FINAL BASIC ASSESSMENT REPORT

Basic Assessment for the proposed development of the up to 100 MW Padloper Solar PV Facility 6 (i.e., Padloper PV 6), the proposed development of 132 kV Electrical Grid Infrastructure between the proposed Padloper PV 4 and the proposed Padloper PV 6 (i.e., Padloper EGI 6), and their associated infrastructure, near Murraysburg in the Western Cape Province

APPENDIX D.10:
Geotechnical





Desktop Geotechnical Study for the Proposed Padloper Solar Cluster near Murraysburg, Western Cape and Northern Cape.

REPORT:	***PREPARED BY:***
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Revision 1.0

01 July 2023

GROUNDWATER AND EARTH SCIENCES
GEOSS
SOUTH AFRICA (Pty) Ltd

EXECUTIVE SUMMARY

GEOSS South Africa (Pty) Ltd (GEOSS) was appointed by African Clean Energy Developments (Pty) Ltd (ACED) (hereafter referred to as the "Project Developer") on behalf of Padloper PV (Pty) Ltd (hereafter referred to as the "Project Applicant") to undertake a desktop Geotechnical Assessment for the proposed Padloper Solar Photovoltaic (PV) Cluster in the Northern Cape and Western Cape provinces near Murraysburg. To connect to the existing Gamma Main Transmission Substation (MTS), ACED is proposing to develop seven (7) Solar Photovoltaic (PV) facilities with a capacity ranging between 100 MW and 250 MW each along with the associated 7 x 132 kV overhead power lines and their associated infrastructure.

The Geotechnical Study characterises the geotechnical conditions for the Proposed Padloper Solar Cluster, i.e., Padloper Solar Facilities 1-7. The primary objective of the 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. The information that has been provided is for planning purposes only and forms part of the environmental Basic Assessment (BA) processes for each of the projects making up the Padloper Solar Cluster.

A summary of the pertinent findings of the Geotechnical Study is 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 sandstone, siltstone and mudrock.
    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 geological 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 to be low.
8. Intrusive centre-line investigations should be conducted 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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TABLE OF CONTENTS

1. INTRODUCTION 1
1.1 Terms of Reference 1
1.2 Objectives and Methodology 1
1.3 Proposed Development 1
1.4 Scope and Limitations of Assessment 2
1.5 Information Available 3
1.6 Assessment Methodology 3
1.7 Assumptions and Limitations 3
2. SETTING 4
2.1 Site Location and Description 4
2.2 Topography and Site Features 4
2.3 Climate 6
2.4 Weinert 'N' Value 7
2.5 Geology 8
2.5.1 Geological Zones 8
2.6 Geotechnical Properties and Engineering Geology 8
2.6.1 Sandstones, Siltstones and Mudstones (Zone A) 8
2.6.2 Dolerite (Zone B) 9
2.6.3 Quaternary Sediments (Zone C) 9
2.7 Expected soil profile 9
2.8 Slope Classification 10
2.9 Hydrogeology 10
2.10 Seismicity 15
3. GEOTECHNICAL EVALUATION AND RECOMMENDATIONS 15
3.1 General 15
3.2 Drainage 15
3.3 Foundations 16
3.4 Potential Development Constraints 16
3.5 Excavation 16
3.6 Problem Soils 16
4. PRELIMINARY GEOLOGICAL AND GEOTECHNICAL IMPACT ASSESSMENT 16
4.1 Impact of the Project During Construction Phase 17
4.2 Impact of the Project During Operational Phase 21
4.3 Impact of the Project During Decommissioning Phase 24
4.4 Cumulative Impacts 27
5. IMPACT ASSESSMENT SUMARY 35

6. LEGISLATIVE AND PERMIT REQUIREMENTS 35
6.1 Loss of Geological Material (Soil Erosion) 35
6.2 Contamination of Geologic Materials 35
7. RECOMMENDATIONS 36
8. CONCLUSIONS 37
9. REFERENCES 38
10. APPENDIX A: IMPACT ASSESSMENT METHODOLOGY 40
11. APPENDIX B: GEOTECHNICAL INFORMATION 45
11.1 Karoo Supergroup (Zone A) 45
11.2 Dolerite (Zone B) 48
11.3 Quaternary Sediments (Zone C) 53
12. APPENDIX C: SITE RECONNAISSANCE PHOTOGRAPHS 54
13. APPENDIX D: SPECIALIST DECLARATION 61

LIST OF MAPS AND FIGURES

Map 1: Locality map showing the general location of the proposed Padloper Study Area and surrounds 5
Map 2: Aerial map showing the approximate boundaries of the development. 11
Map 3: Aerial imagery overlain by slope classification (based on Stiff *et al.* 1996). 12
Map 4: Geological setting of the area (3122 – Victoria West, 3124 – Middelburg, 3222 – Beaufort West and 3224 – Graaf-Reinet, GCS 1989) NOTE: Abrahamskraal formation subsequently remapped as Balfour formation. 13
Map 5: Geological zones superimposed on aerial imagery. 14

Figure 1: Monthly average air temperature for the study area (Schulze, 2009) 6
Figure 2: Monthly average air temperature for the study area (Schulze, 2009) 6
Figure 3: Climatic 'N' value = 5 plotted for southern Africa (after Weinert, 1967). 7
Figure 4: Elements of typical Karoo hillslopes and anticipated soil profiles (Brink, 1982) 9
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). 15
Figure 6: Guide to assessing risk/impact significance as a result of consequence and probability. 44
Figure 7: Relation between shrinkage and surface area for a variety of rocks including Karoo sandstone (Brink, 1983). 46
Figure 8: Variations of the shear strength to unconfined compressive strength ratio with the UCS for dolerite compared with other rock types (Brink, 1983). 50
Figure 9: Relation between tensile strength and UCS of fresh dolerite specimen from South Africa (Brink, 1983). 50
Figure 10: Photo taken of surficial material near MBH2. 55
Figure 11: Typical spiny scrub and shrubs supported by fine gravelly sand substrate on Farm 7/46 Middelvlei. 56

Figure 12: Drainage channel encountered in central area within Farm 7/46 Middelvlei. 56
Figure 13: Fractured/jointed nature (annotated in red) of mudrocks and shales of the Karoo Supergroup observed near D1. 57
Figure 14: Surface materials consisting of angular sandy fine gravels (colluvium) with occasional rounded dolerite cobbles encountered near MBH22. 57
Figure 15: Well developed soil profile encountered in drainage channel north of MBH21; note lenses of angular coarse gravel suspended in sand-dominated soil profile..... 58
Figure 16: Typical plateau landforms separating often wide drainages, photograph captured on road between Murraysburg and Richmond..... 58
Figure 17: Surface texture of Murraysburg-Aberdeen/Nelspoort road that appears to be well-maintained, captured south of Murraysburg. Aggregate mainly comprises angular dolerite fragments that appears to be well-graded, with some shales and siltstone fragments (which have presumably been blended to achieve adequate binding of the surface). 59
Figure 18: Close-up of dolerite and mudstone fragments picked out of gravel road. 59
Figure 19: Example of typical woolsack weathering of dolerite outcrops, encountered across the Study Area. 60

LIST OF TABLES

Table 1: Geological formations within the study area (CGS, 1991). 8
Table 2: Impact Summary Tables: Construction Phase 18
Table 3: Impact Summary Tables: Operational Phase 22
Table 4: Impact Summary Tables: Decommissioning Phase 25
Table 5: Cumulative Impact Summary Tables: Construction Phase 28
Table 6: Cumulative Impact Summary Tables: Operational Phase 31
Table 7: Cumulative Impact Summary Tables: Decommissioning Phase 33
Table 8: Overall Impact Significance (Post Mitigation) 35
Table 9: Strength and deformation characteristics of some Karoo Sandstones (Brink, 1983)..... 45
Table 10: Geotechnical properties of Ecca Group sandstone at Matimba Power Station (Brink, 1983). 45
Table 11: Drying and shrinkage determinations on some sandstones of the Beaufort Group (Brink, 1983). 46
Table 12: Road construction characteristics of some Karoo sandstones (Brink, 1983). 47
Table 13: Changes in engineering properties of Adelaide Subgroup sandstone aggregates under traffic (Brink, 1983)..... 47
Table 14: Engineering properties of very hard rock dolerite from various locations (Brink, 1983). 48
Table 15: Strength properties of fresh dolerite from various locations (Brink, 1983)..... 49
Table 16: Weathering classes and characteristics of dolerite in South Africa (Brink, 1983). 51
Table 17: Influence of climate on selected physical properties of weathering classes of dolerites (Brink, 1983). 52
Table 18: Concrete making properties of dolerite (Brink, 1983). 52
Table 19: 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). 53

ABBREVIATIONS AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ACED	African Clean Energy Developments (Pty) Ltd
BH	Borehole
CGS	Council for Geoscience
CSIR	Council for Scientific and Industrial Research
EC	electrical conductivity
EIA	Environmental Impact Assessment
Eskom	Electric Supply Commission
g	Gravity
GEOSS	Geohydrological and Spatial Solutions South Africa
kV	kilovolt
L/s	litres per second
m	metres
mamsl	metres above mean sea level
mm	milimetres
MOD	Modified AASHTO
MPa	Megapascal
mS/m	milli-Siemens per metre
PV	Photovoltaic
MTS	Main Transmission Substation
BESS	Battery Energy Storage System
ESF	Energy Solar Facility
NPGA	Nominal Peak Horizontal Ground Acceleration

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).

Problem Soil: A soil which may exhibit adverse geotechnical conditions for structures, e.g. unstable slopes or inadequate, bearing capacity or potentially expansive soils (i.e. clays that expand when wet) (Slocombe, 2001).

Suggested citation for this report:

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Cover photo:

Photo captured during field visit.

GEOSS project number:

2022_03-4708E

Review:

Dale Barrow (31 January 2023)

SPECIALIST EXPERTISE

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- Geotechnical site investigation and site assessment.
- Field mapping
- Rock & soil profiling
- Material classification and material use determination.
- Hydrocensus studies
- Borehole drilling supervision and analysis
- Groundwater monitoring - development and analysis of groundwater level and quality data.
- ArcGIS, QGIS

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2014	B.Sc Earth Science	University of Stellenbosch, South Africa

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January 2019 to December 2022	Martin & East (PTY) Ltd
January 2018 to October 2018	Ndodana Consulting Engineers (PTY) Ltd

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- 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.

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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)

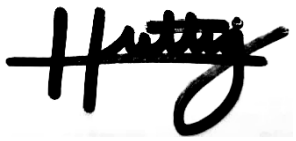
EMPLOYMENT RECORD

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, Hardy Luttig 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.



Hardy Luttig
GEOSS South Africa (Pty) Ltd.
BSc, MEng
31 January 2023



Shane Teek
GEOSS South Africa (Pty) Ltd.
Pr. Sci. Nat. – 126397
27 January 2023.

1. INTRODUCTION

1.1 Terms of Reference

Geohydrological Spatial Solutions South Africa (Pty) Ltd (GEOSS) was appointed by African Clean Energy Developments (Pty) Ltd (ACED) (hereafter referred to as the "Project Developer") on behalf of Padloper PV (Pty) Ltd (hereafter referred to as the "Project Applicant") to undertake a desktop Geotechnical Assessment for the proposed Padloper Solar Photovoltaic (PV) Cluster in the Northern Cape and Western Cape provinces near Murraysburg. To connect to the existing Gamma Main Transmission Substation (MTS), ACED is proposing to develop seven (7) Solar Photovoltaic (PV) facilities with a capacity ranging between 100 MW and 250 MW each along with the associated 7 x 132 kV overhead power lines and their associated infrastructure.
In their confirmation of appointment ACED stated that listed components and exact specifications should be seen as worst-case scenario for the projects.

