figure 2-4: Abstract of 2722 Kuruman, 1:250 000 Geological Map Series Showing the Geology Underlying the Site. (Council for Geoscience, 1979)

2.3 Regional Hydrogeology

The regional groundwater environment characterising the study area comprises fractured rock aquifers associated with the Asbestos Hill sequence, overlying the karstic aquifers of the Campbell Subgroup. Quaternary aquifers may also occur above the fractured aquifers. The fractured aquifers often have low yields ranging between 0.1 L/s and 0.5 L/s.

The depth of groundwater obtained from the existing registered borehole database (National Groundwater Archive) in the vicinity of the study area indicates groundwater levels between 4.0 m and 20.0 m.

2.4 Seismicity

Figure 2-5 provides indicative seismic risk across South Africa and the corresponding peak ground accelerations (PGA) with a 10% probability of exceedance within a 50-year period. Based on this map, the site is not located in a seismic hazard area, therefore, a baseline PGA value of less than 0.04 g is considered applicable for this site.

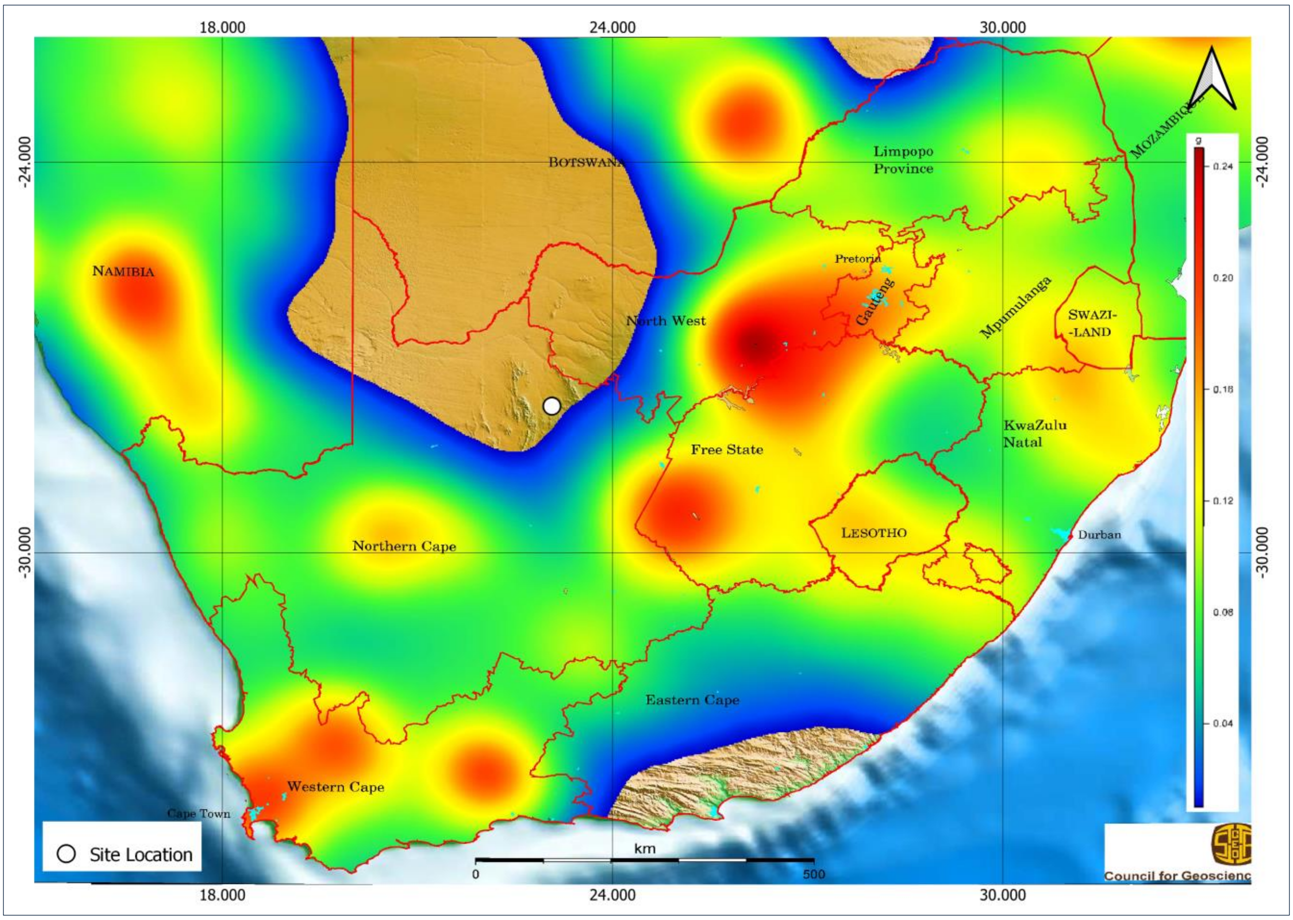

Figure 2-5: Seismic Hazards Map of South Africa (Council for Geoscience, 2003)

3 Previous Geotechnical Studies

SMEC report database was consulted to review geotechnical work that was previously undertaken near the site. A geotechnical investigation was conducted by Vela VKE Engineers (Pty) Ltd in 2012, about 3 km northwest of the site within the same lithology (Report no. PJ098/30/2012/06/2385). The investigation comprised excavation of 140 no. test pits to depths between surface level and 3.5 m.

The test pits indicated three generalised profiles:

Profile A

- 0.00 m – 0.35 m Very loose to loose, SAND. Aeolian Kalahari Sand.
- 0.35 m – 0.40 m Very strongly cemented, CALCRETE.
- Refusal on very strongly cemented CALCRETE.

Profile B

- 0.00 m – 0.60 m Loose to medium dense, GRAVELS and COBBLES. Alluvium.
- 0.60 m – 1.40m Cemented to strongly cemented, CALCRETE.
- Refusal on strongly cemented CALCRETE.

Profile C

