High Level Geotechnical Desktop Study Visual Impact Assessment

Desktop Geotechnical Specialist Study for the 400 kV Gamma Gridline Corridor, near Three Sisters, South Africa.

REPORT:	***PREPARED BY:***
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GROUNDWATER AND EARTH SCIENCES
GEOSS
SOUTH AFRICA (Pty) Ltd

EXECUTIVE SUMMARY

Red Cap Energy (Pty) Ltd ('Red Cap') has received Environmental Authorisation for three wind farms, collectively known as Nuweveld Wind Farm Development, and a 400 kV grid corridor located close to Beaufort West in the Western Cape Province. The approved grid corridor links the Nuweveld projects to the Droërivier Substation ~65 km to the south of the wind farms.

The project scope includes an appraisal of the geotechnical conditions. The primary objective of the desktop assessment is to summarise the geology of the area, including the likely distribution of potential geotechnical challenges related to the underlying geology. The impacts of the proposed development have been assessed according to impact assessment tables provided by Red Cap. The information that has been provided is for planning purposes only and forms part of the environmental Basic Assessment process.

A summary of the pertinent findings are as follows:

1. Increased soil erosion may transpire as an impact of development, this may persist for the life of the project. However, the impact of this is expected to be low and is anticipated to have little effect on the site from a geotechnical point of view.
2. Variable soil and rock conditions will exist across the site, broadly these have been divided based on geological conditions, as follows:
    a. Zone A – Karoo mudrock and sandstone
    b. Zone B – Karoo dolerite
    c. Zone C – Areas of thicker soil cover (generally within drainage channels)
3. It is anticipated that conventional foundations can be employed for all structures. Karoo mudrock and sandstone should be avoided when selecting aggregates for concrete mixes.
4. The footprint of each proposed structure would have to be investigated prior to the compilation of final design(s).
5. Owing to the variable geologic and soil conditions across the proposed development area, the subgrade conditions will vary across the site. Dolerite has been proven to perform well as an aggregate for wearing courses. Dolerite has also been incorporated as an aggregate in concrete mixes.
6. The excavatability of the stratum on site is anticipated to be variable, based on material composition and texture, the degree of weathering, and the nature of discontinuities within the rock and/or soil mass.
7. The seismicity in the region is considered low.
8. Intrusive centre-line investigations will be required to confirm the anticipated conditions at each of the final pylon positions. Any road cuttings should be designed by an appropriately qualified professional.
9. GEOSS has endeavoured to highlight and characterise all potential geotechnical risks that are presented by the site that has been proposed for development. However, due to the anisotropic (variable) nature of earth materials, each point on the site will present results that differ. For this reason, it is considered of the utmost importance that the foundation excavations be inspected prior to casting to ensure that soil with an adequate bearing capacity is obtained beneath each footing. These works should be carried out by an appropriately qualified individual.

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ABBREVIATIONS & SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
BH	Borehole
CGS	Council for Geoscience
EC	electrical conductivity
EOH	End of Hole
g	Gravity
L/s	litres per second
LL	Liquid Limit
LS	Linear Shrinkage
m	metres
mm	millimetre
MOD	Modified AASHTO
mS/m	milli-Siemens per metre

GLOSSARY OF TERMS

Aquifer: a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].

Electrical Conductivity: the ability of groundwater to conduct electrical current, due to the presence of charged ionic species in solution (Freeze and Cherry, 1979).

Fractured aquifer: Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.

Groundwater: Water found in the subsurface in the saturated zone below the water table or piezometric surface i.e., the water table marks the upper surface of groundwater systems.

Pedocrete: Superficial deposits, not of sedimentary origin, which have formed through either weathering residues, or cementation or replacement of existing soils (by precipitates derived from soil-water and or groundwater), or a combination of such processes. Several chemical agents replace or cement, e.g. calcium carbonates (calcrete) and/or iron oxides (ferricrete).

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Cover photo:

Photo captured from Google Street view 2022.

GEOSS project number:

2021_11-4585 (Phase A)

SPECIALIST EXPERTISE

CURRICULUM VITAE – Michael Baleta

GENERAL

Nationality:	South African
Profession:	Engineering Geologist / Geotechnical Engineering
Position:	Engineering Geologist
Specialization:	Groundwater exploration, development, management and monitoring including numerical modelling. Hydrogeological impact studies and assessment of groundwater – surface water interaction.
Year of birth & ID #:	1984 – 840420 5065 085
Language skills:	English (mother tongue), Afrikaans (average),

KEY SKILLS

- Geotechnical site investigation and site assessment.
- Site supervision of subcontractors for geotechnical exploration and construction
- Geotechnical design
- Geotechnical remediation, mode of failure determination and design of remedial works
- Geotechnical software: PLAXIS Geotechnical FEA, RockWare (RockPlot), dotPLOT

RELEVANT EXPERIENCE

- Completed numerous successful municipal, industrial, agricultural, and residential geotechnical and groundwater supply projects
- Implementation of long-term groundwater monitoring and management plans
- Groundwater chemical characterization, contamination, and remediation studies

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

2009	B.Sc (Hons) Structural Geology	University of Stellenbosch, South Africa
2008	B.Sc Geology – Applied Earth Science	University of Stellenbosch, South Africa

Memberships

- South African Council for National Scientific Professions (SACNASP) Mem. No. 400695/15
- Geological Society of South Africa

SPECIALIST EXPERTISE

CURRICULUM VITAE – SHANE TEEK

GENERAL

Nationality:	South African
Profession:	Geotechnical Specialist & Hydrogeologist
Specialization:	Soil classification for engineering purposes. Groundwater exploration and sampling.
Position in firm:	Geotechnical Geologist & Hydrogeologist at GEOSS – South Africa (Pty) Ltd.
Date commenced:	17 July 2021
Year of birth & ID #:	1994 – 9404135162084
Language skills:	English (good – speaking, reading, and writing) Afrikaans (good - speaking, reading, and writing).

KEY SKILLS

- Geotechnical investigations
- Compilation of factual reports.
- Field mapping.
- Soil and rock profiling.
- Material classification and material use determination.
- Supervision of geotechnical contractors.
- Groundwater geophysics and conducting hydrocensus studies.
- Groundwater development - borehole drilling and test pumping supervision and analysis.
- Groundwater monitoring - development and analysis of groundwater level and quality data.
- Groundwater management - sustainable aquifer development and management.
- Groundwater contamination assessments.
- ArcGIS, QGIS, Python, FLAC/SLOPE, Midas GTS NX.

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

2021	M.Eng. (Civil Engineering – Cum Laude)	University of the Stellenbosch, South Africa
2016	B.Sc. Hons. (Earth Science)	University of the Stellenbosch, South Africa
2015	B.Sc. (Geology: Earth Science)	University of the Stellenbosch, South Africa

Memberships

- Geological Society of South Africa – Member No. 970413
- South African Council for National Scientific Professions (SACNASP) Mem. No. 126397/20
- Founding member of the UNESCO Groundwater Youth Network (GWYN)

EMPLOYMENT RECORD

July 2021 to present	GEOSS South Africa (Pty) Ltd, South Africa
Jan 2020 to June 2021	Geotechnics Africa Western Cape, South Africa
Feb 2019 to July 2019	Polytechnique Montréal, Canada
Jan 2017 to Dec 2017	Remote Exploration Services, South Africa.

SPECIALIST DECLARATION

We, Michael Baleta and Shane Teek, as the appointed independent specialist hereby declare that we:

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- have and will not have no vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- are fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2010 (specifically in terms of regulation 17 of GN No. R. 543) and any specific environmental management Act, and that failure to comply with these requirements may constitute and result in disqualification;
- have provided the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not; and
- am aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Michael Baleta
GEOSS South Africa (Pty) Ltd.
Pr. Sci. Nat. – *400695/15*
10 August 2022

Shane Teek
GEOSS South Africa (Pty) Ltd.
Pr. Sci. Nat. – 126397/20
28 August 2022.

1. INTRODUCTION

1.1 Terms of Reference

Red Cap Energy (Pty) Ltd ('Red Cap') has received Environmental Authorisation for three wind farms and for a 400 kV grid corridor collectively known as Nuweveld Wind Farm Development, located close to Beaufort West in the Western Cape Province. The approved grid corridor links the Nuweveld projects to the Droërivier Substation ~65 km to the south of the wind farms (**Map 1**).

To expand the capacity of Eskom grid and improve the functionality of the grid in the area, an additional 400 kV grid connection is required from the Nuweveld Collector Substation to the Gamma Substation, ~90 km to the east (the project or the Gamma Gridline Project).

GEOSS South Africa (Pty) Ltd was requested by Matthew Law and Surina Laurie of Red Cap to complete a high-level geotechnical desktop study for the proposed Gamma Gridline Project.

1.2 Objectives and Methodology

The project scope includes an appraisal of the geotechnical conditions.

The primary objective of the desktop assessment is to summarise the geology of the area, including the likely distribution of potential geotechnical challenges related to the underlying geology. The following high-level information is presented in this report:

- Whether problem soils are likely to be encountered on-site.
- An assessment of expected the excavatability within the respective geological areas.
- Whether any geohazards are immediately apparent within the site area.
- A general discussion of possible and likely engineering characteristics of the respective geological materials.
- Possible development constraints that may be present across the site.
- An evaluation of the seismic potential of the area based on available published literature.
- Suggested further works prior to construction.
- Broad recommendations that may be used to guide the geotechnical design of the proposed infrastructure and installation of associated services.

The information that has been provided is for planning purposes only and forms part of the environmental Basic Assessment process.

1.3 Proposed Development

Red Cap Energy (Pty) Ltd ('Red Cap') has received Environmental Authorisation for three wind farms and for a 400 kV grid corridor collectively known as Nuweveld Wind Farm Development, located close to Beaufort West in the Western Cape Province.

As well as the Nuweveld Wind Farm Development, Red Cap is also proposing to develop four additional wind farms and associated grid connections, known as the Hoogland Projects. The Hoogland Wind Farms are located north and south of the Nuweveld complex, and the Hoogland grid connections will terminate at the Nuweveld Collector Substation (refer to **Map 1**) and are the subject of separate applications.

To expand the capacity of Eskom grid and improve the functionality of the grid in the area, an additional 400 kV grid connection is required from the Nuweveld Collector Substation to the Gamma Substation, ~90 km to the east (the Gamma Gridline Project). This additional line will improve functionality by creating a 400 kV ring-line between the Droërivier Substation, Gamma Substation and Nuweveld projects, and create opportunities for other wind farm developments (such as the proposed Hoogland projects) to tie-into the grid either at the Nuweveld Collector Substation or along the new 400 kV line. As such, the proposed new line will allow Eskom to release further renewable energy potential in an area that is becoming a renewable energy development node in South Africa, thereby helping to alleviate South Africa's power crisis.

The 400 kV gridline would have a ≤ 55 m wide servitude, which may be kept clear of taller vegetation (trees) and, where required and feasible, accommodate access tracks needed for construction and maintenance.

Lattice type pylons will be used to support the grid connection lines for this project. Different lattice type pylon will be required along the gridline depending on the topography and span characteristics. Most of the pylons will be cross-rope suspension towers, with self-supporting towers being used at turn points, at steep slopes or where a very large distance needs to be spanned. All pylon types would attach to concrete plinths and foundations of varying sizes depending on pylon type. Guy wires with concrete anchor blocks will also be required for providing additional support and to stabilise some of the pylons/ towers.