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 geotechnical 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 (BA) processes for the Padloper Solar Cluster (i.e. Solar Facilities 1-7 and EGI 1-7).

1.3 Proposed Development

ACED is proposing the development of a cluster of seven (7) solar photovoltaic (PV) energy facilities, comprising a capacity ranging between 100 MW and 250 MW each, and associated grid connection infrastructure on various properties near Murraysburg in the Western Cape and Northern Cape provinces.

The development will expand the capacity of the Eskom Holdings (Pty) Ltd (Eskom) grid and improve the functionality of the grid area via 7 x 132 kV overhead power lines connecting the onsite substation to the existing Gamma MTS via the proposed authorised Ishwati Emoyeni Collector Station.

A preliminary number of 330 3.5 MW inverters will be required across all projects. Therefore, there will be 165 Inverter-Transformation Stations each occupying 0.022 ha. Each PV facility will have an on-site substation complex extending 2 ha in area, and will have a height of up to 18 m.

We understand that each PV Facility will have a temporary laydown area of up to 22 ha. There will be 1 site office at each Energy Solar Facility (SEF) which will include a warehouse/workshop and an operational and maintenance (O&M) control centre (300 m^2 footprint). Each SEF will have two guardhouse facilities with a footprint of up to 36 m^2 as well as two ablution facilities of up to 242 m^2. It is proposed that the BESS is located at the project substation site and laydown area. Each SEF will have one BESS facility.

Internal roads between PV facilities will be 5 m wide with a total preliminary length of 55.15 km. Existing access roads will be used as far as practically achievable however, should any upgrading be required the existing access roads will be upgraded to have a 6 m wide road surface with 1 m wide drainage on either side. Site access points are proposed to be on the western side of development areas, from an existing farm road running further north.

All on-site medium voltage cabling (22 or 33kV) will be buried to a maximum depth of 1.5 m.

The construction period for each project is planned to be between 18 – 36 months. It is estimated that during the construction phase ± 10 000 m^3 of water will be required per project while the largest site (Padloper Solar Facility 5) will use up to 50 000 m^3 per year during construction. During the operational phase ± 5000 m^3 of water per annum per project will be required for a minimum of 20-year operational lifespan of the solar energy facility. Padloper Solar Facility 5 will alone require ± 15 000 m^3 per annum during its operational phase.

In order of priority water for the facility will be sourced as follow:

1. Borehole/s drilled on site
2. Arrangements with the local municipality
3. Investigation into a third-party water supplier which may include a nearby mine or other private services company

During the time of report compilation the loads to be imposed on the respective founding stratum of the proposed structures were unknown.

1.4 Scope and Limitations of Assessment

The primary aims of this investigation were to confirm the general geotechnical conditions of the sites and to determine potential geotechnical impacts on the environment based on existing,

available desktop information i.e., information extracted from published literature, and Geotechnical reports compiled for other wind and solar PV projects in the vicinity. No site visit was undertaken.

This desktop 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 3222, Beaufort West.
- The 1: 250 000 geological series map – Sheet 3224, Graaf-Reinet.
- The 1: 250 000 geological series map – Sheet 3124, Middelburg.
- The 1: 250 000 geological series map – Sheet 3122, Victoria West.
- The 1: 500 000 hydrogeological map – Sheet 3122, Victoria West.
- Aerial imagery (Google Earth imagery).
- Engineering Geology of South Africa (relevant) Volumes 1, 3 and 4 (Brink, 1979; 1983; 1985).
- Information pertaining to project specific details was extracted from the letter of appointment of 26 August 2022, titled: "Confirmation of appointment to undertake Groundwater and Geotechnical assessments for the proposed Padloper Solar Photovoltaic Cluster, Northern and Western Cape".

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 desktop 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 per project was specified between 18 – 36 months keeping in mind that projects may be constructed in parallel. 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 emphasise 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.

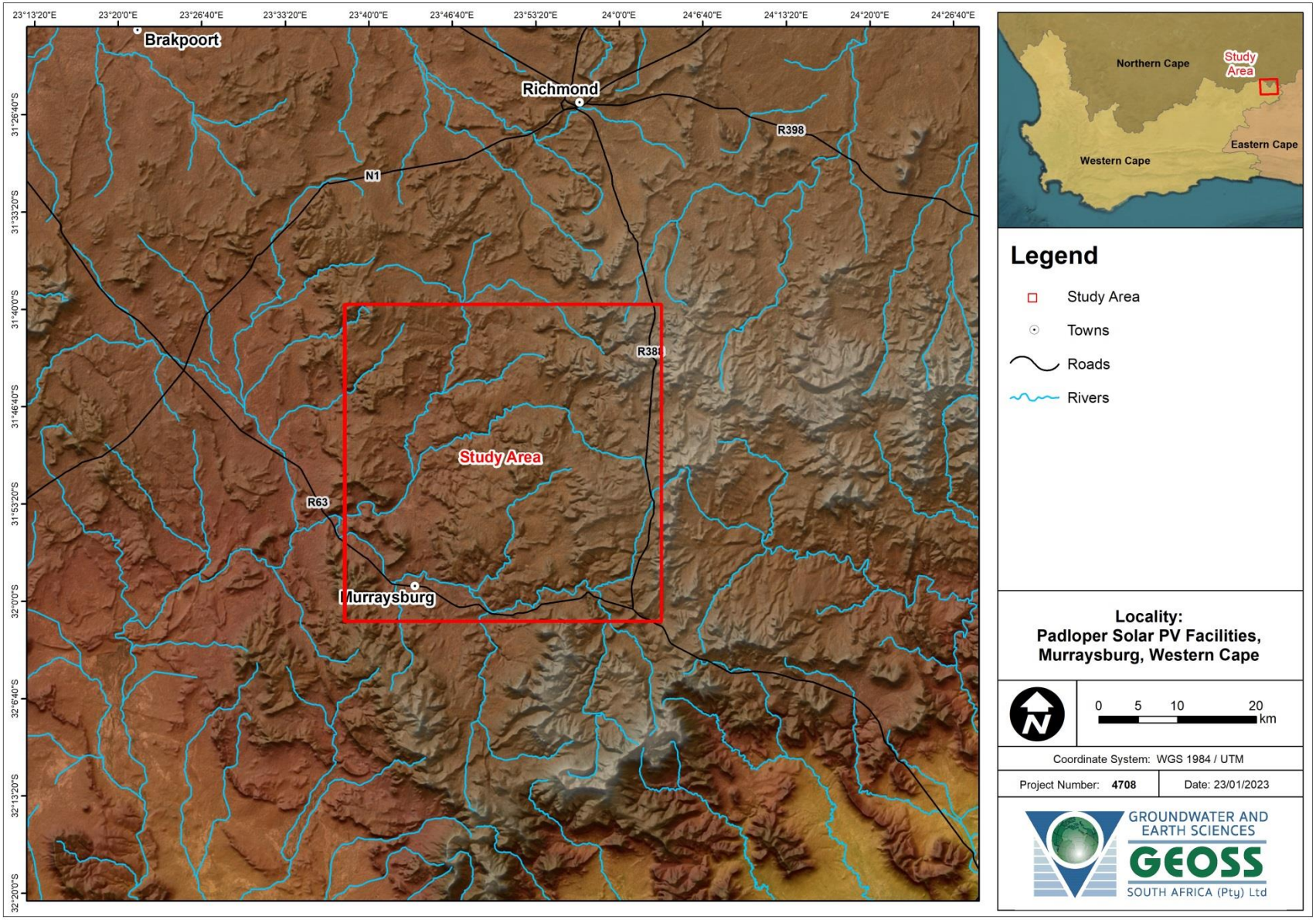
2. SETTING

2.1 Site Location and Description

The extent of the developable area of the Padloper Solar Photovoltaic Facility (or site/s) is 2 588 ha, located between 12 km north east and 30 km north of Murraysburg; some 45 km south of Richmond, and approximately 80 km southeast of Victoria West (**Map 2**). The project aims to link the Padloper Solar Cluster and will connect to the proposed authorised Ishwati Emoyeni Collector Station via dedicated 132 kV overhead power lines.

2.2 Topography and Site Features

The elevation of the site ranges between about 1260 and 1445 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 (**Figure 10**; **Figure 12**; **Figure 15**). Most rivers in the area of the facility drain in a southerly to south-westerly direction into the Buffelsrivier. The study area is generally covered by spiny shrubs (**Figure 11**).



Map 1: Locality map showing the general location of the proposed Padloper Study Area and surrounds.

2.3 Climate

The nearest town to the Padloper Solar Cluster is Murraysburg which is located in the Central Karoo of the Western Cape (**Map 1**). This area forms part of the Nama Karoo Biome (semi-desert) that receives low rainfall with a mean annual precipitation of 288 mm per annum. Generally, the study area experiences cold and dry winters with warm to hot summers. It receives the bulk of its annual rainfall during summer and early autumn (i.e., between December and April). **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).

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

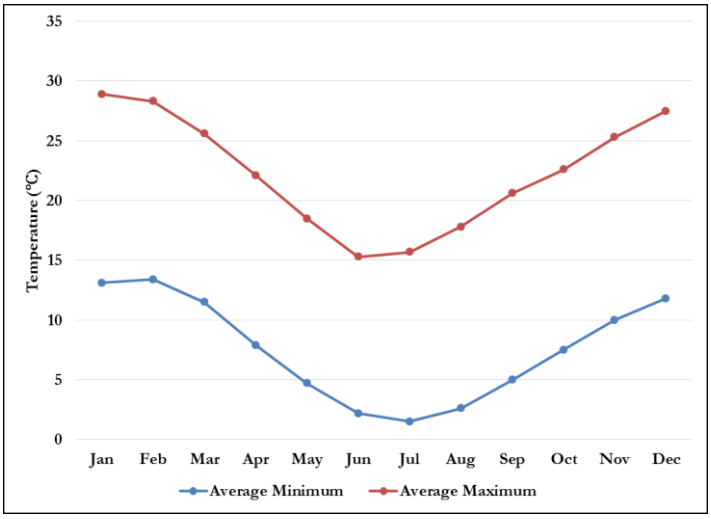


Figure 1: Monthly average air temperature for the study area (Schulze, 2009).

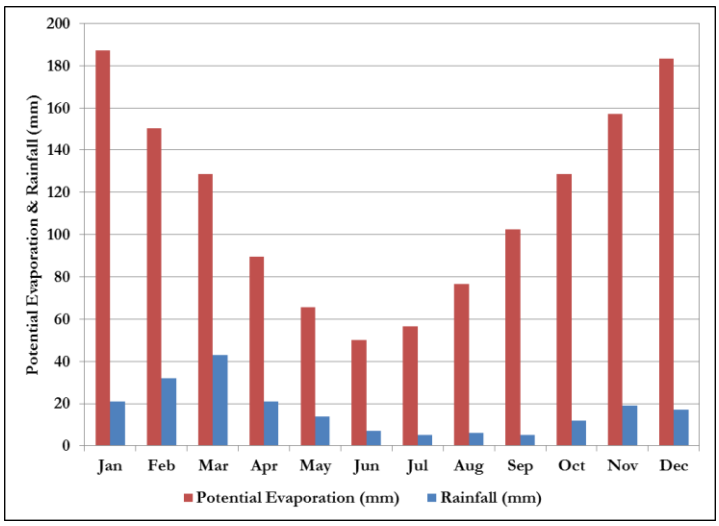


Figure 2: Monthly average air temperature for the study area (Schulze, 2009).