- 0.00 m – 3.50 m Very loose to loose, SAND (collapsible sand). Aeolian Kalahari Sand.
- No refusal, maximum reach of Tractor Loaded Backhoe (TLB).

Furthermore, the borehole data for boreholes drilled about 6 km north of the study area (VGIconsult, 2015) indicate the occurrence of the hardpan calcrete to the depths between 0 and 10.0 m, underlain by BIF interlayered with shale. Some boreholes indicated that BIF / shale is outcropping to surface.

No ground water seepage was encountered in any of the trial pits during the investigation. It must be noted that the investigation was carried out in winter.

4 Geotechnical Evaluation

4.1 Conceptual Geological Profile

Based on data gathered, it is foreseeable that the site will primarily be underlain by Aeolian sands and/or strongly cemented hardpan calcrete, overlying interlayered BIF and shale.

Based on the previous studies, the bedrock is expected to occur below the strongly cemented calcrete layer below 10.0 m, but is also expected to outcrop to surface in places.

Based on the information gathered and evaluation thereof, the following ground units are envisioned along the grid corridor:

- **Aeolian sands:** silty sands (possibly collapsible) are expected to be predominant at the site from the surface up to depths exceeding 3.5 m.
- **Hardpan calcrete**: gravel (strongly cemented) expected towards the northern parts of the grid corridor, underlying transported sand or from surface to the depths exceeding 10.0 m.
- **Gravel and cobbles** are expected to occur from surface to the depths of 0.6 m, overlying the calcrete layer.
- **BIF/ shale bedrock:** Medium hard to hard rock expected to occur from 10 m, but may outcrop to the surface or be shallower in parts of the corridor.

In the immediate vicinity of the site, groundwater is expected to occur at depths greater than 4.0 m below ground level. A perched groundwater table is however anticipated on the soil/rock contact during rainy seasons.

Variations to the above conceptual geological profile and strength index will manifest through intrusive investigations.