The footprints of the 400 kV towers are conservatively assumed to be 100 m^2 each. The average span of the 400 kV line will be 400 m.

Temporary laydown areas will be identified along the power line route, with the main equipment and construction yards being based in one of the surrounding towns or at a wind farm site camp and laydown areas. It is anticipated that the total area required for the temporary laydown areas is up to 5 ha.

Existing access roads and tracks (upgraded to between 2 m and 4 m wide tracks, where needed) will be used for construction and maintenance of the line as far as possible and new access tracks would be established, where needed.

A 300 m x 300 m expansion to the Gamma Substation (including transformers and other standard substation infrastructure) and forms a component of the project.

1.4 Scope and Limitations of Assessment

The primary aims of this investigation were to confirm the general geotechnical conditions of the site and to determine potential geotechnical impacts on the environment based on existing, available desktop information i.e. information extracted from published literature, and consultancy reports compiled in the vicinity. No site visit was undertaken.

This study was conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical profession practising under similar conditions.

Geological conditions are seldom uniform and the geological and geotechnical conditions in the corridor will need to be established in the field prior to commencement of construction (i.e. through field investigations and testing). The engineering recommendations provided in this report are therefore preliminary.

1.5 Information Available

Data was acquired from the following topocadastral, geological, and hydrogeological sources:

- The 1: 50 000 topocadastral map – Sheets 3122CD, 3122DC, 3122DA, 3122DB, 3122DD, 3123DD, 3123CA, 3123CB and 3123CD.
- The 1: 250 000 geological series map – Sheet 3122, Victoria West.
- The 1: 500 000 hydrogeological map – Sheet 3122, Beaufort West.
- Aerial imagery (Google Earth imagery).
- Engineering Geology of South Africa (relevant) Volumes 2 and 4 (Brink, 1981; 1985).

Data hosted GEOSS' internal database generated during previous geotechnical and hydrogeological investigations undertaken in the area, as well as published geological, geotechnical and hydrogeological literature available for the region were also consulted.

1.6 Assessment Methodology

This desktop study involved gathering, reviewing and interpreting all relevant data to the project.

1.7 Assumptions and Limitations

The assessment that has been made is based on a desk study, review of literature, and analysis of the information. The report is not based on detailed intrusive works, i.e. trial pit excavation, soil profiling, geotechnical drilling, and/or testing.

The assessments in this report are high level, and follow up work will be undertaken prior to final design and construction, to confirm actual soil conditions.

The duration of the construction phase was not provided at the time that this report was compiled. A construction duration of 2 year was assumed. Please note that the impact rating will change should the construction duration increase. A description of the weighting system and description of terms used is attached in **Appendix A**.

It is important to stress that the impact assessment component of this report highlights risks/impacts of construction, operation and decommissioning of such a proposed facility on the geotechnical conditions that are expected on/across the site.

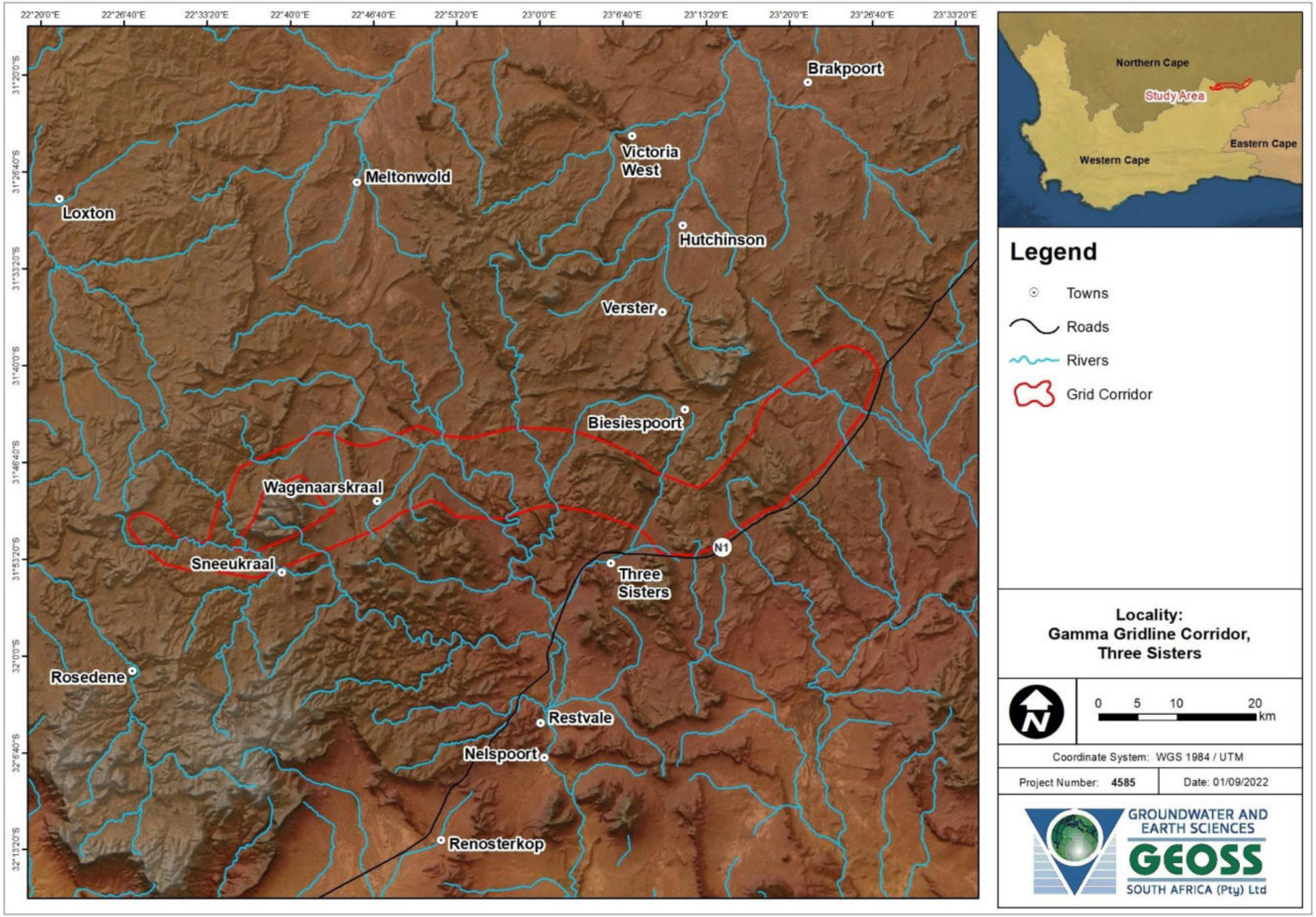
2. SETTING

2.1 Site Location and Description

The extent of the Gamma Gridline Corridor (or site) is in excess of 900 km^2, located about 7 km north of Three Sisters; some 45 km south of Victoria West, and approximately 50 km southeast of Loxton (**Map 1**). The project aims to link the existing Gamma substation to the approved Nuweveld Collector Substation. The approximate extent of Gamma Grid Connection Corridor is shown in **Map 2.**

2.2 Topography and Site Features

The elevation of the site ranges between about 1170 and 1751 metres above mean sea level (mamsl). Higher lying areas are characterised by intrusions and lower lying areas are characterised by drainage channels infilled with quaternary sediments, i.e. ephemeral river beds (see **Map 3**). Most rivers in the Corridor drain in a southerly to south-westerly direction.



Map 1: Locality map showing the location of the proposed Gamma Gridline Corridor and surrounds.

2.3 Climate

The study area has been divided into an eastern and western extent to report the climate data for the area.

Figure 1 shows the monthly average air temperature and **Figure 2** shows the monthly median rainfall and evaporation distribution for the study area (Schulze, 2009).

Generally, the study area experiences cold and dry winters with warm to hot summers.

The long term (1950 – 2000) mean annual precipitation for the study area varies between 233 mm/a in the east, to 189 mm/a in the west. Generally, the bulk of the rainfall is received in the summer and early autumn months (i.e. between January and May).

Potential evaporation exceeds the rainfall year-round across the study area.

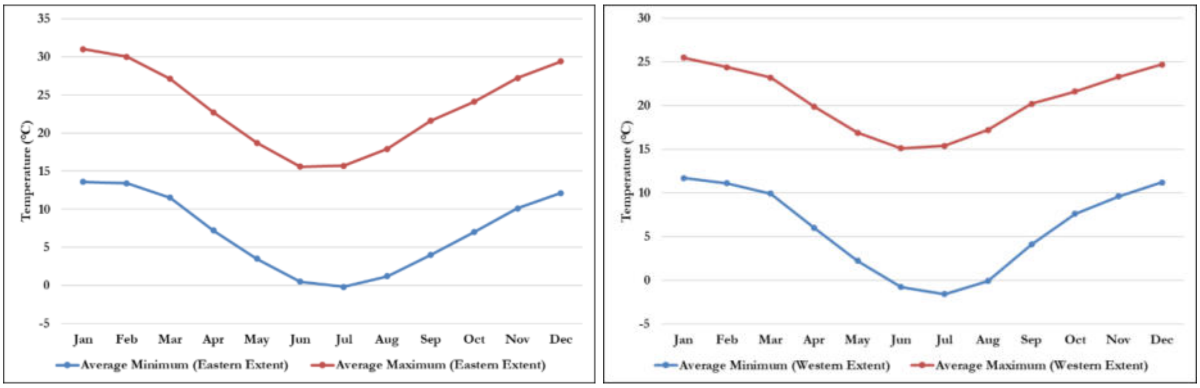


Figure 1: Monthly average air temperature for the Eastern and Western Extents of Study Area (Schulze, 2009).

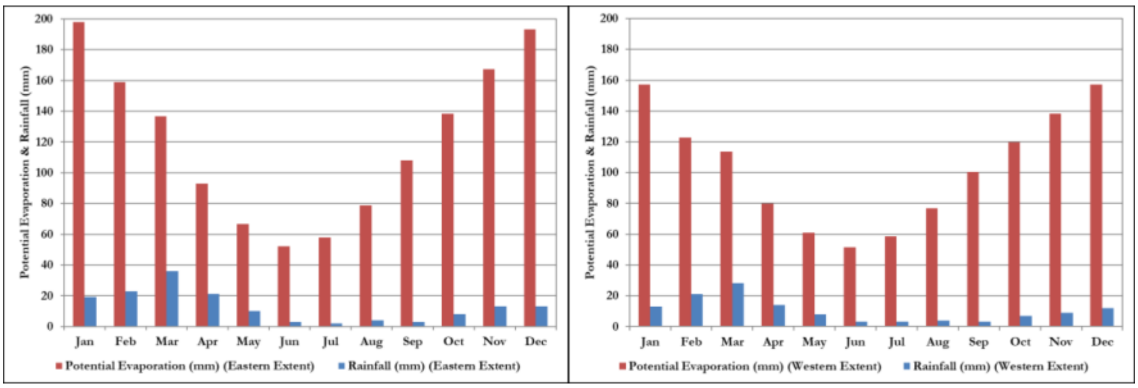


Figure 2: Monthly average air temperature for the Eastern and Western Extents of Study Area (Schulze, 2009).