2.4 Weinert 'N' Value

Climate has a significant effect on the formation of residual soils and rock weathering. It is an indicator of the typical soil conditions that may be encountered on a specific site (Weinert, 1975). In **Figure 3** a general modal developed by Weinert (1975) categorise the climate of southern Africa based on what he termed the N-value. The Weinert 'N'-value for the project area is shown to be greater than 5 (Brink, 1979).

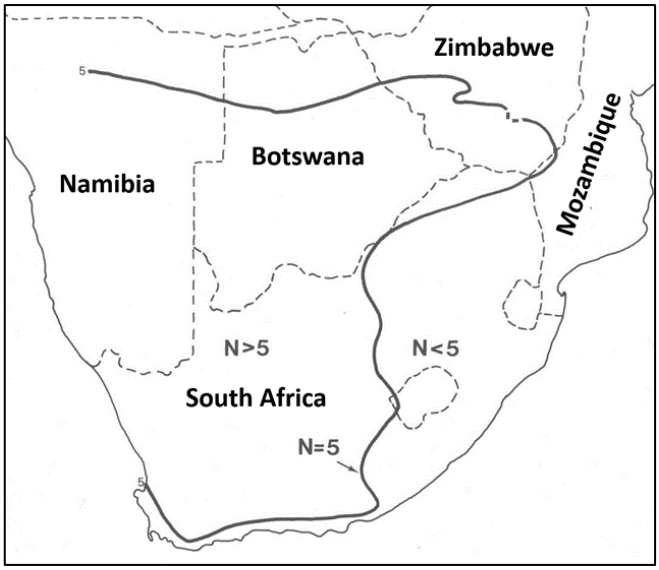


Figure 3: Climatic 'N' value = 5 plotted for southern Africa (after Weinert, 1967).

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 (**Figure 13**) 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*
Pb		Balfour	Beaufort	Greenish- to bluish-grey and greyish-red mudstone, siltstone, subordinate sandstone.
Pt		Teekloof	Beaufort	Brownish-red and greenish-grey mudstone, subordinate siltstone and sandstone
Pth	Hoedemaker	Teekloof	Beaufort	

2.5.1 Geological Zones

The site has been broadly classified into two 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, Siltstones and Mudstones (Zone A)

Weathering of less competent mudstone/siltstone layers in the closely intercalated sandstones and mudstones/siltstones often create problems with regards to slope stability as the exposed layers of sandstone is undercut (Brink, 1983). Water flow in sandstones might get impeded by relatively impermeable mudstones/siltstones creating porewater pressures to develop on the interface (Brink, 1983). Where sandstones are thickly bedded and highly jointed, joint-controlled block and wedge failures can potentially occur (Brink, 1983).

According to Brink (1983) and references therein, the two main types of instabilities that are found are the movement of completely weathered material and colluvial material and the sliding of blocks of rock on bedding planes. The two mechanisms initiating slope instability affecting mudrocks slopes include (1) the influence of water, and (2) the change of slope morphology. The slope instability types and mechanisms initiating instabilities predominantly occur in Natal (Brink, 1983). These types of instabilities, although rare in the Groot Karoo, might occur in highly eroded areas

and in zones of excessive ponding and poor draining conditions as mudrocks can potentially weather to form clay.

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. Surrounding sediments were not severely affected by the magma forming the sills however, the magma forming the dykes had a more radical effect transforming mudrock into hornfels and sandstone into quartzite. As a rule of thumb dolerite dykes affect 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 (**Figure 19**) (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 which typically develop as thick soil packages (**Figure 14**) (CGS, 1991). The geotechnical characteristics of such materials are variable in nature. From a construction point of view, sandy quaternary sediments may have a collapsible grain structure while challenging excavation conditions might occur in areas associated with terrace gravels, particularly where boulders are encountered (Brink, 1985). Furthermore, Brink (1985) also mentions that coarse colluvium is often suitable for road construction where the properties of the constituent lithologies are suitable.

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 (Brink, 1983). 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 (**Figure 16**). 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**).

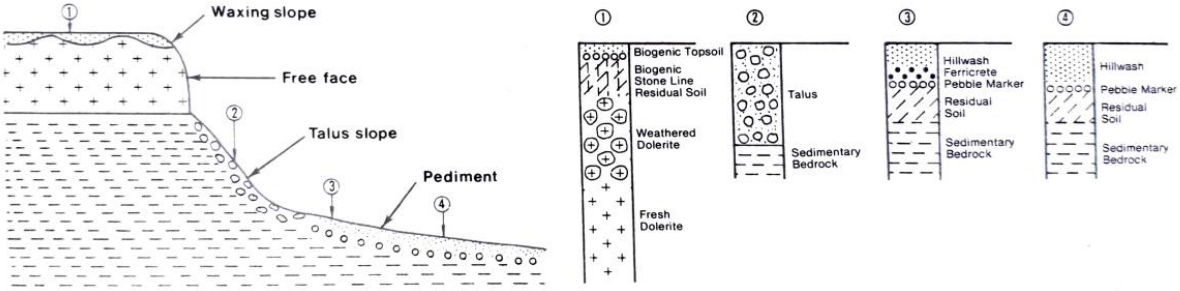


Figure 4: Elements of typical Karoo hillslopes and anticipated soil profiles (Brink, 1982)

2.8 Slope Classification

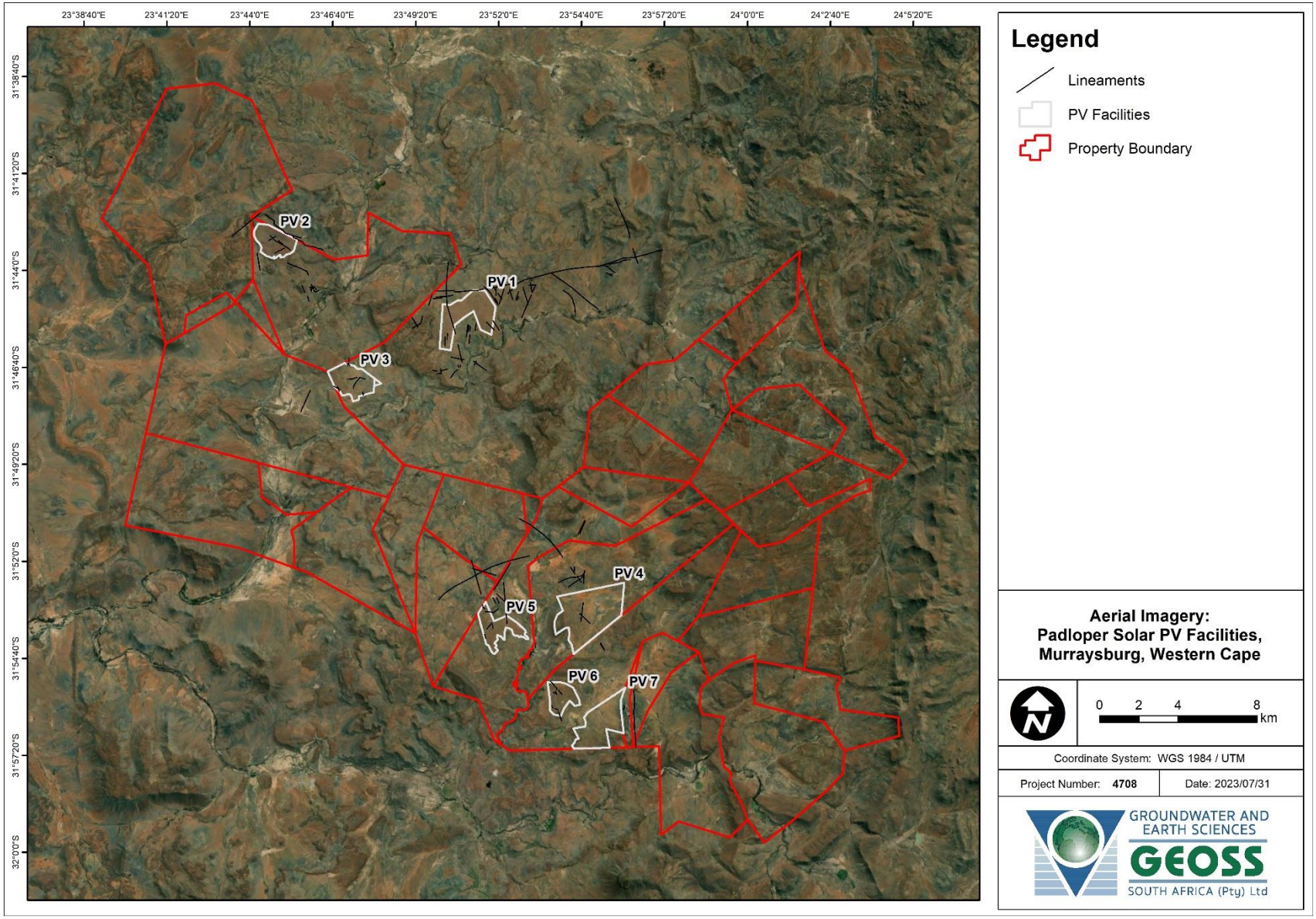
The topography in the region has been classified in terms of development based on classes suggested by Stiff *et al.* (1996), see **Map 3**. A digital elevation model (DEM, 2018) has been used to determine slope gradients, which have been classified in terms of development potential in the region where development is to take place. The majority of the region is classified as "most favourable" and "intermediate" due to the generally flat nature of the site. A portion along the western boundary of Padloper Solar Facility 5 is classified as least favourable due to a large topographical feature along this boundary (**Map 3**).