4.2 Geo-hazards Potential

4.2.1 Undermining

The mining practice in the area, specifically Sishen mine, is mainly surface mining, therefore, undermining related instabilities are not expected

4.2.2 Slope Instability

The site area and surroundings are located on a relatively flat topography with ~ 3% slope gradient. Therefore no natural slope-related instabilities are expected at the site.

4.2.3 Areas Subject to Flooding

There are no rivers or water courses located near the site, therefore flooding is not expected. However, it is a requirement that all development is placed at least 100 m away from a potential 1:50 year flood line.

4.2.4 Dolomite Dissolution

The dolomitic Ghaap Group is located south of the site, therefore, issues relating to dolomitic land are not anticipated along the grid corridor.

4.3 Collapsible Soils

Aeolian soils are expected to be collapsible, therefore where these are encountered, foundation settlement may occur if the ground profile becomes saturated.

4.4 Stability of Excavations

Due to sandy nature of Aeolian soils, collapse of trench excavations is also anticipated during construction ;

4.5 Groundwater

Groundwater is expected below 4.0 m. Water seepage may occur at the soil/rock interface during wet season. Water runoff into open works may also occur during construction work.

4.6 Excavatability

Soft rock excavations are anticipated within the transported soil grading to intermediate excavations within the hardpan calcrete horizon.

Hard rock excavations are expected on BIF/ shale bedrock.

4.7 Corrosivity

Based on the previous experience in the region, the transported and pedogenic layers are expected to be corrosive. Future planning should consider a possible corrosive nature of the environment.

4.8 Material Utilisation Potential

Aeolian soils are expected to have poor strength and unsuitable for use as construction material. Calcrete gravel, based on the previous work, classified as G5-G6 material and is expected to be suitable for use during construction. However, these assumptions need to be confirmed by laboratory analyses.

4.9 Geological/ Geotechnical Risk Assessment

Conceivable geotechnical risks towards the proposed development of the Mogobe grid corridor are provided hereunder. These risks should form part of the objective of geotechnical investigations for the design of the proposed infrastructure and related environmental studies.

Table 1: Risk assessment from a geological/ geotechnical perspective

Risk	Causes	Impacts	Significance before mitigation	Mitigation	Significance after mitigation
Unexpected ground conditions	• Potential problem soils including collapse and corrosiveness • Occurrence of uncontrolled fill • Boulders	• Settlement of foundations • Instabilities during construction e.g. trench collapse • Corrosion of buried structures • Changes in design • Project delays • Increased project costs	High	• Conduct geotechnical site investigations and laboratory testing, • Foundations to be designed for the prevailing ground conditions • Monitor construction works by a professional Engineering Geologist or Geotechnical Engineer	Low
Flooding	• Prolonged rain • Rise in groundwater levels	• Changes in foundation designs, • Work stops, • Increased costs of repairs, • Project delays	Medium	• Identify areas of high risk (drainage lines/watercourses) through topographical and hydrological studies • Long term monitoring of groundwater levels • Stabilize cleared areas during construction	Low
Material sourcing	• Unsuitability of on-site materials for use in construction • Lack of potential sources near the site	• High costs for commercially sourced material • Project delays	Medium	• Laboratory testing of on-site materials for suitability for use during construction • Identify commercial sources near the site • Conduct material assessment for identified potential sources	Low

5 Recommendations

5.1 Geotechnical Feasibility of Project

Based on information obtained for the Mogobe grid corridor and interpretation thereof, there appears to be no fatal flaws for the project's development not to proceed beyond the pre-feasibility stage from a geological and geotechnical perspective.

5.2 Conceptual Founding Solutions

The conventional footing foundations can be envisaged for the expected ground profile/s along the grid corridor. These can comprise either pad or spread foundations placed on competent soil strata or on rock. However, the investigations and foundation recommendations for powerlines in South Africa are guided by the Eskom's TRMSCAAC 6 (2012). Based on this guideline, soil classifications, that is, soil nominations are required for each ground profile from which a foundation design can be determined. Therefore intrusive investigations will be required for the foundation types to be accurately determined.