2.4 Weinert 'N' Value

The present and past climate is a useful indicator of the typical soil conditions that may be encountered on a particular site (Weinert, 1975). Weinert (1975) developed a general model to categorise the climate of southern Africa based on what he termed the 'N'-value (see **Figure 3)**. The Weinert 'N'-value for the project area is shown to be greater than 5 (Brink, 1983).

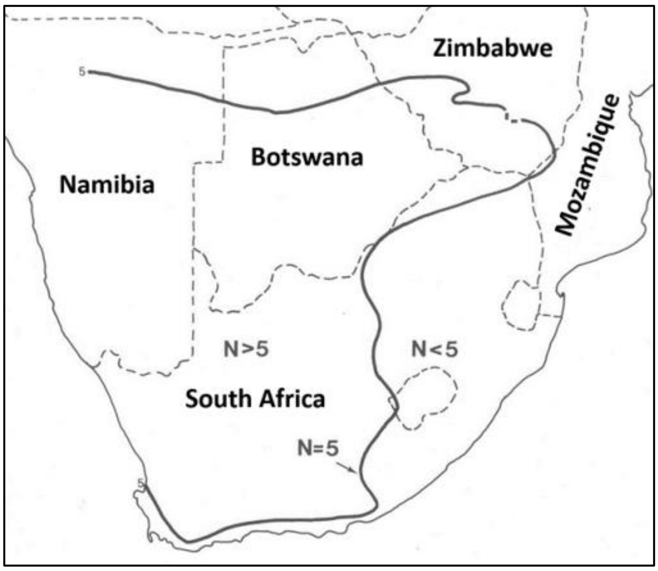


Figure 3: Climatic 'N' value = 5 plotted for southern Africa (after Weinert, 1967).

Weinert (1975) showed that where 'N'-values are greater than 5, residual soils are typically shallow, transported soils of variable thickness with calcrete and/or other pedocretes (Brink, 1979).

2.5 Geology

The Council for Geoscience (CGS) has mapped the geology of the area at a scale of 1:250 000 (CGS, 1991). The geological setting is shown in **Map 4** and the main geology of the area is listed in **Table 1**. The site is mostly underlain by mudstones and sandstones of the Karoo-aged Teekloof Formation of the Beaufort Group, which have been intruded by Jurassic-aged dolerites, and overlain by quaternary-aged alluvium (**Map 4**).

Table 1: Geological formations within the study area (CGS, 1991).

Code	Member	Formation	Group	Description
	Quaternary-aged sediments			Alluvium
Jd	*Intrusive*			*dolerite*
Pto	Oukloof	Teekloof	Beaufort	Purple mudstone, sandstone
Pth	Hoedemaker			Red and purple mudstone, subordinate sandstone
Ptp	Oukloof			Purple green, and grey mudstone, sandstone

2.5.1 Geological Zones

The site has been broadly classified into three zones of similar geological and geotechnical characteristics (Zones A, B and C). The zones are presented in **Map 5**, and are expanded upon in subsequent sections.

2.6 Geotechnical Properties and Engineering Geology

2.6.1 Sandstones and mudstones (Zone A)

Problems with slope stability may be experienced where sandstones and shales/mudrocks of the Karoo Supergroup are closely intercalated, as weathering of the fine-grained rocks may result in undercutting (Brink, 1983). Porewater pressure may develop at the interface between sand- and mud-/siltstones (Brink, 1983).

Where sandstones are thickly bedded and highly jointed, joint-controlled block and wedge failures can potentially occur (Brink, 1983).

2.6.2 Dolerite (Zone B)

The end of the Karoo age was terminated by the intrusion of dolerite dykes and sills into the Karoo sedimentary rocks. The intrusive dolerites only had a limited thermal metamorphism effect on the surrounding Karoo sediments, as a rule of thumb, causing changes to the host lithology of equivalent thickness to the dyke itself (Brink, 1983).

During the late 1960s and early 1970s, several tests were undertaken to determine strength properties of dolerite rock. The general description of dolerite was as follows, bluish-grey, very hard to extremely hard rock, variably fine- and medium-grained, variably jointed and fractured, with calcite, chlorite and zeolite minerals present on the joint and fracture surfaces in varying amounts (Brink, 1983). Of relevance to this assessment, dolerite rocks are considered to be erosion resistant.

2.6.3 Quaternary Sediments (Zone C)

Quaternary sediments in the region include alluvium, and terrace gravels (CGS, 1991). The geotechnical characteristics of such materials are variable in nature. Typical construction constraints with such materials include a potentially collapsible grain structure associated with sandy sediments, and challenging excavation conditions associated with terrace gravels, particularly where boulders are encountered.

2.7 Expected soil profile

In the region between Orange River and Beaufort West, the sandstones and mudrocks of the Karoo supergroup often dip gently. The topography is generally undulating, and areas of strong relief are usually present where intrusive dolerite sills create a capping characterised by a landscape of mesas and buttes. According to Brink (1983), the hillslopes of such topography, here and in most arid areas of the world, usually display up to four soil profiles (**Figure 4**).

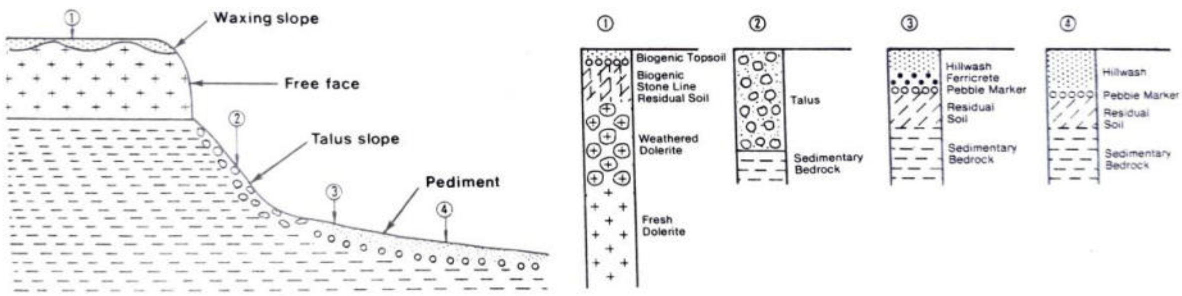


Figure 4: Elements of typical Karoo hillslopes and anticipated soil profiles (Brink, 1982)

2.8 Slope Classification

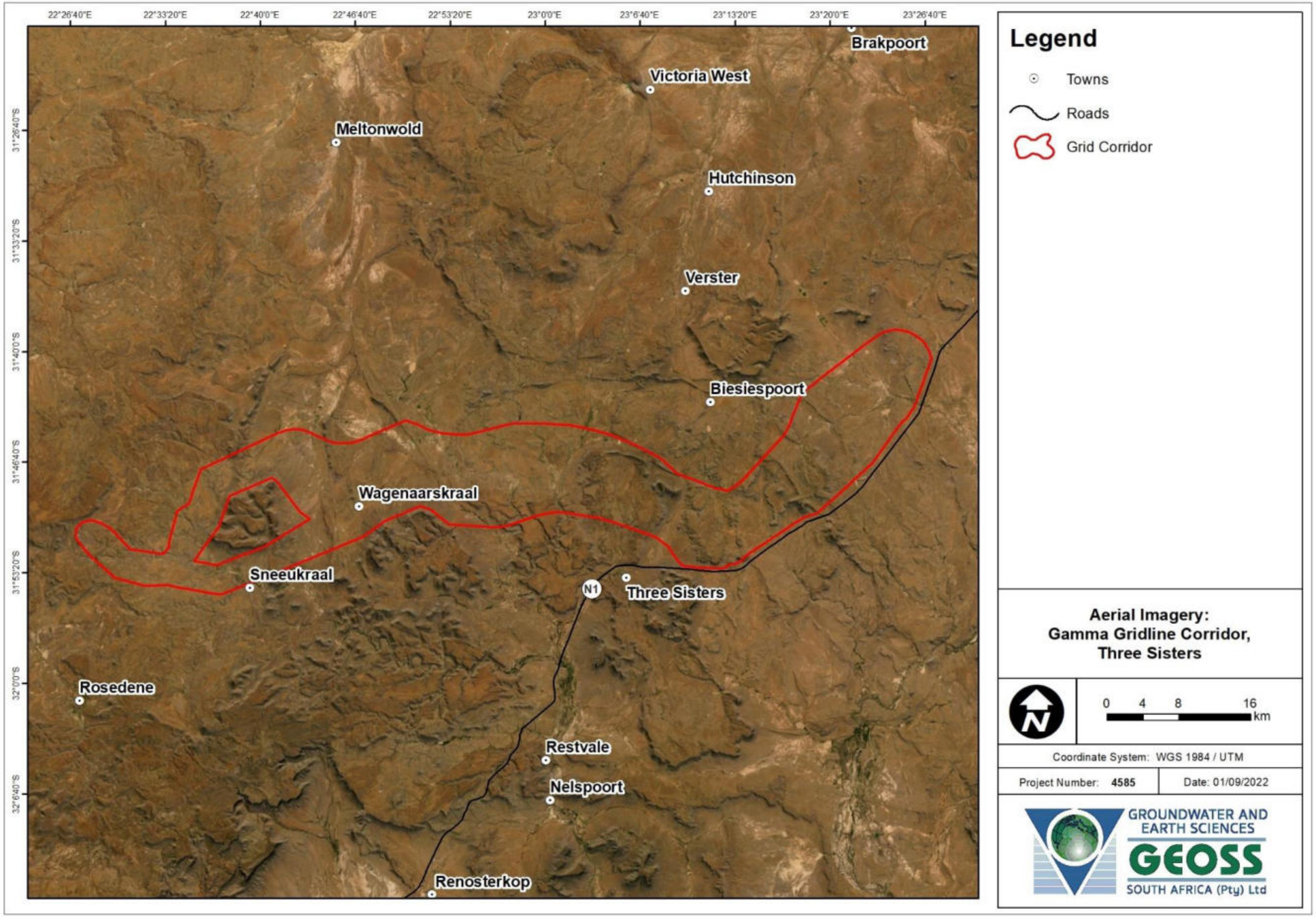
The topography is the region has been classified in terms of development based on classes suggested by Stiff et al. (1996), see **Map 3**. The majority of the region is classified as "favourable" due to the generally flat nature of the site.