2.9 Hydrogeology

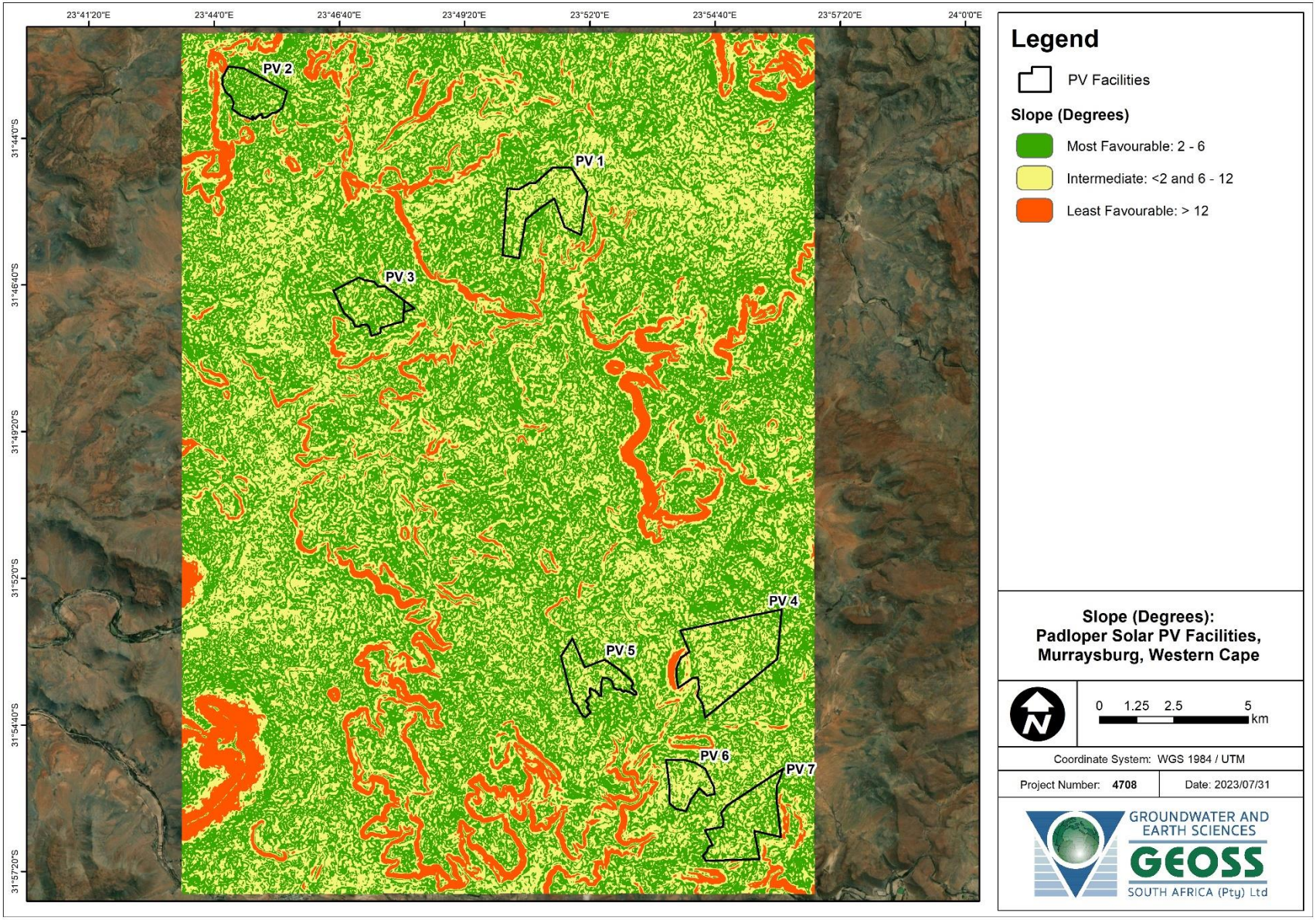
In the region earmarked for development, two aquifer types dominate, fractured aquifers, and intergranular and fractured. The fractured aquifers indicate a yield potential of between 0.5 to 2.0 L/s (DWAF, 2002). The intergranular and fractured aquifers are shown to have an indicative yield potential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

The regional groundwater quality is classified as "marginal" directly underlying the study area with an associated electrical conductivity (EC) of 70 – 300 mS/m (DWAF, 2002).

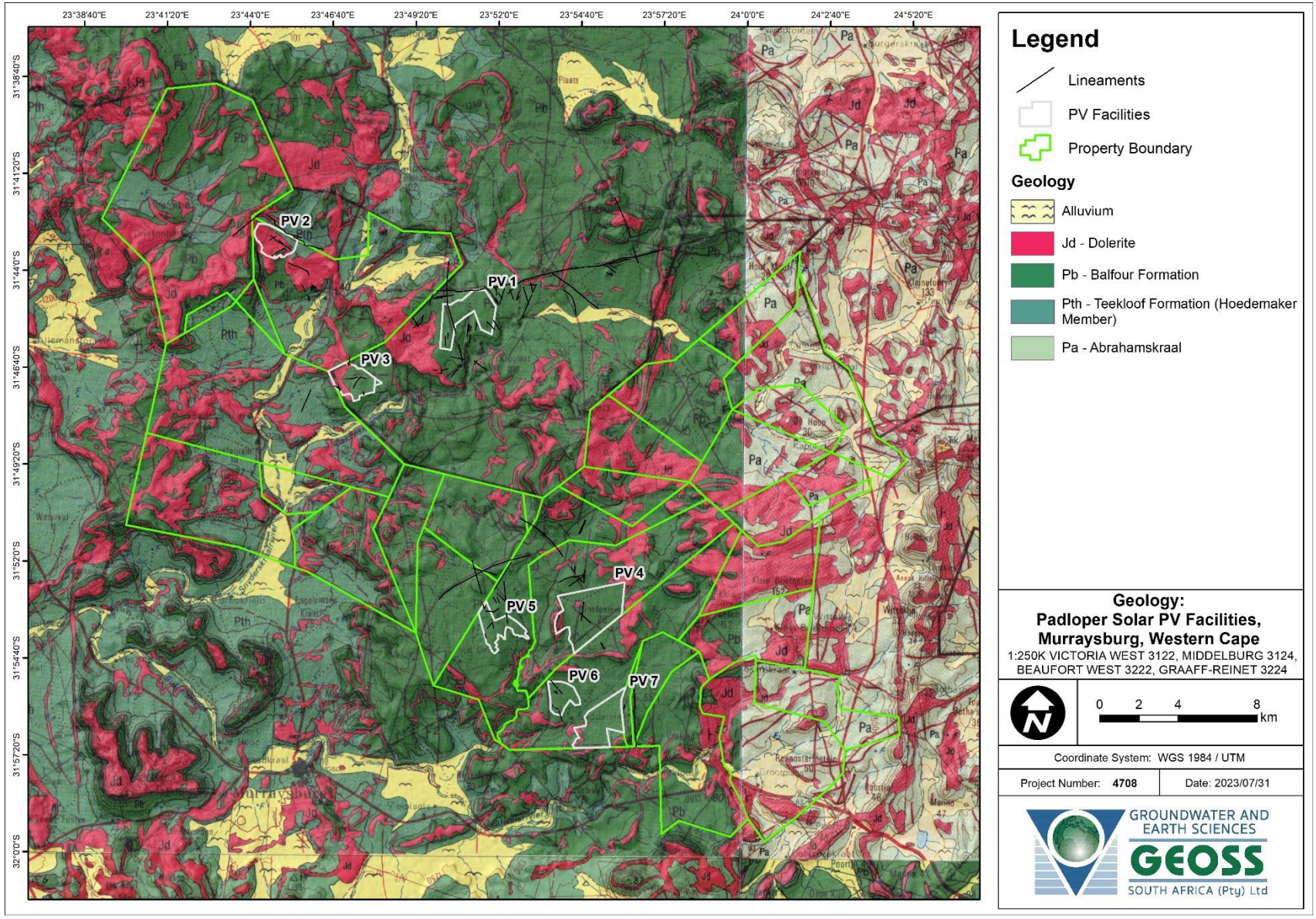
It should be noted that the above classifications are based on regional datasets, and therefore only provide an indication of conditions to be expected.



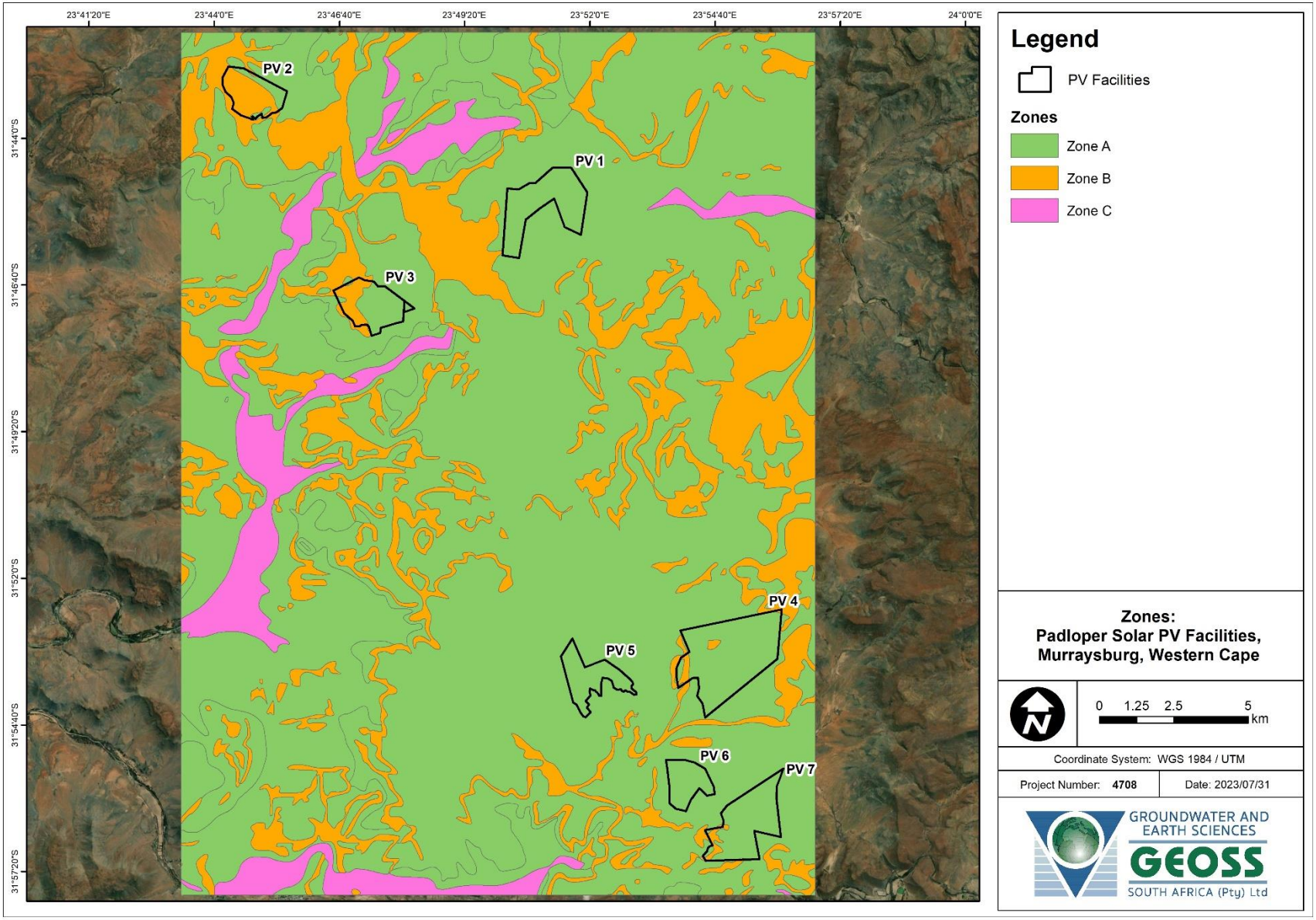
Map 2: Aerial map showing the approximate boundaries of the development.



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



Map 4: Geological setting of the area (3122 – Victoria West, 3124 – Middelburg, 3222 – Beaufort West and 3224 – Graaf-Reinet, GCS 1989) NOTE: Abrahamskraal formation subsequently remapped as Balfour formation.



Map 5: Geological zones superimposed on aerial imagery.

2.10 Seismicity

It is common practice 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 Dunaiski, (2009) delineated such regions in southern Africa, the approximate position of Murraysburg is shown in red on Figure 5 relative to these regions. The region surrounding Murraysburg 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.