5.3 Further Geotechnical Investigations

This desktop study has been compiled for pre-feasibility purposes only; thus, the information presented here will not be suitable for the design of the structures. Thus, for economic design and to reduce the probability of failure of the proposed development, geotechnical field investigations coupled with laboratory work will be required for engineering design. Based on information obtained from this desktop study, SMEC has recommended the following further investigations :

- Machine excavation of test pits along the proposed grid corridor is anticipated to facilitate recovery of bulk material samples. Test pits to be excavated using a Tractor Loader Backhoe (TLB) to a refusal depth or the machine's reach.
- Profiling of soil and rock horizons by a professional Engineering Geologist or Geotechnical Engineer.
- Field mapping across the site of rock mass outcrops along the grid corridor by a professional Engineering Geologist or Geotechnical Engineer.
- Retrieval of soil and rock samples for determination of index and engineering properties including, but not limited to:
    - Foundation Indicator tests, including determination of Atterberg limits, grading and hydrometer analyses to determine clay content and activity.
    - Modified AASTHO and CBR tests to determine the utilisation of in situ material in new construction activities.
    - Chemical analysis tests on soil samples to determine aggressiveness towards buried ferrous services and foundations.
    - Collapse potential of soils.
- Compile a comprehensive interpretive geotechnical report with recommendations, inter alia, on the following:
    - Foundation options;
    - Site development and excavatability; and
    - Material utilisation.

The geotechnical site investigations for the proposed development are anticipated to take a week, and the interpretive report including the laboratory results can be concluded in 4 to 6 weeks.

6 Conclusion

This geotechnical desktop study report highlights the anticipated geological and subsequent ground conditions expected along the grid corridor.

Generally, the grid infrastructure is located on a flat topography, and no natural slope instabilities.

Based on the desktop study, the following ground units can be expected on site:

- **Aeolian sands**: silty sands (possibly collapsible) are expected to be predominant at the site from the surface up to depths exceeding 3.5 m.
- **Hardpan calcrete**: gravel (strongly cemented) expected towards the northern parts of the grid corridor, underlying transported sand or from surface to the depths exceeding 10.0 m.
- **Gravel and cobbles** are expected to occur from surface to the depths of 0.6 m, overlying the calcrete layer.
- **BIF/ shale bedrock**: Medium hard to hard rock expected to occur from 10 m, but may outcrop to the surface or be shallower in parts of the corridor.

Groundwater is expected from 4.0 m below existing ground level. However, occurrence of perched water table is expected due to impervious strata.

In terms of drainage, there are no drainage lines locally bounding the site. It is however recommended that appropriate studies are conducted to identify and delineate possible flood lines.

The main concerns regarding development of the project sites and which will need to be determined via on-site investigations are:

- Founding conditions;
- Corrosivity of soils;
- Collapsible soils;
- Undefined depth to permanent groundwater table.

SMEC is, therefore, of the opinion that the project can proceed to the next stage which will assist in defining and quantifying the geotechnical risks to development and choosing the most appropriate founding solution.

7 Closing

This report acts merely to aid in the feasibility determination of the project, and it is imperative that geotechnical investigations of the site be undertaken should the development move forward. SMEC has undertaken several investigations for similar developments and has highlighted the minimum requirements for geotechnical investigations that will inform the respective engineering design. Undertaking geotechnical investigations will generate the necessary geomechanical design parameters of the soils and rock mass that will mitigate the risk of failure of the proposed structures and unforeseen geotechnical issues across the site.

It must be noted that the information and recommendations given in this desktop study report are generalised and based on limited data for the site and surroundings. Inconsistencies from what has been reported here may likely be observed during the later investigation phases.

Furthermore, all recommendations this report makes serve merely as guidelines for the Client's consideration. Anticipated founding conditions and conceptual solutions, as described herein, must be proven before design and construction to ensure the proper economic viability of the proposed project.

8 References

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