2.9 Hydrogeology

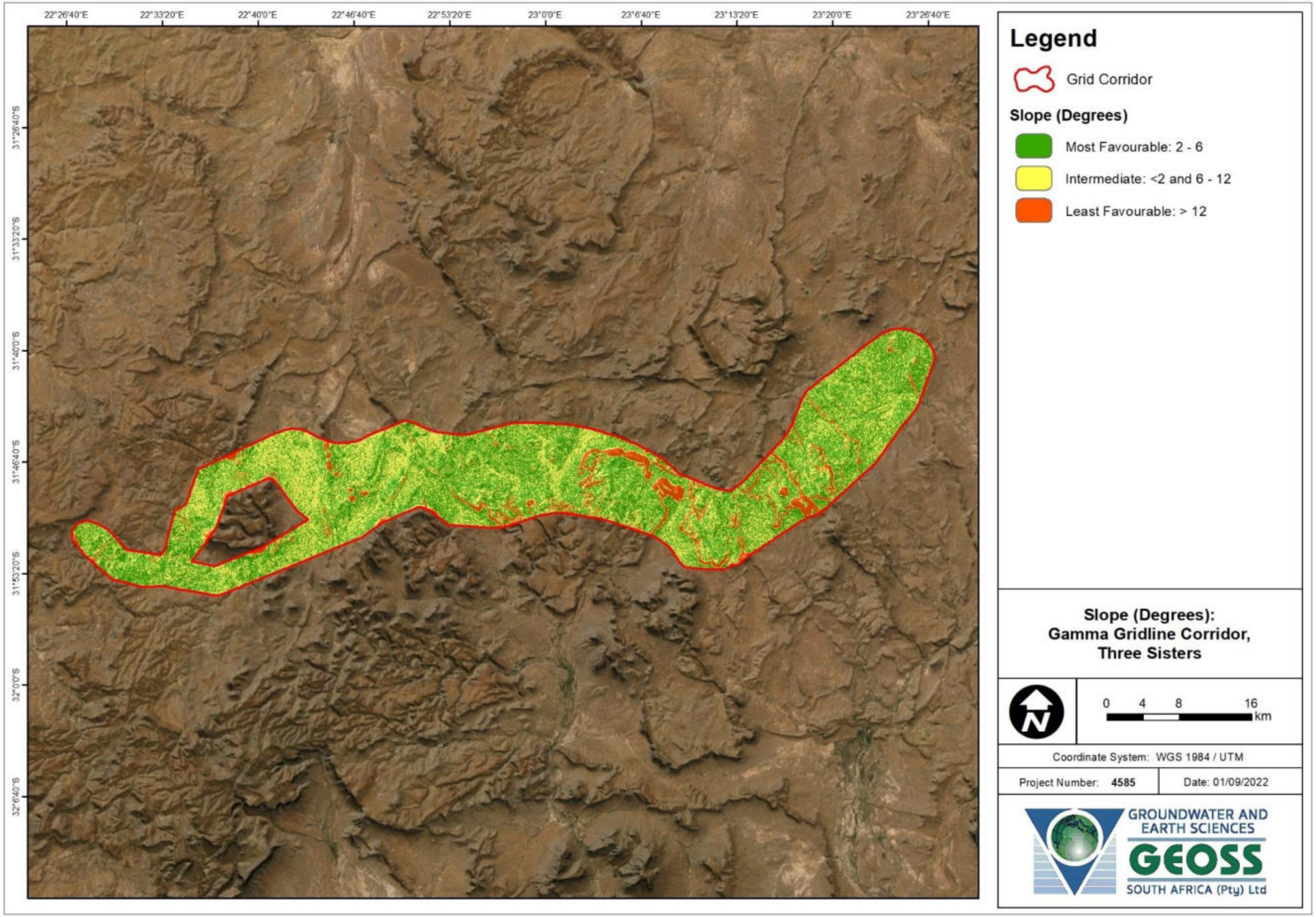
In the region earmarked for development, two aquifer types dominate, intergranular and fractured, and fractured aquifers. The intergranular and fractured aquifers are shown to have an indicative yield potential of 0.1 to 0.5 L/s (DWAF, 2002). The fractured aquifers indicate a yield potential of between 0.5 to 2.0 L/s (DWAF, 2002).

The regional groundwater quality is classified as "ideal to marginal" directly underlying the study area with an associated electrical conductivity (EC) of 0 – 300 mS/m (DWAF, 2002).

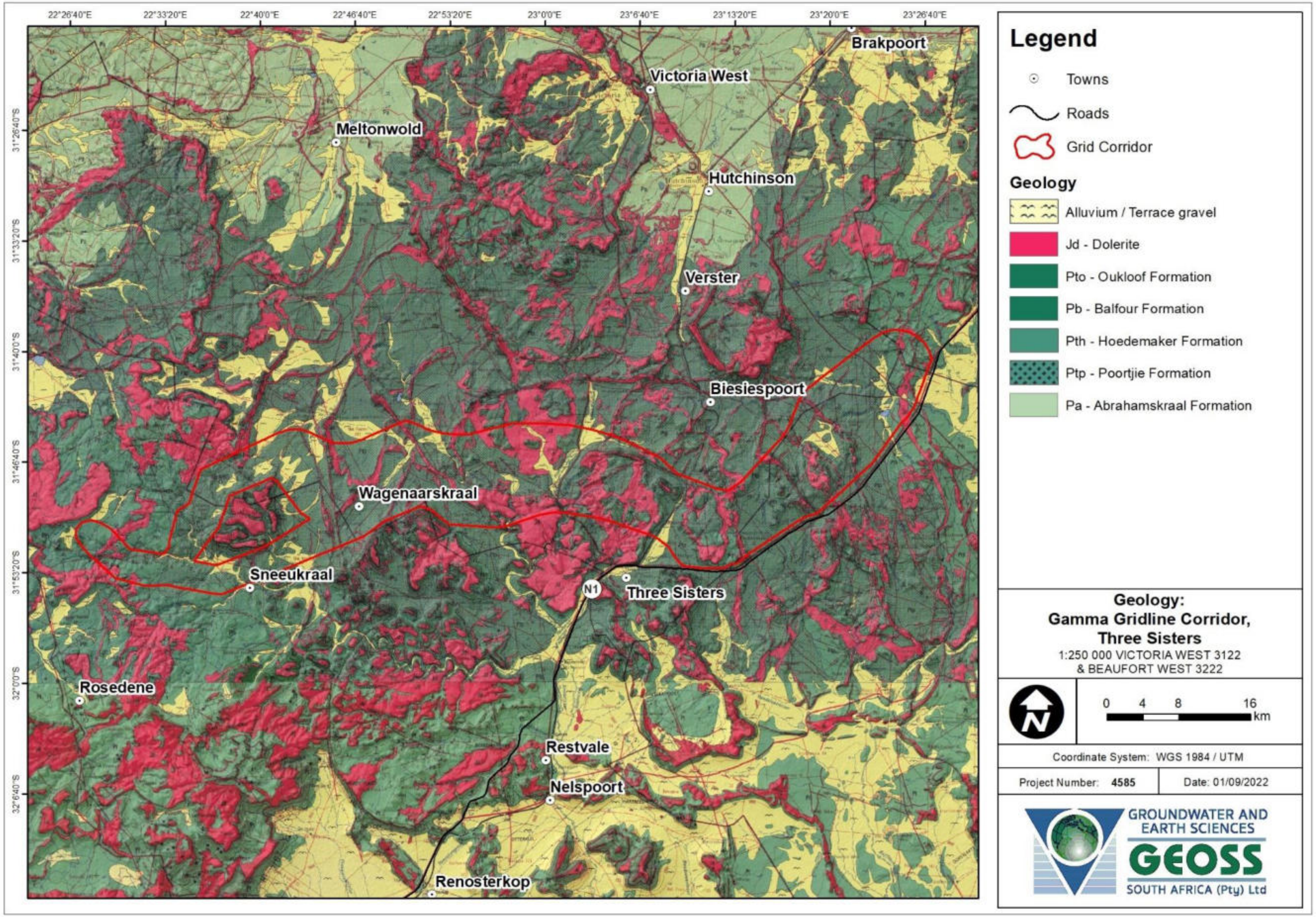
It should be noted that the above classifications are based on regional datasets, and therefore only provide an indication of conditions to be expected.



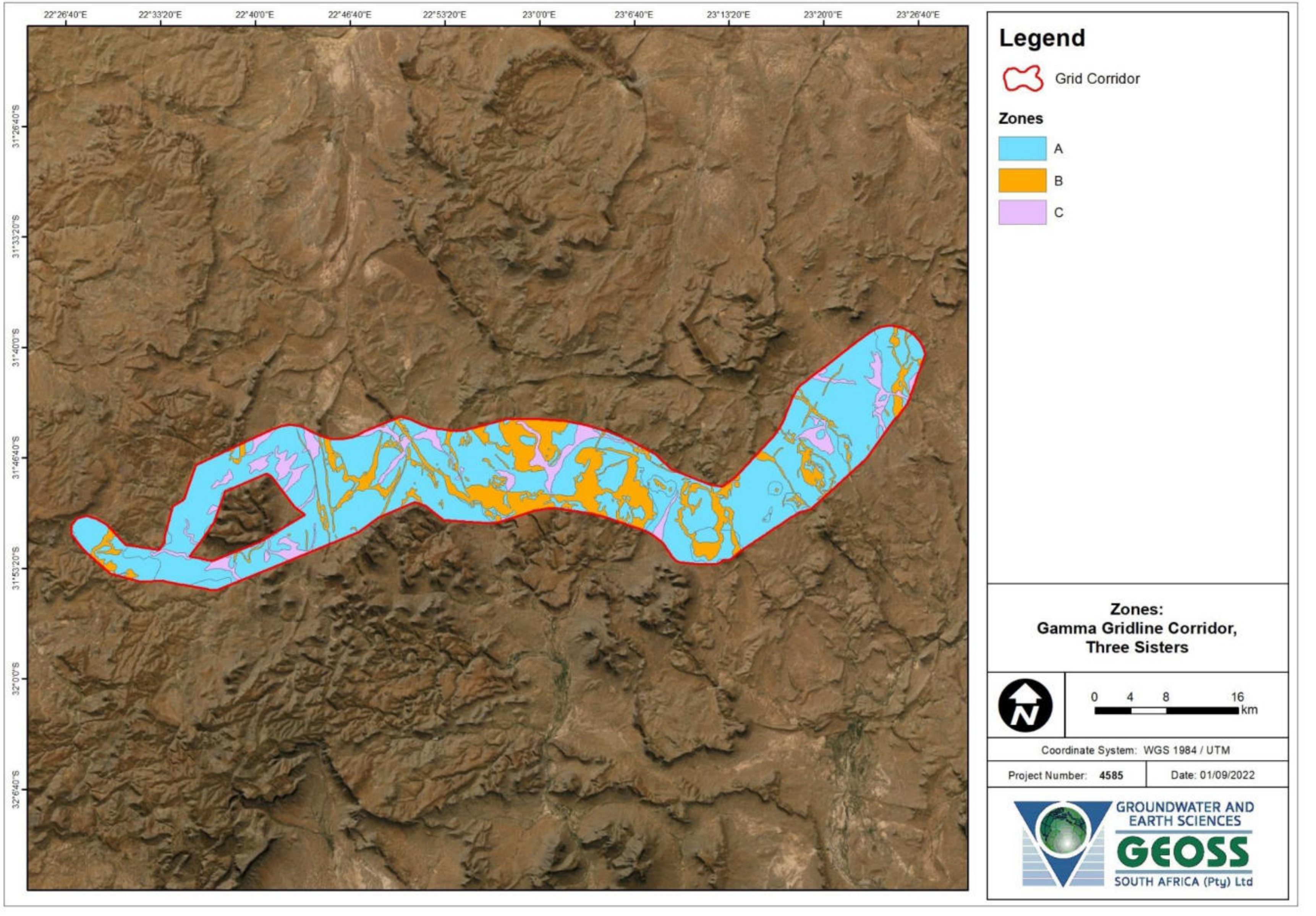
Map 2: Aerial map showing the approximate boundaries of the development.



Map 3: Aerial imagery overlain by slope classification (based on Stiff et al. 1996).



Map 4: Geological setting of the area (3122 – Victoria West, GCS 1989).



Map 5: Geological zones superimposed on aerial imagery.