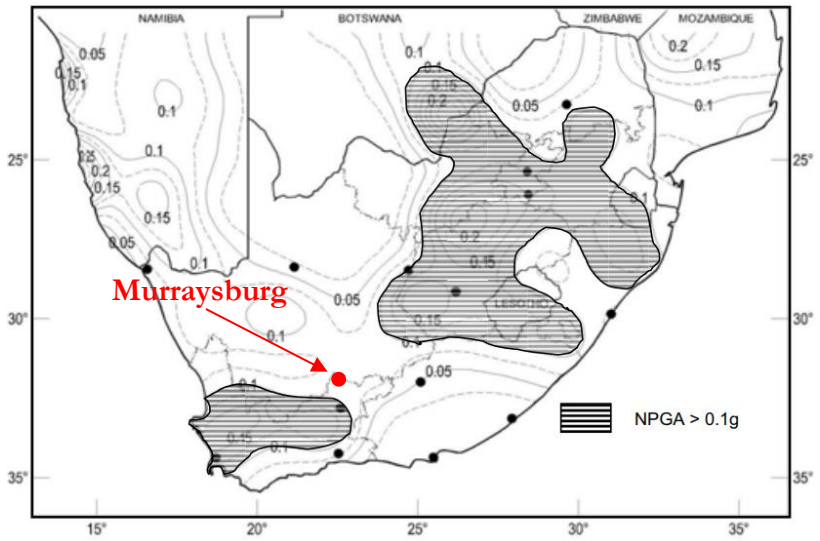


Figure 5: Zones in South Africa with nominal peak ground acceleration of more than 0.1 g for 10% in 50 years probability (after Retief and Dunaiski, 2009).

3. GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

3.1 General

It is anticipated that in regions planned for solar panel construction that no exceptional geotechnical risks will be encountered and conventional foundation solutions for the PV tables/monopoles could be adopted.

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. Mobility and accessibility between clusters and access points to sites also play a vital role to a successful and efficient project. Effective construction methods and maintenance will be required.

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 slopes are shown to be less than 2° (**Figure 11**).

There are regions which are characterised by erosion scars, for example in existing farm roads (**Figure 12**). 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 photovoltaic cell, pylon and support structures that is to be developed within the study area would have to be investigated in more detail prior to construction.

3.4 Potential Development Constraints

Based on the slope map generated for the region (**Map 3**), along the western boundary Padloper Solar Facility 4 there is a notable topographic feature, i.e., a mountainous region with steeper slopes which may render construction of Solar PV panels in this area unfavourable.

3.5 Excavation

Excavation classes across the area might vary. Closer to the banks of drainage channels slightly thicker soil cover should be present allowing for easy excavation (SANS 1200). The excavation class, where dolerite is present, will be very dependent on the degree of weathering of the actual dolerite outcrop. 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 (**Figure 16**; **Figure 19**).

3.6 Problem Soils

Problem soils are not of a concern for the study area however, there is a possibility that some of the soil present can be slightly expansive or have a potentially collapsible grain structure (**Figure 15**). However, this is not expected to hamper the development.

4. PRELIMINARY GEOLOGICAL AND GEOTECHNICAL IMPACT ASSESSMENT

The project will have an impact on the geological environment with regards to existing soils and rock units underlying the different cluster sites. It will be impacted mainly by the stripping of topsoil, foundation excavations, trenching and the developments and/or upgrading of roads. It is worth mentioning that bulk earthworks will have a major impact on soils and rocks.

Increased soil erosion is the major geotechnical concern with regards to this project. It will be increased due to the stripping of vegetation. Water runoff is now more likely than infiltration into the ground. Surface runoff will further be encouraged by compaction operations most likely after vegetation stripping and during road construction. This will most likely channel stormwater and upon discharge cause an increase in erosion as well. 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.

Coupled with the potential for the displacement of geologic materials is the risk of soil contamination from on-site activities. Conventional construction and earthworks make use of construction equipment, which with poor maintenance, cause leakages and result in refuelling spillages during construction and/or decommissioning.

Potential risks associated with the operational phase mainly include erosion and contamination of geologic materials.

The above is discussed in subsequent sections with particular reference to possible activities and phases of development.

4.1 Impacts of the Project During Construction Phase for PV1 – PV7

The impact table for the Construction Phase is presented in **Table 2**. In summary, the main known considerations addressed in the impact table include:

- Removal of rocks and other geologic materials for site levelling and grading, resulting in loss of geologic materials, e.g. topsoil removal/loss, and potentially the destruction of habitats of endemic species.
- Contamination of geologic materials as a consequence of the construction activities by earthworks machinery and other apparatus.

Table 2: Impact Summary Tables: Construction Phase for PV1 – PV7

Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
CONSTRUCTION PHASE						
Impact 1 *•Displacement of geologic materials (i.e., Removal of rocks and other geologic materials for site levelling and grading, resulting in loss of geologic materials, e.g. topsoil removal/loss, and potentially the destruction of habitats of endemic species.)*	*Status*	*Negative*	*Low*	*Favour dolerite as an aggregate (as opposed to Karoo sandstones and mudstones). Subject to investigation.* *• Any road cuttings should be designed by an appropriately qualified professional.* *• Drainage in the region should be designed and managed appropriately.* *• Investigate and confirm the geotechnical suitability of each structure (or other appropriate level of investigation) prior to construction (i.e. determine that soil with an adequate bearing capacity is obtained beneath each footing). Such investigations would not be required to fulfil the requirements of the BA process. However, it would be necessary prior to construction.* *• Only strip vegetation necessary for the next phase of construction.* *• Install temporary drainage to divert stormwater away from active construction activities, where required.* *• Stormwater Management Plan must be developed in the preconstruction phase. It should detail the stormwater structures and management interventions that must be installed to manage the increase of surface water flow directly into any natural systems (in consultation with suitably qualified professionals). Effective stormwater management must include effective stabilisation (e.g. gabions and Reno mattresses) of exposed soil.*	*Very Low*	*Medium*
	Spatial Extent	*Local*				
	Duration	*Short term*				
	Consequence	*Moderate*				
	Probability	*Very likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

				• *Suitable stormwater management systems must be installed along roads and other areas and be monitored during the first few months of use. Any erosion/sedimentation must be resolved through any additional interventions that may be necessary (e.g., extension, energy dissipaters, spreaders, etc.).* • *Where impacted through construction-related activities, all sloped areas must be stabilised to ensure proper rehabilitation is effected and erosion is controlled.* • *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.* • *Any rehabilitation should be scheduled to ensure rehabilitation can take place at the optimal time for vegetation establishment.* • *Where earthwork is being undertaken near any watercourses, slopes must be stabilised using suitable materials, e.g. sandbags or geotextile fabric, to prevent sand and rock from entering the channel.* • *Appropriate rehabilitation and re-vegetation measures for any disturbed watercourse banks must be implemented timeously. In this regard, the banks should be appropriately and incrementally stabilised as soon as development allows.*		

Table 2: Impact Summary Tables: Construction Phase (cont.)

Impact	***Impact Criteria***		***Significance and Ranking (Pre-Mitigation)***	***Potential mitigation measures***	***Significance and Ranking (Post-Mitigation)***	***Confidence Level***
CONSTRUCTION PHASE						
Impact 2 *•Contamination of geologic materials (i.e., Contamination of geologic materials as a consequence of the construction activities by earthworks machinery and other apparatus.)*	*Status*	*Negative*	*Low*	*• 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.* *• 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.* *• 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.* *• If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilt material, as reported. Proof of disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes.*	*Very Low*	*Medium*
	Spatial Extent	*Local*				
	Duration	*Short term*				
	Consequence	*Moderate*				
	Probability	*Very likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

4.2 Impacts of the Project During Operational Phase for PV1 – PV7

The impact table for the Operational Phase is presented in **Table 3**. In summary, the main known considerations addressed in the impact table, include:

- Increased unnatural hard surfaces yielding increased runoff, potentially increasing erosion.
- Contamination of geologic materials as a consequence of typical maintenance activities, as example, washing of solar panels, or spillages associated with battery energy storage facilities.

Table 3: Impact Summary Tables: Operational Phase for PV1 – PV7

Impact	***Impact Criteria***		***Significance and Ranking (Pre-Mitigation)***	***Potential mitigation measures***	***Significance and Ranking (Post-Mitigation)***	***Confidence Level***
OPERATIONAL PHASE						
Impact 1 *•Increased unnatural hard surfaces yielding increased runoff, potentially increasing erosion.*	*Status*	*Negative*	*Low*	*• Install drainage to divert stormwater away from activities, roads/tracks, structures, where required.* *• Generic management for typical infrastructure of the proposed development, including:* *1. 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, where possible and lawful. Effective stormwater management must include effective stabilisation (e.g. gabions and Reno mattresses) of exposed soil etc.* *2. 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 any additional interventions that may be necessary (e.g., extension, energy dissipaters, spreaders, etc.).* *3. Sloped areas stabilised using design structures or vegetation as specified in the design to prevent erosion of embankments.* *4. No regular maintenance activities to take place outside of the authorised footprint and all vehicles to remain on authorised roads and tracks.*	*Very Low*	*Medium*
	Spatial Extent	*Local*				
	Duration	*Long*				
	Consequence	*Moderate*				
	Probability	*Likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

Table 3: Impact Summary Tables: Operational Phase (cont.)

Impact	***Impact Criteria***		***Significance and Ranking (Pre-Mitigation)***	***Potential mitigation measures***	***Significance and Ranking (Post-Mitigation)***	***Confidence Level***
OPERATIONAL PHASE						
Impact 2 *•Contamination of geologic materials*	*Status*	*Negative*	*Low*	*• During the execution of the operations, appropriate measures to prevent pollution and contamination of the riparian environment must be implemented e.g. including ensuring that construction equipment is well maintained;* *• Provision must be made for refuelling at the storage area by protecting the soil with an impermeable groundcover/ bunding. Where dispensing equipment is used, a drip tray must be used to ensure small spills are contained.* *• 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.* *• If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilled material, as reported. Proof of disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes.*	*Very Low*	*Medium*
	Spatial Extent	*Local*				
	Duration	*Short term*				
	Consequence	*Moderate*				
	Probability	*Very likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

4.3 Impacts of the Project During Decommissioning Phase for PV1 – PV7

The impact table for the Decommissioning Phase is presented in Table 4. In summary, the main known considerations are somewhat similar to the construction phase and addressed in the impact table include:

- Increased unnatural hard surfaces yielding increased runoff, potentially increasing erosion.
- Contamination of geologic materials as a consequence of the construction activities by earthworks machinery and other apparatus.

Table 4: Impact Summary Tables: Decommissioning Phase for PV1 – PV7

Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
DECOMMISSIONING PHASE						
Impact 1 *•Increased unnatural hard surfaces yielding increased runoff, potentially increasing erosion.*	*Status*	*Negative*	*Very low*	*• Only drive and park vehicles where necessary.* *• 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 environmental management procedures for infrastructure.*	*Very Low*	*Medium*
	Spatial Extent	*Local*				
	Duration	*Short*				
	Consequence	*Slight*				
	Probability	*Likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				
Impact 2 *•Contamination of geologic materials*	*Status*	*Negative*	*Very low*	*• During the execution of the decommissioning, appropriate measures to prevent pollution and contamination of the riparian environment must be implemented e.g. including ensuring that equipment is well maintained;* *• 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.* *• 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.* *• If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilled material, as reported. Proof of*	*Very Low*	*Medium*
	Spatial Extent	*Local*				
	Duration	*Short*				
	Consequence	*Slight*				
	Probability	*Likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

Impact	*Impact Criteria*		*Significance and Ranking (Pre-Mitigation)*	*Potential mitigation measures*	*Significance and Ranking (Post-Mitigation)*	*Confidence Level*
				disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes.		

4.4 Cumulative Impacts

The impact table for the cumulative effects of the proposed development and similar developments that have been proposed for the surrounding areas are presented in this section. In general, the impacts of the neighbouring developments are similar, however, their intensities increase due to the consequence of general increase in activity, increasing the chance for impacts to occur.

In summary, the cumulative impacts identified during the time of the investigation include the impacts related to the construction, operational and decommissioning phases across the proposed development including the entire Padloper Solar Cluster, and the neighbouring similar developments in the region occurring within a similar timeframe.

The cumulative impacts and mitigation measures for the Construction, Operational and Decommissioning Phases are contained in **Table 5**, **Table 6** and **Table 7**, respectively.

Table 5: Cumulative Impact Summary Tables: Construction Phase (inclusive of Padloper PV1 – 7)

Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
CONSTRUCTION PHASE						
Impact 1 *•Displacement of geologic materials*	*Status*	*Negative*	*Moderate*	*• Only strip vegetation necessary for the next phase of construction.* *• Install temporary drainage to divert stormwater away from active construction activities, where required.* *• Stormwater Management Plan must be developed in the preconstruction phase. It 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 (in consultation with suitably qualified professionals). Effective stormwater management must include effective stabilisation (e.g. gabions and Reno mattresses) of exposed soil.* *• Suitable stormwater management systems must be installed along roads and other areas and be monitored during the first few months of use. Any erosion/sedimentation must be resolved through any additional interventions that may be necessary (e.g., extension, energy dissipaters, spreaders, etc.).* *• Where impacted through construction-related activities, all sloped areas must be stabilised to ensure proper rehabilitation is effected and erosion is controlled.* *• 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.*	*Low*	*Medium*
	Spatial Extent	*Regional*				
	Duration	*Medium-term*				
	Consequence	*Substantial*				
	Probability	*Very likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

Impact	*Impact Criteria*		*Significance and Ranking (Pre-Mitigation)*	*Potential mitigation measures*	*Significance and Ranking (Post-Mitigation)*	*Confidence Level*
				• *Any rehabilitation should be scheduled to ensure rehabilitation can take place at the optimal time for vegetation establishment.* • *Where earthwork is being undertaken in near any watercourses, slopes must be stabilised using suitable materials, e.g. sandbags or geotextile fabric, to prevent sand and rock from entering the channel.* • *Appropriate rehabilitation and re-vegetation measures for any disturbed watercourse banks must be implemented timeously. In this regard, the banks should be appropriately and incrementally stabilised as soon as development allows.*		

Table 5: Cumulative Impact Summary Tables: Construction Phase (cont.)

Impact	***Impact Criteria***		***Significance and Ranking (Pre-Mitigation)***	***Potential mitigation measures***	***Significance and Ranking (Post-Mitigation)***	***Confidence Level***
CONSTRUCTION PHASE						
Impact 2 *•Contamination of geologic materials*	*Status*	*Negative*	*Moderate*	*• 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.* *• 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.* *• 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.* *• If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilled material, as reported. Proof of disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes.*	*Low*	*Medium*
	Spatial Extent	*Regional*				
	Duration	*Medium-term*				
	Consequence	*Substantial*				
	Probability	*Very likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

Table 6: Cumulative Impact Summary Tables: Operational Phase (inclusive of Padloper PV 1 – 7)

Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
OPERATIONAL PHASE						
Impact 1 *•Displacement of geologic materials*	*Status*	*Negative*	*Moderate*	*• Install drainage to divert stormwater away from activities, roads/tracks, structures, where required.* *• Generic management for typical infrastructure of the proposed development, including:* *1. 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, where possible and lawful. Effective stormwater management must include effective stabilisation (gabions and Reno mattresses) of exposed soil etc.* *2. 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 any additional interventions that may be necessary (e.g., extension, energy dissipaters, spreaders, etc.).* *3. Sloped areas stabilised using design structures or vegetation as specified in the design to prevent erosion of embankments.* *4. No regular maintenance activities to take place outside of the authorised footprint and all vehicles to remain on authorised roads and tracks.*	*Low*	*Medium*
	Spatial Extent	*Regional*				
	Duration	*Medium-term*				
	Consequence	*Substantial*				
	Probability	*Very likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

Table 6: Cumulative Impact Summary Tables: Operational Phase (cont.)

Impact	***Impact Criteria***		***Significance and Ranking (Pre-Mitigation)***	***Potential mitigation measures***	***Significance and Ranking (Post-Mitigation)***	***Confidence Level***
OPERATIONAL PHASE						
Impact 2 *•Contamination of geologic materials*	*Status*	*Negative*	*Moderate*	*• During the execution of the operations, appropriate measures to prevent pollution and contamination of the riparian environment must be implemented e.g. including ensuring that construction equipment is well maintained.* *• Provision must be made for refuelling at the storage area by protecting the soil with an impermeable groundcover/ bunding. Where dispensing equipment is used, a drip tray must be used to ensure small spills are contained.* *• 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.* *• If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilled material, as reported. Proof of disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes.*	*Low*	*Medium*
	Spatial Extent	*Regional*				
	Duration	*Medium-term*				
	Consequence	*Substantial*				
	Probability	*Very likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

Table 7: Cumulative Impact Summary Tables: Decommissioning Phase (inclusive of Padloper PV 1 - 7)

Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
	DECOMMISSIONING PHASE					
Impact 1 *•Increased unnatural hard surfaces yielding increased runoff, potentially increasing erosion.*	*Status*	*Negative*	*Moderate*	*• Only drive and park vehicles where necessary.* *• 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 environmental management procedures for infrastructure.*	*Low*	*Medium*
	Spatial Extent	*Local*				
	Duration	*Short*				
	Consequence	*Substantial*				
	Probability	*Likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				
Impact 2 *•Contamination of geologic materials*	*Status*	*Negative*	*Moderate*	*• During the execution of the decommissioning, appropriate measures to prevent pollution and contamination of the riparian environment must be implemented e.g. including ensuring that equipment is well maintained;* *• Provision must be made for refuelling at the storage area by protecting the soil with an impermeable ground cover. Where dispensing equipment is used, a drip tray must be used to ensure small spills are contained.* *• 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.*	*Low*	*Medium*
	Spatial Extent	*Local*				
	Duration	*Short*				
	Consequence	*Substantial*				
	Probability	*Likely*				
	Reversibility	*Moderate*				
	Irreplaceability	*Moderate*				

				• *If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilled material, as reported. Proof of disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes.*		

5. IMPACT ASSESSMENT SUMARY

The overall impact significance findings, following the implementation of the proposed mitigation measures, are shown in the **Table 8**.

Table 8: Overall Impact Significance (Post Mitigation)

Phase	**Overall Impact Significance**
Construction	Very Low
Operational	Very Low
Decommissioning	Very Low
Nature of Impact	**Overall Impact Significance**
Cumulative - Construction	Low
Cumulative - Operational	Low
Cumulative - Decommissioning	Low

6. LEGISLATIVE AND PERMIT REQUIREMENTS

Based on the impacts that might happen during the construction, operation and decommissioning phases of the proposed development this section has been divided as follow:

- Loss of geological material.
- Removal of geological material.
- Contamination of geologic materials as a consequence of typical maintenance activities.

The norms and references given below are not exhaustive.

6.1 Loss of Geological Material (Soil Erosion)

Relevant legislation and guidelines pertaining to soil conservation, particularly soil erosion, includes:

- Conservation of Agricultural Resources Act No. 43 of 1983
- Environmental Conservation Act No. 73 of 1989
- National Forestry Act No. 84 of 1998
- National Environmental Management Act No. 107 of 1998
- The Department of Water Affairs and Forestry, February 2005. Environmental Best Practice Specifications: Construction Integrated Environmental Management Sub-Series No. IEMS 1.6. Third Edition. Pretoria.

6.2 Contamination of Geologic Materials

Relevant literature pertaining to contamination of soil includes:

- National Environmental Management: Waste Act (Act No. 59 of 2008)
- National Water Act (Act No. 36 of 1998) Section 19.

7. RECOMMENDATIONS

The primary concern of this development is alteration of the stability of the soil across the site. Changes in the soil conditions across the site are anticipated mainly to arise as a consequence of increased/concentrated runoff, yielding increased erosion. The areas planned for the development of the solar facilities are generally of low relief and the topography is gently undulous, therefore, no major cut slopes and/or rock face stabilisations are anticipated for this development. Should such cuts or stabilisations be required the designs should be carried out by an appropriately qualified professional.

A summary of the recommended mitigation measures, environmental management program inputs (applicable to each solar facility comprising the Padloper Solar Cluster):

- Install temporary drainage to divert stormwater away from active construction activities, where required.
- Stormwater Management Plan must be developed in the preconstruction phase. It 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 (in consultation with suitably qualified professionals). Effective stormwater management must include effective stabilisation (e.g. gabions and Reno mattresses) of exposed soil.
- Suitable stormwater management systems must be installed along roads and other areas and be monitored during the first few months of use. Any erosion/sedimentation must be resolved through any additional interventions that may be necessary (e.g., extension, energy dissipaters, spreaders, etc.).
- Where impacted through construction-related activities, all sloped areas must be stabilised to ensure proper rehabilitation is affected and erosion is controlled.
- 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.
- Any rehabilitation should be scheduled to ensure rehabilitation can take place at the optimal time for vegetation establishment.
- Where earthwork is being undertaken in near any watercourses, slopes must be stabilised using suitable materials, e.g. sandbags or geotextile fabric, to prevent sand and rock from entering the channel.
- Appropriate rehabilitation and re-vegetation measures for any disturbed watercourse banks must be implemented timeously. In this regard, the banks should be appropriately and incrementally stabilised as soon as development allows.
- Where impacted through construction-related activities, all sloped areas must be stabilised to ensure proper rehabilitation is affected and erosion is controlled.
- 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.
- 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.
- If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilt material, as reported. Proof of disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes.

- Sloped areas stabilised using design structures or vegetation as specified in the design to prevent erosion of embankments.
- Maintenance activities should take place within authorised footprint of facility and all vehicles to remain on authorised roads and tracks (unless exceptional circumstances prevail).
- Only drive and park vehicles where necessary.
- Implement generic environmental management procedures for infrastructure.
- 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. Where possible and applicable.
- Reinstate natural topography where cut-to-fill embankments have been constructed.