2.10 Seismicity

It is common practise to design structures for seismic loads when the nominal peak acceleration exceeds a 0.1 g once every 475 years (Retief and Dunaiski, 2009). Retief and Dunaisk, (2009) delineated such regions in southern Africa, the approximate position of Three Sisters is shown in red on **Figure 5** relative to these regions. The region surrounding Three Sisters is shown to have a nominal peak ground of less than 0.1 g; therefore, typically seismic loads are not considered when designing structures in this area.

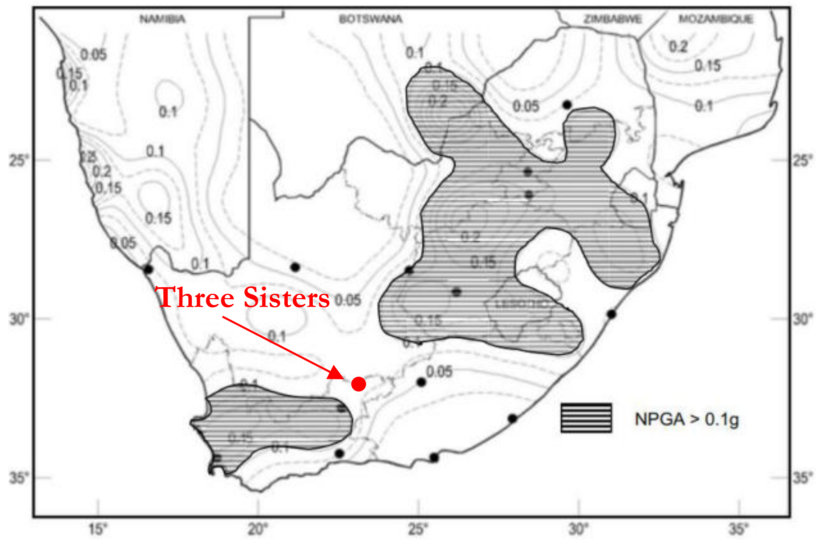


Figure 5: Zones in South Africa with nominal peak ground acceleration of more than 0.1 g for 10% in 50 years probability (after Retief and Dunaiski, 2009).

3. GEOTECHNICAL EVALUATION & RECOMMENDATIONS

3.1 General

Large pylons are subjected to high wind shear and thus dense soil with a moderate to high shear strength and bearing capacity is required for founding. Therefore, foundation conditions are a key constraint on engineering costs and affect project feasibility.

3.2 Drainage

There is little evidence of surface ponding across the site area. However, cognisance of this should be taken in further investigations, particularly in areas where slops are shown to be less than 2°.

There are regions which are characterised by erosion scars, this would have to be evaluated when the final development layout is known, and/or later during detailed geotechnical investigations.

3.3 Foundations

It is anticipated that Conventional foundations can be adopted in all areas of the site. The foundation conditions at the position of each pylon and structure that is to be developed within the study area would have to be investigated in more detail prior to construction.

3.4 Excavation

Excavation classes across the area will vary greatly. In and along the banks of drainage channels slightly thicker soil cover should be present allowing for easy excavation (SANS 1200). Where Dolerite is present, the excavation class will depend on the degree of weathering of the dolerite rock. Similarly, the excavation class of the mudrocks and sandstones of the Beaufort Group will vary depending on the degree of weathering.

In areas of unweathered medium hard rock pneumatic rock breakers and/or blasting may be required for installation of foundations, and where roads are to traverse challenging terrain.

3.5 Problem Soils

Problem soils are not expected in the study area. Some soils present may be slightly potentially expansive or have a potentially collapsible grain structure, but this is not expected to hamper development.

4. PRELIMINARY GEOLOGICAL & GEOTECHNICAL IMPACT ASSESSMENT

4.1 Impact of the Project on the Geological Environment during the Construction period

The impact of the project on the geological environment will predominantly relate to the impact that the development will have on the soils / rock units beneath the site through topsoil stripping, excavations for foundations (where required), trenching, the construction of access tracks and associated light infrastructure. Bulk earthworks, where required, for the construction of platforms and access tracks, may generate a significant impact on the soils and rocks where construction takes place.

The primary concern associated with geotechnical works is increased soil erosion on site, due to stripping of vegetation during the construction phase of the project. Removal of vegetation reduces infiltration, thereby increasing runoff yielding increased erosion. Further, compaction during earthworks reduce rainwater infiltration and increase surface runoff and increase erosion. The construction of paved and/or hard-surfaced areas increases runoff and often localises discharge of stormwater, which may lead to increased erosion and consequently loss of topsoil. Disturbance of the soil may extend beyond the footprint of the structures should such conditions persist for long periods of time, e.g. more than 10 years.

4.2 Geotechnical Impact Assessment

For ease of reference, separate impact rating tables have been presented in the subsequent sections for the construction phase, the operational phase and the decommissioning phase:

- Expected impacts on soil, during the construction phase, within the development area of the Gamma Gridline Corridor are presented in **Table 2**.
- Expected impacts on soil, during the operational phase, within the development area of the Gamma Gridline Corridor are presented in **Table 3**.
- Expected impacts on soil, during the decommissioning phase, within the development area of the Gamma Gridline Corridor are presented in **Table 4**.

Table 2: Impact table of soil erosion, contamination and destabilisation due to the Construction Phase.

Ref:	Geotech	1		
Project phase	Construction			
Impact	Geological Impact – soil erosion and contamination			
Description of impact	Stripping of vegetation during construction causing erosion; Excavation of rock; Machinery and earth moving plant causing spills contaminating soils.			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	• Only strip vegetation necessary for the next phase of construction.. • Install temporary drainage to divert stormwater away from active construction activities, where required. • Park within designated areas. • Stormwater Management Plan must be developed in the preconstruction phase and should detail the stormwater structures and management interventions that must be installed to manage the increase of surface water flows directly into any natural systems. Effective stormwater management must include effective stabilisation (gabions and Reno mattresses) of exposed soil. • Suitable stormwater management systems must be installed along roads and other areas and monitored during the first few months of use. Any erosion / sedimentation must be resolved through whatever additional interventions maybe necessary (i.e., extension, energy dissipaters, spreaders, etc). • No-Go Areas (areas that shall be excluded from any construction activity or general access by the construction team) within the development sites or servitudes shall be clearly indicated on maps and included with the micro-siting reports or attached to the EMPr. • Implement the generic EMPr for overhead transmission infrastructure, including: a. Where impacted through construction related activity, all sloped areas must be stabilised to ensure proper rehabilitation is affected and erosion is controlled; b. Sloped areas stabilised using designed structures or vegetation as specified in the design to prevent erosion of embankments. The contract design specifications must be adhered to and implemented strictly; c. The rehabilitation must be timed so that rehabilitation can take place at the optimal time for vegetation establishment; d. Where earthwork is being undertaken in close proximity to any watercourse, slopes must be stabilised using suitable materials, i.e. sandbags or geotextile fabric, to prevent sand and rock from entering the channel; and e. Appropriate rehabilitation and re-vegetation measures for the watercourse banks must be implemented timeously. In this regard, the banks should be appropriately and incrementally stabilised as soon as development allows. f. During the execution of the works, appropriate measures to prevent pollution and contamination of the riparian environment must be implemented e.g. including ensuring that construction equipment is well maintained; g. Provision must be made for refuelling at the storage area by protecting the soil with an impermeable groundcover. Where dispensing equipment is used, a drip tray must be used to ensure small spills are contained; and h. Where refuelling away from the dedicated refuelling station is required, a mobile refuelling unit must be used. Appropriate ground protection such as drip trays must be used.			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	impact will last between 1 and 5 years	Short term	impact will last between 1 and 5 years
Extent	Limited	Limited to the site and its immediate surroundings	Very limited	Limited to specific isolated parts of the site
Intensity	Low	Natural and/ or social functions and/ or processes are somewhat altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Likely	The impact may occur	Rare / improbable	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere
Confidence	Medium	Determination is based on common sense and general knowledge	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Low - negative**		**Very Low - negative**	
Comment on significance	The significance of the impact on the geological envrionment is considered low without mitigation and very low to negligible with appropriate mitigation measures.			

Table 3: Impact table of soil erosion, contamination and destabilisation due to the Operational Phase.

Ref:	Geotech	2		
Project phase	**Operation**			
Impact	Geological Impact – soil erosion and contamination			
Description of impact	Concentration of runoff and/or ponding due to hard surfaces, i.e. paved areas; reinstated and compacted ground surrounding turbines; borrow areas; and support structures. Concentration of natural drainage (and increasing runoff) due to paved areas. Increased siltation within natural water courses due to increased runoff and soil erosion.			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	• Investigate and confirm the geotechnical suitability of each pylon position prior to construction (i.e. that soil with an adequate bearing capacity is obtained beneath each footing). • Select pylon positions on 1:4 slopes or shallower, where possible. • Favour dolerite as a cement aggregate (as opposed to Karoo sandstones and mudstones). • Any road cuttings should be designed by an appropriately qualified professional. • Drainage in the region should be designed and managed appropriately. • Stormwater Management Plan must be developed in the preconstruction phase and should detail the stormwater structures and management interventions that must be installed to manage the increase of surface water flows directly into any natural systems. Effective stormwater management must include effective stabilisation (gabions and Reno mattresses) of exposed soil. • Suitable stormwater management systems must be installed along roads and other areas and monitored during the first few months of use. Any erosion / sedimentation must be resolved through whatever additional interventions maybe necessary (i.e., extension, energy dissipaters, spreaders, etc). • No regular maintenance activities to take place outside of the authorised footprint and all vehicles to remain on authorised roads and tracks. • Implement the generic EMPr for overhead transmission infrastructure, including: a. Sloped areas stabilised using design structures or vegetation as specified in the design to prevent erosion of embankments. The contract design specifications must be adhered to and implemented strictly.			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Long term	Impact will last between 10 and 15 years	Long term	Impact will last between 10 and 15 years
Extent	Local	Extending across the site and to nearby settlements	Limited	Limited to the site and its immediate surroundings
Intensity	Low	Natural and/ or social functions and/ or processes are somewhat altered	Negligible	Natural and/ or social functions and/ or processes are negligibly altered
Probability	Probable	The impact has occurred here or elsewhere and could therefore occur	Rare / improbable	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere
Confidence	Medium	Determination is based on common sense and general knowledge	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Low - negative**		**Very Low - negative**	
Comment on significance	The significance of the impact on the geological envrionment is considered low without mitigation and very low to negligible with appropriate mitigation measures.			

Table 4: Impact table of soil erosion, contamination and destabilisation due to the Decommissioning Phase.

Ref:	Geotech	3		
Project phase	**Decommissioning**			
Impact	Geological Impact – soil erosion and contamination			
Description of impact	Soil/rock destabilisation and erosion due to infrastructure removal. Spillages from vehicles.			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	• Vehicles should be well maintained, parked over drip trays/hard-surfaced areas, and parked within designated areas. • Land rehabilitation to near natural state, i.e. removal of foundations and backfilling of any resultant voids within the soil, as well as removal of hard surfaced areas. Replacement soil should be sourced locally to ensure homogeneity. • Reinstate natural topography where cut-to-fill embankments have been constructed. • Implement generic EMPr for overhead transmission infrastructure.			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	impact will last between 1 and 5 years	Short term	impact will last between 1 and 5 years
Extent	Limited	Limited to the site and its immediate surroundings	Very limited	Limited to specific isolated parts of the site
Intensity	Low	Natural and/ or social functions and/ or processes are somewhat altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Likely	The impact may occur	Rare / improbable	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere
Confidence	Medium	Determination is based on common sense and general knowledge	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Low - negative**		**Very Low - negative**	
Comment on significance	The significance of the impact on the geological envrionment is considered low without mitigation and very low to negligible with appropriate mitigation measures.			