8. 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 potential impact of the proposed development during the construction, operational and decommissioning phases of the projects is expected to be very low (post-mitigation) 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 sandstones, siltstones and mudstones
    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. Before finalizing the design, it is imperative to conduct an investigation into the footprint of each of the seven Padloper PV facility projects, encompassing the associated onsite infrastructure.
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 investigations will be required to confirm the anticipated conditions at each of the Padloper PV project positions and all other associated structures once EA has been obtained for each project, but prior to construction.
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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10. APPENDIX A: IMPACT ASSESSMENT METHODOLOGY

The impact assessment includes:

- *the nature, status, significance and consequences of the impact and risk;*
- *the extent and duration of the impact and risk;*
- *the probability of the impact and risk occurring;*
- *the degree to which impacts and risks can be mitigated;*
- *the degree to which the impacts and risks can be reversed; and*
- *the degree to which the impacts and risks can cause loss of irreplaceable resources.*

Terminology used in impact assessment can overlap. To avoid ambiguity, please note the following clarifications (that are based on NEMA and the EIA Regulations):

- *The term environment is understood to have a broad interpretation that includes both the natural (biophysical) environment and the socio-economic environment. The term socio-ecological system is also used to describe the natural and socio-economic environment and the interactions amongst these components.*
- *Significance = Consequence x Probability, which means that significance is equivalent to risk.*
- *The impact can have a positive or negative status. The significance of a negative impact may be called a risk, and the significance of a positive impact may be called an opportunity.*

The following principles are to underpin the application of this methodology:

- *Transparent and repeatable process - specialists are to describe the thresholds and limits they apply in their assessment, wherever possible.*
- *Adapt parameters to context (where justified) – the methodology proposes some thresholds (e.g. for spatial extent, in Step 3 below), however, if the nature of the impact requires a different definition of the categories of spatial extent, then this can be provided and described.*
- *Combination of a quantitative and qualitative assessment – where possible, specialists are to provide quantitative assessments (e.g. areas of habitat affected, decibels of noise, number of jobs), however, it is recognised that not all impacts can be quantified, and then qualitative assessments are to be provided.*

As per the DFFE Guideline 5: Assessment of Alternatives and Impacts, the following methodology is applied to the prediction and assessment of impacts and risks. Potential impacts and risks have been rated in terms of the direct, indirect and cumulative:

- *Direct impacts are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity. These impacts are usually associated with the construction, operation or maintenance of an activity and are generally obvious and quantifiable.*
- *Indirect impacts of an activity are indirect or induced changes that may occur as a result of the activity. These types of impacts include all the potential impacts that do not manifest immediately when the activity is undertaken or which occur at a different place as a result of the activity.*
- *Cumulative impacts are impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities. Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time and can include both direct and indirect impacts.*

The impact assessment methodology includes the aspects described below.

- ***Step 1**: **Nature** of impact/risk - The type of effect that a proposed activity will have on the environment.*

- ***Step 2**: **Status** - Whether the impact/risk on the overall environment will be:*
  - *Positive - environment overall will benefit from the impact/risk;*
  - *Negative - environment overall will be adversely affected by the impact/risk; or*
  - *Neutral - environment overall not be affected.*

- ***Step 3**: **Qualitatively** determine the **consequence** of the impact/risk by identifying the **a) SPATIAL EXTENT; b) DURATION; c) REVERSIBILITY; AND d) IRREPLACEABILITY**.*

    - ***A) Spatial extent** – The size of the area that will be affected by the impact/risk:*
        - *Site specific;*
        - *Local (<10 km from site);*
        - *Regional (<100 km of site);*
        - *National; or*
        - *International (e.g. Greenhouse Gas emissions or migrant birds).*

    - ***B) Duration** – The timeframe during which the impact/risk will be experienced:*
        - *Very short term (instantaneous);*
        - *Short term (less than 1 year);*
        - *Medium term (1 to 10 years);*
        - *Long term (the impact will cease after the operational life of the activity (i.e. the impact or risk will occur for the project duration)); or*
        - *Permanent (mitigation will not occur in such a way or in such a time span that the impact can be considered transient (i.e. the impact will occur beyond the project decommissioning)).*

    - ***C) Reversibility** of the Impacts - the extent to which the impacts/risks are reversible assuming that the project has reached the end of its life cycle (decommissioning phase):*
        - *High reversibility of impacts (impact is highly reversible at end of project life i.e. this is the most favourable assessment for the environment);*
        - *Moderate reversibility of impacts;*
        - *Low reversibility of impacts; or*
        - *Impacts are non-reversible (impact is permanent, i.e. this is the least favourable assessment for the environment).*

    - ***D) Irreplaceability** of Receiving Environment/Resource Loss caused by impacts/risks – the degree to which the impact causes irreplaceable loss of resources assuming that the project has reached the end of its life cycle (decommissioning phase):*
        - *High irreplaceability of resources (project will destroy unique resources that cannot be replaced, i.e. this is the least favourable assessment for the environment);*
        - *Moderate irreplaceability of resources;*
        - *Low irreplaceability of resources; or*
        - *Resources are replaceable (the affected resource is easy to replace/rehabilitate, i.e. this is the most favourable assessment for the environment).*

*Some of the criteria are quantitative (e.g. spatial extent and duration) and some may be described in a quantitative or qualitative manner (e.g. reversibility and irreplaceability). The specialist then combines these criteria in a qualitative manner to determine the **consequence**.*

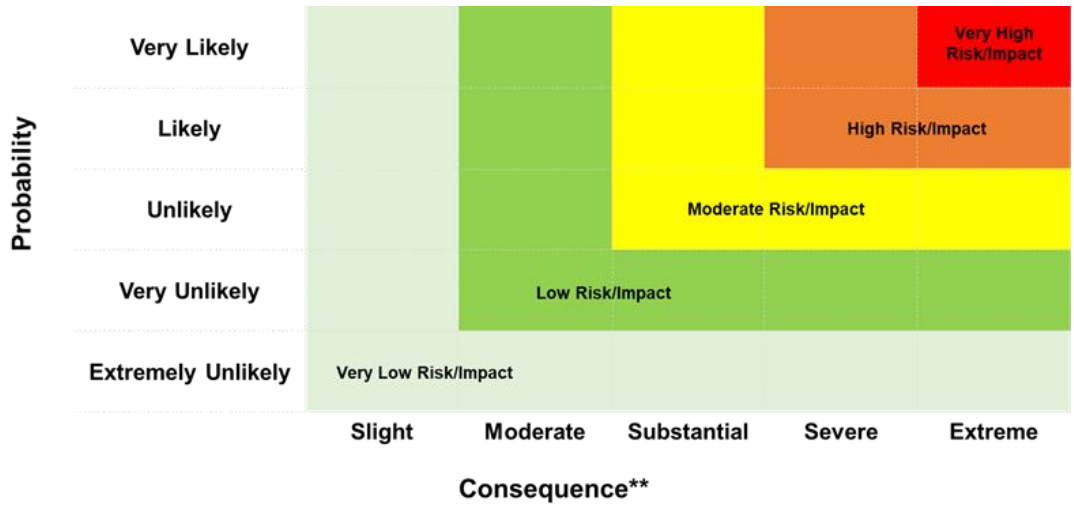
The consequence terms ranging from slight to extreme must be calibrated per Specialist Study so that there is transparency and consistency in the way a risk/impact is measured. For example, from a biodiversity and ecology perspective, the consequence ratings could be defined according to a reduction in population or occupied area in relation to Species of Conservation Concern (SCC) status, ranging from slight consequence for defined areas of Least Concern, to extreme consequence for defined areas that are Critically Endangered. For example, from a social perspective, a slight consequence could refer to small and manageable impacts, or impacts on small sections of the community; a moderate consequence could refer to impacts which affect the bulk of the local population negatively or may produce a net negative impact on the community; and an extreme consequence could refer to impacts which could result in social or political violence or institutional collapse.

- ***Consequence** – The anticipated consequence of the risk/impact is generally defined as follows:*
    - *Extreme (extreme alteration of natural or socio-economic systems, patterns or processes, i.e. where environmental or socio-economic functions and processes are altered such that they permanently cease);*
    - *Severe (severe alteration of natural or socio-economic systems, patterns or processes, i.e. where environmental or socio-economic functions and processes are altered such that they temporarily or permanently cease);*
    - *Substantial (substantial alteration of natural or socio-economic systems, patterns or processes, i.e. where environmental or socio-economic functions and processes are altered such that they temporarily or permanently cease;*
    - *Moderate (notable alteration of natural or socio-economic systems, patterns or processes, i.e. where the natural or socio-economic environment continues to function but in a modified manner; or*
    - *Slight (negligible and transient alteration of natural or socio-economic systems, patterns or processes, i.e. where natural systems/environmental or socio-economic functions, patterns, or processes are not affected in a measurable manner, or if affected, that effect is transient and the system recovers).*

- ***Step 4**: Rate the **probability** of the impact/risk using the criteria below:*

    - ***Probability** – The probability of the impact/risk occurring:*
        - *Extremely unlikely (little to no chance of occurring);*
        - *Very unlikely (<30% chance of occurring);*
        - *Unlikely (30-50% chance of occurring)*
        - *Likely (51 – 90% chance of occurring); or*
        - *Very Likely (>90% chance of occurring regardless of prevention measures).*

- ***Step 5**: Use both the **consequence** and **probability** to determine the **significance** of the identified impact/risk (qualitatively as shown in Figure 1). Significance definitions and rankings are provided below:*



[Qualitatively determined based on Spatial Extent, Duration, Reversibility and Irreplaceability]

Figure 6: Guide to assessing risk/impact significance as a result of consequence and probability.

- ***Significance*** *– Will the impact cause a notable alteration of the environment?*
  - *Very low (the risk/impact may result in very minor alterations of the environment and can be easily avoided by implementing appropriate mitigation measures, and will not have an influence on decision-making);*
  - *Low (the risk/impact may result in minor alterations of the environment and can be easily avoided by implementing appropriate mitigation measures, and will not have an influence on decision-making);*
  - *Moderate (the risk/impact will result in moderate alteration of the environment and can be reduced or avoided by implementing the appropriate mitigation measures, and will only have an influence on the decision-making if not mitigated);*
  - *High (the risk/impact will result in major alteration to the environment even with the implementation on the appropriate mitigation measures and will have an influence on decision-making); and*
  - *Very high (the risk/impact will result in very major alteration to the environment even with the implementation on the appropriate mitigation measures and will have an influence on decision-making (i.e. the project cannot be authorised unless major changes to the engineering design are carried out to reduce the significance rating)).*

With the implementation of mitigation measures, the residual impacts/risks are ranked as follows in terms of significance:

- *Very low = 5;*
- *Low = 4;*
- *Moderate = 3;*
- *High = 2; and*
- *Very high = 1.*

The specialists must provide a written supporting motivation of the assessment ratings provided.

- ***Step 6****: Determine the* ***Confidence Level*** *– The degree of confidence in predictions based on available information and specialist knowledge:*
  - *Low;*
  - *Medium; or*
  - *High.*

11. APPENDIX B: GEOTECHNICAL INFORMATION

11.1 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 9: Strength and deformation characteristics of some Karoo Sandstones (Brink, 1983).

		Vryheid Formation*			Estcourt Formation			
		UCS (MPa)	E_t (GPa)	Bulk density (kg/m³)	UCS (MPa)	$E_{t(50)}$ (GPa)	Poisson's ratio ν	Bulk density (kg/m³)
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 10: Geotechnical properties of Ecca Group sandstone at Matimba Power Station (Brink, 1983).

		Density (kg/m³)	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 11: 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.