Table 5: Impact table of soil erosion, contamination and destabilisation due to Cumulative Impacts

Project phase	**Cumulative Impacts**			
Impact	Soil erosion, contamination and destabilisation			
Description of impact	Widespread soil destabilisation, erosion and contamination due to agricultural activities and renewable energy development, including associated transmission infrastructure. Increased siltation within natural water courses due to increased runoff and soil erosion.			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	• Do not enter No-Go areas • Limit disturbance footprints to the area absolutely necessary for the project • Use existing access tracks where feasible • Observe limits of acceptable disturbance for areas of high, medium and low sensitivity • Implement the generic EMPr for overhead transmission infrastructure.			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Permanent	Impact may be permanent, or in excess of 20 years	Permanent	Impact may be permanent, or in excess of 20 years
Extent	Regional	Impacts felt at a regional / provincial level	Local	Impacts felt at a regional / provincial level
Intensity	High	Natural and/ or social functions and/ or processes are notably altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Low	The affected environment will not be able to recover from the impact - permanently modified
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Low	The resource is not damaged irreparably or is not scarce
Significance	**Medium - negative**		**Low - negative**	
Comment on significance	The region has experienced impacts on geological/geotechnical conditions (e.g. soil erosion) due to conventional agricultural practise in the area occurring for many years rendering the cumulative impact without mitigation negative medium. With mitigation, these cumulative impacts (of construction of the Gamma Gridline and agricultural practises) the significant rating is considered negative, but low.			

4.3 Alternatives

In the event of the development not proceeding (i.e. the no-go alternative being selected) project related geotechnical impacts would be avoided; however regional cumulative impacts (such as from agriculture and renewable energy development in the region would persist). As the project is located wholly within a Strategic Transmission Corridor (specifically identified to host high voltage transmission infrastructure), cumulative impacts from this infrastructure can be anticipated.

4.4 Summary of Impacts on Geological and Geotechnical Conditions

The impacts to be considered from a geotechnical standpoint for the proposed Gamma Gridline Corridor are contained in **Table 6**.

Table 6: Summary table of impacts on geological and geotechnical conditions

DESCRIPTION OF IMPACT	Overall Significance	
	No-Go Alternative	Preferred Alternative
Impact table of soil erosion, contamination and destabilisation due to the Construction Phase	Insignificant	Very Low
Impact table of soil erosion, contamination and destabilisation due to the Operational Phase	Insignificant	Very Low
Impact table of soil erosion, contamination and destabilisation due to the Decommissioning Phase.	Insignificant	Very Low
Impact table of soil erosion, contamination and destabilisation due to Cumulative Impacts	Medium	Very Low

5. CONCLUSIONS

This report summarises the results from a desktop specialist study which aimed to project a high-level overview of envisaged risks from a geotechnical standpoint, and provide broad recommendations for high-level designs. Based on the findings of this study, development should proceed provided the mitigation measures are implemented. The following conclusions can be drawn from the investigation:

1. The impact of the proposed development is expected to be very low and is anticipated to have little effect on the site from a geotechnical point of view.
2. Increased soil erosion may transpire as an impact of development, this may persist for the life of the project. However, the impact of this is expected to be very low and is anticipated to have little effect on the site from a geotechnical point of view.
3. Variable soil and rock conditions will exist across the site, broadly these have been divided as follows:
    a. Zone A – Karoo mudrocks and sandstones
    b. Zone B – Karoo dolerite
    c. Zone C – Areas of thicker soil cover (generally within drainage channels)
4. It is anticipated that conventional foundations can be employed for all structures. Karoo mudrock and sandstone should be avoided when selecting aggregates for concrete mixes.

5. Each proposed structures footprint would have to be investigated prior to compilation of final design.
6. Owing to the variable geologic and soil conditions across the proposed development area, the subgrade conditions will vary across the site. Dolerite has been proven to perform well as an aggregate for wearing courses. Dolerite has also been incorporated as an aggregate in concrete mixes.
7. The excavatability of the stratum on site are anticipated to variable, based on material composition and texture, the degree of weathering, and the nature of discontinuities within the rock and/or soil mass.
8. The seismicity in the region is considered low.
9. Intrusive centre-line investigations will be required to confirm the anticipated conditions at each of the final pylon positions.
10. Any road cuttings should be designed by an appropriately qualified professional.
11. GEOSS has endeavoured to highlight and characterise all potential geotechnical risks that are presented by the site that has been proposed for development. However, due to the anisotropic (variable) nature of earth materials, each point on the site will present results that differ. For this reason, it is considered of the utmost importance that the foundation excavations be inspected prior to casting to ensure that soil with an adequate bearing capacity is obtained beneath each footing. These works should be carried out by an appropriately qualified individual.

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7. APPENDIX A: IMPACT ASSESSMENT METHODOLOGY

The following points, tables and descriptions presented below were presented by Red Cap to be used as a guideline when assessing potential risks and impacts for the proposed development.

1. Definitions of terminology

CRITERIA	CATEGORY	DESCRIPTION	
Project phase	Construction		
	Operation		
	Decommissioning		
Mitigatability	Low	Mitigation does not exist; or mitigation will slightly reduce the significance of impacts	
	Medium	Mitigation exists and will notably reduce significance of impacts	
	High	Mitigation exists and will considerably reduce the significance of impacts	
Nature	Positive		1
	Negative		-1
Duration	Immediate	Impact will self-remedy immediately	1
	Brief	Impact will not last longer than 1 year	2
	Short term	impact will last between 1 and 5 years	3
	Medium term	Impact will last between 5 and 10 years	4
	Long term	Impact will last between 10 and 15 years	5
	On-going	Impact will last between 15 and 20 years	6
	Permanent	Impact may be permanent, or in excess of 20 years	7
Extent	Very limited	Limited to specific isolated parts of the site	1
	Limited	Limited to the site and its immediate surroundings	2
	Local	Extending across the site and to nearby settlements	3
	Municipal area	Impacts felt at a municipal level	4
	Regional	Impacts felt at a regional / provincial level	5
	National	Impacts felt at a national level	6
	International	Impacts felt at an international level	7
Intensity	Negligible	Natural and/ or social functions and/ or processes are negligibly altered	1
	Very low	Natural and/ or social functions and/ or processes are slightly altered	2
	Low	Natural and/ or social functions and/ or processes are somewhat altered	3
	Moderate	Natural and/ or social functions and/ or processes are moderately altered	4
	High	Natural and/ or social functions and/ or processes are notably altered	5
	Very high	Natural and/ or social functions and/ or processes are majorly altered	6
	Extremely high	Natural and/ or social functions and/ or processes are severely altered	7
Probability	Highly unlikely /	Expected never to happen	1
	Rare / improbable	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere	2
	Unlikely	Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur	3
	Probable	The impact has occurred here or elsewhere and could therefore occur	4
	Likely	The impact may occur	5
	Almost certain / Highly probable	It is most likely that the impact will occur	6
	Certain / definite	There are sound scientific reasons to expect that the impact will definitely occur	7
Confidence	Low	Judgement is based on intuition	
	Medium	Determination is based on common sense and general knowledge	
	High	Substantive supportive data exists to verify the assessment	
Reversibility	Low	The affected environment will not be able to recover from the impact - permanently modified	
	Medium	The affected environment will only recover from the impact with significant intervention	
	High	The affected environmental will be able to recover from the impact	
Resource irreplacea	Low	The resource is not damaged irreparably or is not scarce	
	Medium	The resource is damaged irreparably but is represented elsewhere	
	High	The resource is irreparably damaged and is not represented elsewhere	
Significance	Negligible		
	Minor		
	Moderate		
	Major		

Significance:	negative	positive
Very Low	Very Low - negative	Very Low - positive
Low	Low - negative	Low - positive
Medium	Medium - negative	Medium - positive
High	High - negative	High - positive

8. APPENDIX B: GEOTECHNICAL INFORMATION

8.1 Karoo Supergroup (Zone A)

Karoo sandstone is often not desirable in construction, e.g. as an aggregate, as it may cause concrete to deteriorate over time (Brink, 1977). In this regard, the following has been observed when making use of Karoo sandstones in construction (after Brink, 1983):

1. Deflection and shrinkage of reinforced members.
2. Corrosion of reinforcing steel.
3. Coincident cracking of concrete and reinforcement.
4. Surface crazing or pattern cracking.
5. Premature distress of roads constructed using aggregates derived from Karoo sandstones.

Control of material properties is required when making use of Karoo sandstones in construction.

Table 7: Strength and deformation characteristics of some Karoo Sandstones (Brink, 1983).

		Vryheid Formation*			Estcourt Formation			
		UCS (MPa)	* E_t (GPa)	Bulk density (kg/m^3)	UCS (MPa)	$E_{t(50)}$ (GPa)	Poisson's ratio ν	Bulk density (kg/m^3)
Maximum	x_m	44,7	11,364	2 493	271	13,4	0,28	2 660
Minimum	x_m	8,6	0,621	2 356	57	5,9	0,06	2 350
Mean	$\bar{x}$	27,0	2,426	2 421	116	9,9	0,14	2 473
Number of tests	n	17	17	17	20	9	9	3
Standard deviation	S	12,3	2,9	43,6	56,5	2,43	0,08	164
Coefficient of variation	S/$\bar{x}$	0,45	1,18	0,02	0,49	0,25	0,57	0,07

UCS = Unconfined compressive strength
E_t = Tangent modulus
$E_{t(50)}$ = Tangent modulus at 50 per cent ultimate strength
*Data provided by W. J. Neely.

Table 8: Geotechnical properties of Ecca Group sandstone at Matimba Power Station (Brink, 1983).

		Density (kg/m^3)	UCS (MPa)	Secant modulus (GPa)	Poisson's ratio ν	Point load index (MPa)
Maximum	x_M	2 452,0	83,2	49,7	0,21	7,2
Minimum	x_m	2 332,8	46,6	19,6	0,11	0,1
Mean	$\bar{x}$	2 394,6	69,1	36,1	0,16	2,9
Number of tests	n	19	19	19	19	20
Standard deviation	S	31,7	8,9	10	0,04	1,9
Coefficient of variation	S/$\bar{x}$	0,01	0,13	0,28	0,25	0,66

Table 9: Drying and shrinkage determinations on some sandstones of the Beaufort Group (Brink, 1983).

Subgroup	Locality	Reference	Depths below surface	Linear shrinkage per cent	
				Specimen cut parallel to bedding	Specimen cut 90° to bedding
Adelaide	Graaff-Reinet municipal quarry	Stutterheim (1954)	Quarry face near surface	0,038	0,058
Adelaide	Adendorp quarry (near Graaff-Reinet)	Stutterheim (1954)	Quarry face near surface	0,23	0,84
Tarkastad	Cores from borehole situated at: x = 324,300 y = 1 235,350 approx. lat. 31° 15′ S approx. long. 25° 30′ E (cores supplied by Orange–Fish Tunnel Consultants; tests by NBRI–CSIR	Pienaar (1966)	7 m 48 m 116 m 156 m 222 m 311 m		0,12 0,12 0,07 0,16 0,095 0,11
Adelaide	Aberdeen	Roper (1959)	Near surface	0,024	
Tarkastad	Queenstown	Roper (1959)	Near surface	0,12	
Adelaide	Beaufort West	Roper (1959)	Near surface	0,04*	

* Quartzitic sandstone.

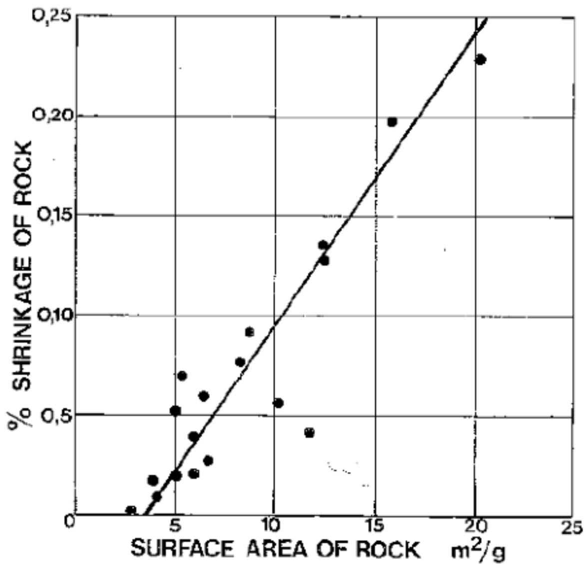

Figure 6: Relation between shrinkage and surface area for a variety of rocks including Karoo sandstone (Brink, 1983).

Table 10: Road construction characteristics of some Karoo sandstones (Brink, 1983).

		Molteno, Elliot and Clarens Formations*			Laingsburg Formation**		
		CBR (%)	CBR +3% cement (%)	10% FACT (kN)	ACV (%)	10% FACT (kN)	Treton (%)
Maximum	x_M	125	417	136	46	410	72,9
Minimum	x_m	24	157	7	9,7	160	16,4
Mean	$\bar{x}$	68	234	46	17,3	282	31,4
No. of tests	n	10	7	10	21	10	21
Standard deviation	S	38	86	35,4	7,7	84,4	13,7
Coefficient of variation	S/$\bar{x}$	0,56	0,37	0,77	0,45	0,23	0,44

* Partly after Holleman (1975)
**Data provided by Ninham Shand Inc

Table 11: Changes in engineering properties of Adelaide Subgroup sandstone aggregates under traffic (Brink, 1983).

		PI		Percentage coarse sand (cs) 0,425mm <cs<2mm		Percentage smaller than 75μm		10% FACT wet/dry ratio
		(a)*	(b)†	(a)	(b)	(a)	(b)	(b)
1. Road in vicinity of East London								
Maximum	x_M	6	8	50	39	12	13	
Minimum	x_m	2	4	24	26	2	7	
Mean	$\bar{x}$	4,3	6,0	33,2	31,0	7,9	9,3	
Number of tests	n	156	32	158	32	158	32	
Standard deviation	S	0,94	1,20	4,14	3,0	1,30	2,53	
Coefficient of variation	S/$\bar{x}$	0,22	0,20	0,12	0,10	0,16	0,27	
2. Road in vicinity of Richmond								(115/215) (53%)
Maximum	x_M	6	9	42	35	11	13	
Minimum	x_m	3	7	26	25	6	7	
Mean	$\bar{x}$	5,2	7,6	31,9	30,8	8,3	9,2	
Number of tests	n	10	5	10	5	10	5	
Standard deviation	S	1,0	1,3	4,4	4,5	1,5	2,4	
Coefficient of variation	S/$\bar{x}$	0,19	0,17	0,14	0,15	0,18	0,26	
3. Road in vicinity of Colesberg								(75/185) (40%)
Maximum	x_M	7	10	47	39	14	19	
Minimum	x_m	5	7	24	18	5	9	
Mean	$\bar{x}$	6,0	9,0	35,5	29,9	8,6	14,0	
Number of tests	n	28	7	28	14	28	7	
Standard deviation	S	0,79	1,15	5,98	5,07	1,93	3,65	
Coefficient of variation	S/$\bar{x}$	0,13	0,13	0,17	0,17	0,22	0,26	
4. Road in vicinity of Noupoort								
Maximum	x_M	6	13	48	56	9	13	
Minimum	x_m	3	6	33	30	5	6	
Mean	$\bar{x}$	4,2	9,8	40,5	38,6	6.6	10,2	
Number of tests	n	13	12	13	12	13	12	
Standard deviation	S	1,07	1,76	3,86	7,3	1,12	2,25	
Coefficient of variation	S/$\bar{x}$	0,25	0,18	0,10	0,19	0,17	0,22	

* (a) Construction control data
† (b) Data obtained during later investigations after distress occurred

8.2 Dolerite (Zone B)

Dolerite has been used extensively in road construction; however, material from chill zones (surrounding metamorphosed rocks) are usually undesirable due to low adhesion properties (Brink, 1983). Dolerite has also been used successfully as a concrete aggregate (Brink, 1983).

Table 12: Engineering properties of very hard rock dolerite from various locations (Brink, 1983).

Locality	Percussion drill-bit penetration rate (minutes/ 200 mm)	Loss of drill-bit length (mm/10 minutes)	Loss of drill-bit gauge (mm/10 minutes)	Abrasiveness (mass loss) (g)	Energy consumed during rod-milling (kWh/kg)	Protodyakonov strength (MPa)
1. Hilton, Pietermaritzburg	—	—	—	53,47	$4,87 \times 10^{-3}$	—
2. Mountain Rise, Pietermaritzburg	—	—	—	67,59	$3,33 \times 10^{-3}$	31,66
3. Kinross	—	—	—	74,71	$2,45 \times 10^{-3}$	34,53
4. Standerton	15,4	0,15	0,22	69,32	$4,87 \times 10^{-3}$	30,95
5. Cradock	—	—	—	64,87	$2,20 \times 10^{-3}$	23,39
6. Beaufort West	12,2	0,26	0,15	61,25	$3,40 \times 10^{-3}$	35,88
7. Bloemfontein	16,2	0,22	0,17	71,20	$3,28 \times 10^{-3}$	32,92
8. Hendrik Verwoerd dam site	13,7	0,19	0,20	61,26	$3,75 \times 10^{-3}$	33,51
9. P.K. le Roux dam site	12,1	0,10	0,13	65,94	$3,10 \times 10^{-3}$	29,92

Table 13: Strength properties of fresh dolerite from various locations (Brink, 1983).

			Site 1 Hilton quarry, Pietermaritz-burg	Site 2 Mountain Rise quarry, Pietermaritz-burg	Site 3 Kinross road cutting	Site 4 Borchards Crushers quarry, Standerton	Site 5 South African Railways quarry, Cradock	Site 6 South African Railways National Roads quarry, Beaufort West
Unconfined Compressive Strength (MPa)	Maximum	x_M	540	368	265	489	363	497
	Minimum	x_m	426	269	233	222	173	298
	Mean	$\bar{x}$	472	336	267	370	293	406
	Number of tests	n	6	9	6	6	15	27
	Standard deviation	S	42,32	33,77	21,34	119,04	53,51	57,66
	Coefficient of variation	$S/\bar{x}$	0,090	0,100	0,060	0,322	0,183	0,142
Tensile Strength (MPa)	Maximum	x_M	38,9	29,8	25,9	35,2	30,6	42,5
	Minimum	x_m	34,9	16,3	22,7	28,2	15,3	22,5
	Mean	$\bar{x}$	37,6	26,3	23,8	30,4	24,4	31,4
	Number of tests	n	6	9	6	6	15	34
	Standard deviation	S	1,47	4,36	1,40	4,12	4,12	4,20
	Coefficient of variation	$S/\bar{x}$	0,039	0,166	0,059	0,136	0,169	0,134
Shear box Strength (MPa)	Maximum	x_M	34,2	33,1	32,2	37,9	36,0	47,2
	Minimum	x_m	14,5	25,6	14,2	25,2	19,2	18,6
	Mean	$\bar{x}$	28,1	29,8	25,0	32,4	28,6	30,3
	Number of tests	n	7	9	6	6	15	27
	Standard deviation	S	8,02	2,59	6,24	4,80	4,50	7,13
	Coefficient of variation	$S/\bar{x}$	0,285	0,087	0,250	0,148	0,157	0,235

			Site 7 Olive Hill quarry, Bloemfontein	Site 8 Hendrik Verwoerd dam			Site 9 P.K. le Roux dam	
				A	B	C	A	B
				Excavations for wall and abutments	Quarry A	Quarry B	Lower quarry	Left flank
Unconfined Compressive Strength (MPa)	Maximum	x_M	386	551	527	465	360	479
	Minimum	x_m	254	133	164	285	238	326
	Mean	$\bar{x}$	303	388	382	391	321	392
	Number of tests	n	15	82	49	28	15	18
	Standard deviation	S	42,50	66,56	67,68	45,28	29,10	56,80
	Coefficient of variation	$S/\bar{x}$	0,140	0,172	0,177	0,116	0,091	0,145
Tensile Strength (MPa)	Maximum	x_M	31,6	46,3	43,5	39,1	31,9	32,7
	Minimum	x_m	23,1	9,5	19,5	26,9	11,9	26,3
	Mean	$\bar{x}$	27,0	30,5	31,7	31,9	25,9	29,9
	Number of tests	n	15	81	50	28	15	18
	Standard deviation	S	2,24	5,67	4,29	2,60	5,12	1,83
	Coefficient of variation	$S/\bar{x}$	0,083	0,186	0,135	0,081	0,198	0,061
Shear box Strength (MPa)	Maximum	x_M	30,5	66,3	49,7	59,2	34,8	24,3
	Minimum	x_m	18,0	16,5	14,3	16,6	16,8	18,8
	Mean	$\bar{x}$	22,7	32,1	32,1	35,9	24,2	21,4
	Number of tests	n	15	81	49	28	15	18
	Standard deviation	S	3,26	9,39	7,95	9,71	4,60	1,76
	Coefficient of variation	$S/\bar{x}$	0,144	0,292	0,248	0,270	0,190	0,082

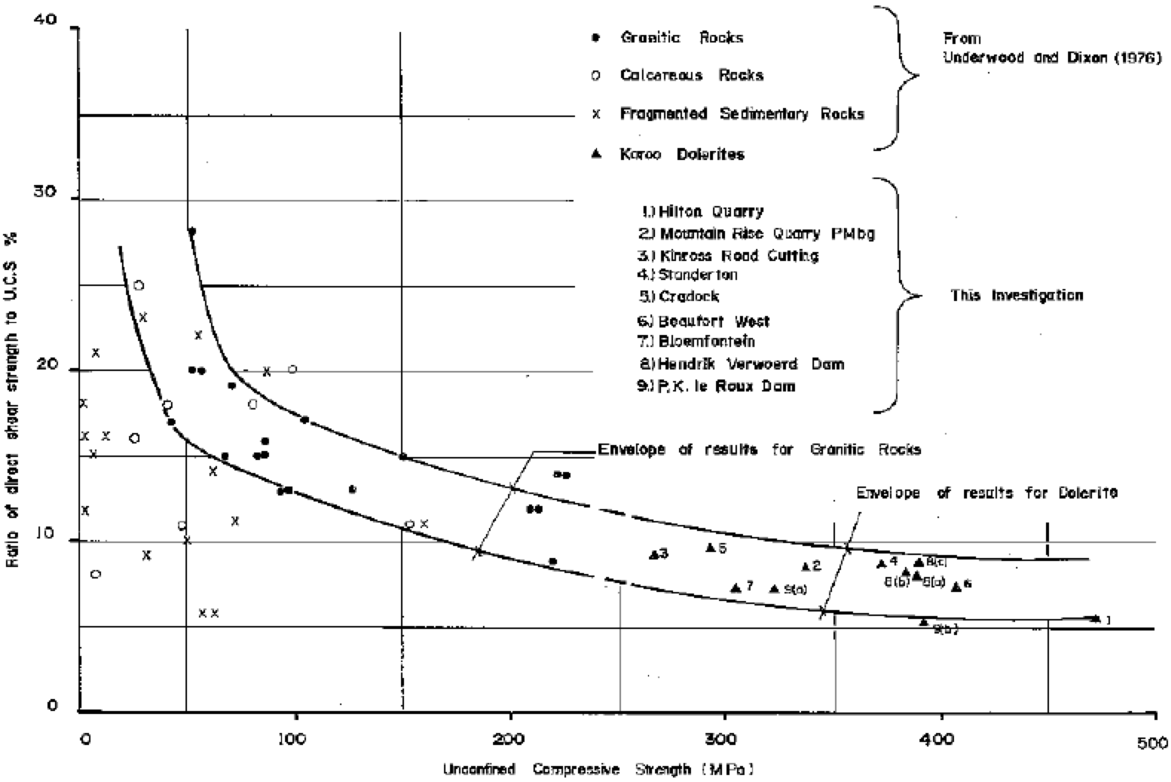

Figure 7: Variations of the shear strength to unconfined compressive strength ratio with the UCS for dolerite compared with other rock types (Brink, 1983).

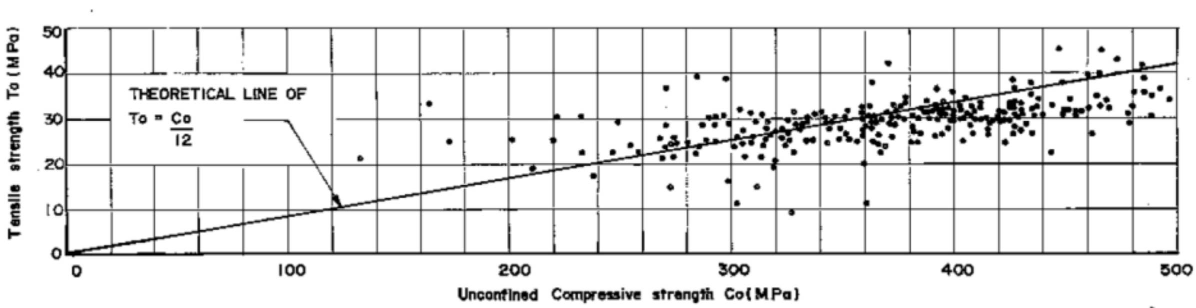

Figure 8: Relation between tensile strength and UCS of fresh dolerite specimen from South Africa (Brink, 1983).

Table 14: Weathering classes and characteristics of dolerite in South Africa (Brink, 1983).

Proposed class	Characteristics	Excavation	Grade of weathering according to AEG (1978)	Weinert (1964, 1980)
Solid dolerite	Fresh rock: hard to extremely hard, variably jointed; <15% weathered material in whole rock mass	Blasting	W1 or W2	Fresh
Fractured dolerite	Fresh angular boulders of <0,5 m diameter, moderately thick zones of weathered material in joint spaces	Blasting or very heavy ripping depending on mass and type of joint fillings	W1 or W2 for boulders, otherwise W3 or W4	Boulders fresh, joint fillings weathered or highly weathered
Boulder dolerite	Boulders with rounded edges and corners and >0,5 m diameter are fresh and strong; up to 1 m thick zones of intensely weathered material between boulders. 'Stacks' of loose boulders to be included in this class	Blasting for boulders, otherwise rippable; bulldozing for 'stacks' of loose boulders	Boulders W1, otherwise W4 or W5	Boulders fresh, otherwise highly weathered (mostly highly decomposed)
Gravel dolerite	Gravelly with solid particles <75 mm diameter. Particles vary from fresh to very weathered material	Can usually be ripped or even picked; blasting rarely required	W4	Highly weathered (mostly highly disintegrated)
Granular (sugar) dolerite	Fine gravelly to occasionally clayey; remnants of boulders with weathered 'onion' shells. May include calcrete where N>5 and ferricrete where N<5	Normally picking, bulldozing or shovelling, occasionally ripping	W4 or W5	Highly weathered (highly disintegrated where N>5, highly decomposed where N<5)
Residual dolerite soil	Soft, homogeneous sandy to clayey soil	Shovelling, bulldozing or picking	W5	Residual soil (sand where N>5, clay where N<5), occasionally highly weathered

Table 15: Influence of climate on selected physical properties of weathering classes of dolerites (Brink, 1983).

Climatic N-value			N = <2			N = 2–5			N = ~5		
			%<0,075 mm	PI	Mod AASHO Max. dens. (kg/m³)	%<0,075 mm	PI	Mod AASHO Max. dens. (kg/m³)	%<0,075 mm	PI	Mod AASHO Max. dens. (kg/m³)
Gravel dolerite	Maximum	x_M	32	28	—	15	19	—	23	17	2 220
	Minimum	x_m	6	8	—	5	1	—	9	6	1 719
	Mean	$\bar{x}$	25	15	—	9	13	—	16	12	2 098
	Number of tests	n	6	6	—	3	12	—	15	15	7
	Standard deviation	s	13,4	6,3	—	4,3	8,3	—	3,6	1,8	176
	Coefficient of variation	$s/\bar{x}$	0,53	0,42	—	0,48	0,64	—	0,23	0,15	0,08
Granular dolerite	Maximum	x_M	85	42	2 006	60	21	2 098	49	22	2 254
	Minimum	x_m	10	8	1 573	10	3	1 970	14	3	1 767
	Mean	$\bar{x}$	37	18	1 790	27	13	1 986	31	9	2 026
	Number of tests	n	23	21	6	15	21	5	54	53	22
	Standard deviation	s	16,9	8,2	159	10,9	4,5	140	11,4	4,2	131
	Coefficient of variation	$s/\bar{x}$	0,46	0,45	0,09	0,40	0,34	0,07	0,37	0,47	0,06
Residual dolerite soil	Maximum	x_M	95	50	—	94	33	1 914	74	33	1 978
	Minimum	x_m	50	11	—	48	3	1 514	44	8	1 621
	Mean	$\bar{x}$	64	23	1 620	71	18	1 673	59	18	1 831
	Number of tests	n	59	23	1	33	33	7	37	37	11
	Standard deviation	s	12,1	10,36	—	17,5	4,4	136	7,7	7,2	105
	Coefficient of variation	$s/\bar{x}$	0,19	0,46	—	0,25	0,25	0,08	0,13	0,40	0,06

Climatic N-value			N = 5–10			N = ~10			N = >10		
			%<0,075 mm	PI	Mod AASHO Max. dens. (kg/m³)	%<0,075 mm	PI	Mod AASHO Max. dens. (kg/m³)	%<0,075 mm	PI	Mod AASHO Max. dens. (kg/m³)
Gravel dolerite	Maximum	x_M	16	32	2 275	21	18	2 323			
	Minimum	x_m	1	2	2 034	3	0	2 066			
	Mean	$\bar{x}$	7	12	2 146	6	8	2 211		No Results	
	Number of tests	n	35	35	5	33	33	12			
	Standard deviation	s	3,1	6,2	88	3,51	4,21	91			
	Coefficient of variation	$s/\bar{x}$	0,44	0,52	0,04	0,55	0,51	0,04			
Granular dolerite	Maximum	x_M	51	29	2 227	24	10	2 195	15	14	2 370
	Minimum	x_m	2	1	1 810	2	0	1 970	1	1	1 842
	Mean	$\bar{x}$	13	9	2 082	9	4	2 082	4	4	2 163
	Number of tests	n	80	80	13	61	61	16	218	216	80
	Standard deviation	s	12,8	6,7	142	5,48	2,82	57	1,59	3,06	114
	Coefficient of variation	$s/\bar{x}$	0,98	0,74	0,07	0,08	0,07	0,03	0,40	0,77	0,05
Residual dolerite soil	Maximum	x_M	56	29	2 291	39	26	2 370	35	18	2 355
	Minimum	x_m	5	1	1 826	4	1	1 810	2	1	1 954
	Mean	$\bar{x}$	25	12	2 066	18	11	2 082	15	6	2 243
	Number of tests	n	103	103	11	52	51	13	261	261	89
	Standard deviation	s	10,2	6,2	121	8,90	5,60	140	5,81	2,91	87
	Coefficient of variation	$s/\bar{x}$	0,41	0,52	0,06	0,11	0,30	0,07	0,39	0,49	0,04

Table 16: Concrete making properties of dolerite (Brink, 1983).

		Specific gravity (or relative density)	Loose bulk density (coarse) (kg/m³)	Loose bulk density (fine) (kg/m³)	Mortar shrinkage (%)	10% FACT (kN)
Maximum	x_M	3,05	1 500	1 700	0,070	340
Minimum	x_m	2,85	1 350	1 350	0,037	180
Mean	$\bar{x}$	2,94	1 420	1 520	0,053	300
Number of tests	n	210	120	46	31	37
Standard deviation	S	0,037	29,24	79,19	0,008	37,65
Coefficient of variation	$S/\bar{x}$	0,013	0,021	0,052	0,152	0,125

Table 17: Deformation characteristics (expressed in MPa) for different weathering classes of dolerite from South Africa as determined by a GB Menard pressure meter and jacking tests (Brink, 1983).

		Residual dolerite soil	Granular dolerite	Gravel dolerite	Boulder dolerite	Fractured dolerite	Fresh dolerite	
							From H.F. Verwoerd dam	From P.K. le Roux dam
Degree of weathering		W5	W4/W5	W4	W3	W2	W1	W1
Maximum	x_M	11,7	200,7	923,3	1 302,0	3 215,5	9 076	19 760
Minimum	x_m	7,3	89,4	404,7	1 071,6	2 034,9	5 615	9 062
Mean	$\bar{x}$	9,2	158,3	593,2	1 156,5	2 625,2	7 692	12 587
Number of tests	n	3	4	3	3	2	18	15

(Final page)

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Desktop Geotechnical Specialist Study for Gamma Gridline Corridor, Three Sisters.

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
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4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
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473 Steve Biko Road
Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

1. SPECIALIST INFORMATION

Specialist Company Name:	GEOSS South Africa			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	3	Percentage Procurement recognition	110%
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E-mail:	shane@geoss.co.za / info@geoss.co.za			

2. DECLARATION BY THE SPECIALIST

I, Shane Tabor Teek, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

GEOSS South Africa

Name of Company:

04 November 2022

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, Shane Tabor Teek, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

GEOSS South Africa

Name of Company

04 November 2022

Date

Signature of the Commissioner of Oaths

04 November 2022

Date