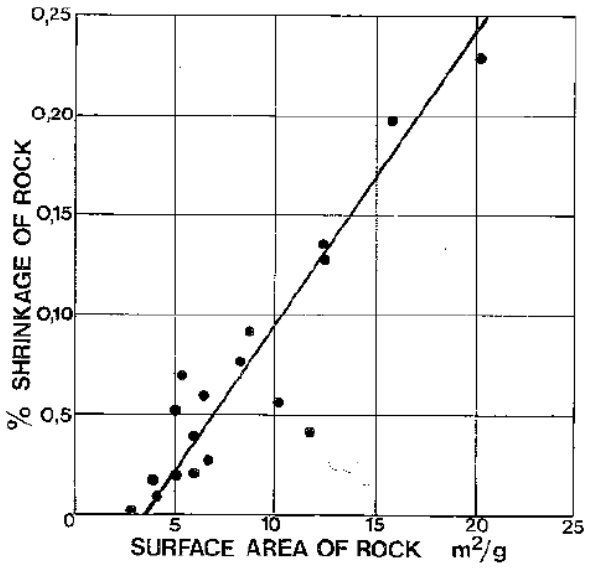


Figure 7: Relation between shrinkage and surface area for a variety of rocks including Karoo sandstone (Brink, 1983).

Table 12: 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 13: 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

11.2 ***Dolerite (Zone B)***

Dolerite has been extensively used as a concrete aggregate because of its sound properties and widespread occurrence in the Karoo (Brink, 1983). Some caution is required when it is considered to use certain marginal basalt-like phases of dolerite sills and dykes as sources of aggregate as these rocks may contain volcanic glass, or its alteration product palagonite which may react deleteriously with certain cements causing shrinkage cracks in concrete (Brink, 1983).

Dolerite is also a very useful source as a road construction aggregate. In bituminous surfacing, the adhesive properties of crushed fresh dolerite are usually satisfactory however, rock from chill zones could be insufficiently adhesive. With regards to subbase and base layers, freshly crushed dolerite is also an ideal aggregate. However, environmental conditions (Weinert N-value) and the stage of weathering must receive careful attention where dolerite is selected as natural gravel as this can have potential catastrophic consequences on pavement layers (Brink, 1983).

In areas where the where the Weinert N-value is more than 5 it is unlikely to encounter foundation problems on weathered dolerite, except where the soil profile contains transported soils with poor founding characteristics (Brink, 1983).

Table 14: 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)	Abrasive-ness (mass loss) (g)	Energy consumed during rod-milling (kWh/kg)	Proto-dyakonov 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 Ver-woerd 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 15: 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	285	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	0,080	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	23,2	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	26,6	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 Excavations for wall and abutments	B Quarry A	C Quarry B	A Lower quarry	B 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

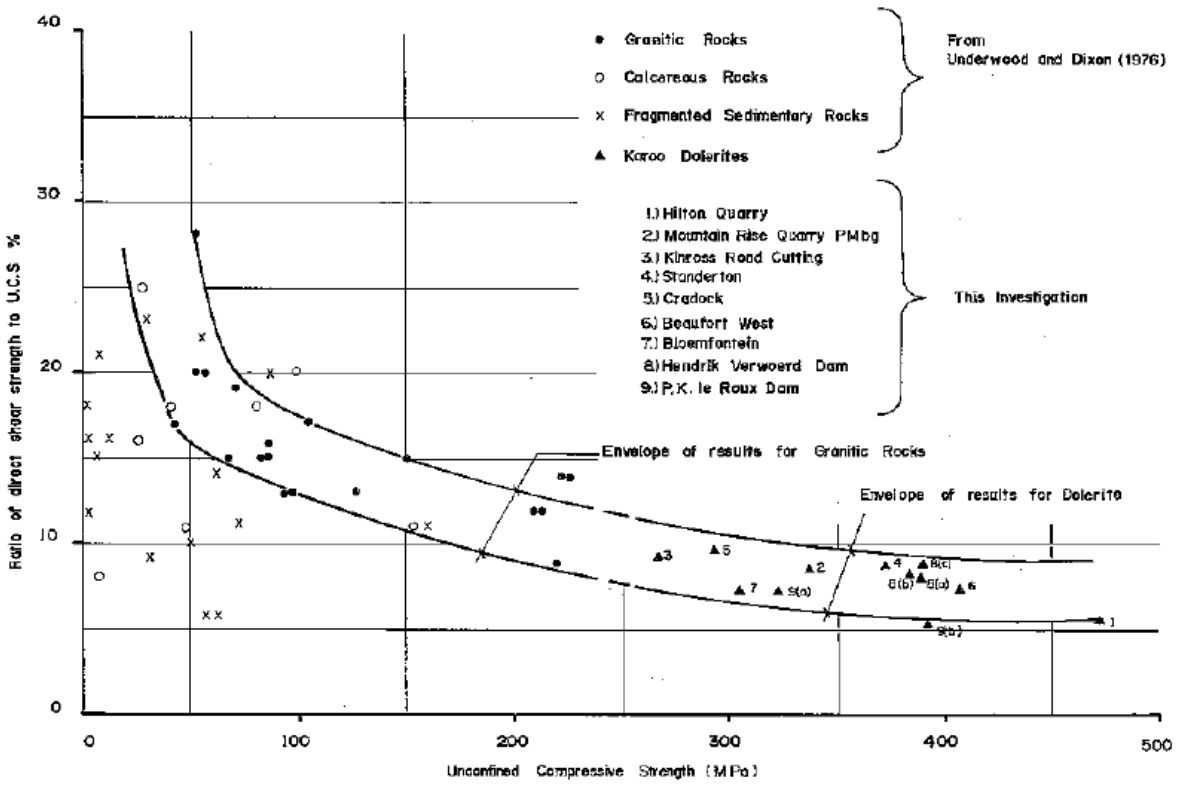


Figure 8: Variations of the shear strength to unconfined compressive strength ratio with the UCS for dolerite compared with other rock types (Brink, 1983).

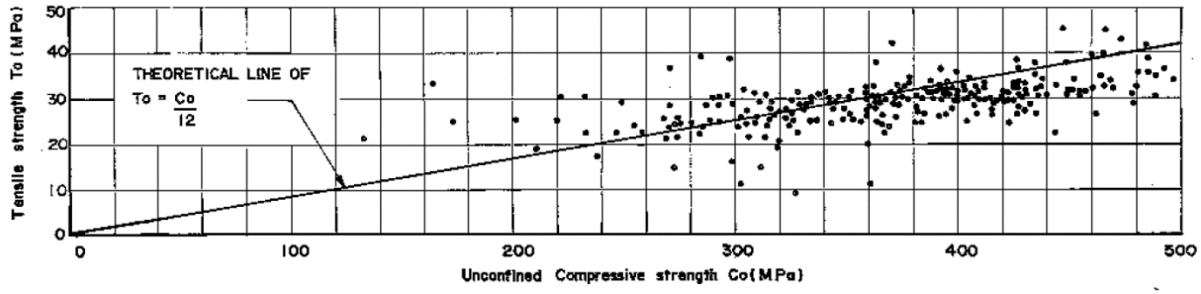


Figure 9: Relation between tensile strength and UCS of fresh dolerite specimen from South Africa (Brink, 1983).

Table 16: Weathering classes and characteristics of dolerite in South Africa (Brink, 1983).

Proposed class	Characteristics	Excavation	Grade of weathering according to AEG (1978)	Grade of weathering according to 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 17: 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	2 008	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	0,06	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 18: 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 19: 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

11.3 ***Quaternary Sediments (Zone C)***

Fine grained clay rich alluvial deposits can potentially present an expansive character. Such deposits have been encountered in drainage channels in a similar climatic and geological setting (Van Rooyen, 2012). Investigation of these potential geotechnical risk factors through intrusive techniques is essential. Finally, coarse grained material from Zone C could potentially serve as a base aggregate for road construction with adequate material characterisation, but not as fine aggregate in concrete (Brink, 1985).

12. APPENDIX C: SITE RECONNAISSANCE PHOTOGRAPHS



Figure 10: Photo taken of surficial material near MBH2.



Figure 11: Typical spiny scrub and shrubs supported by fine gravelly sand substrate on Farm 7/46 Middelvlei.



Figure 12: Drainage channel encountered in central area within Farm 7/46 Middelvlei.

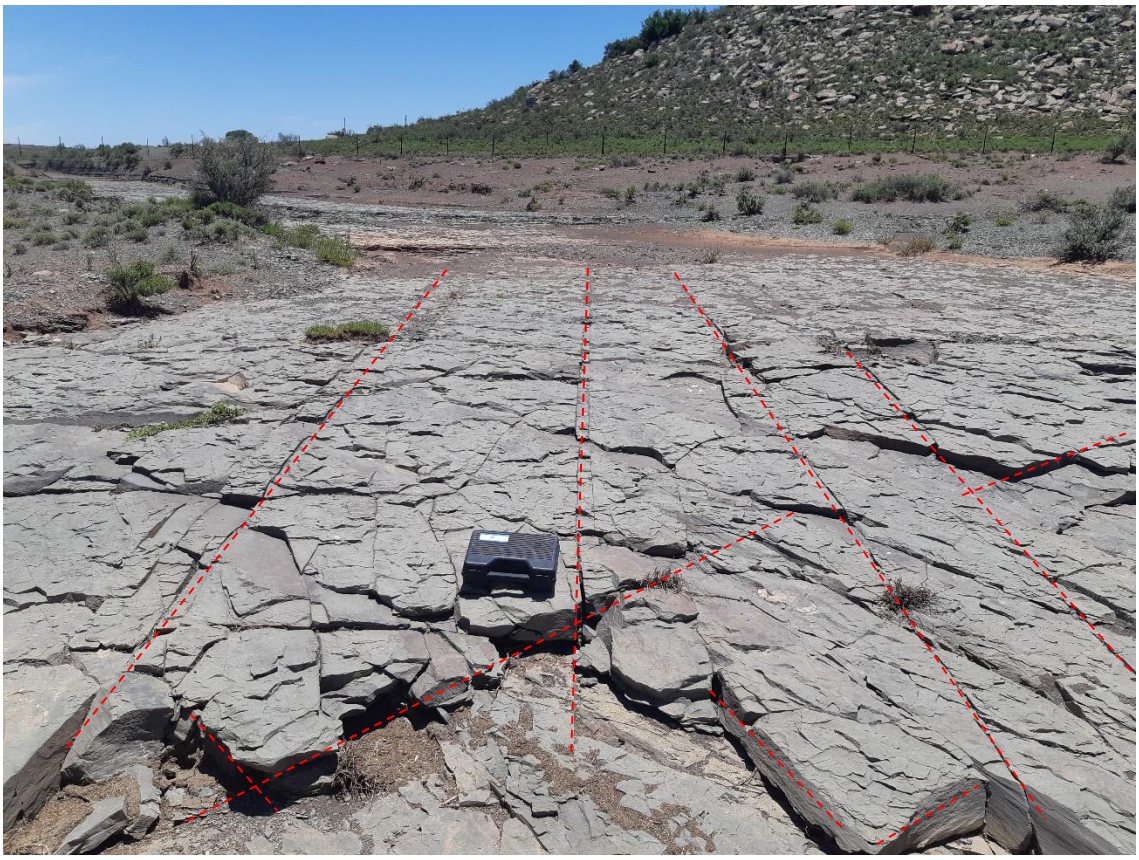


Figure 13: Fractured/jointed nature (annotated in red) of mudrocks and shales of the Karoo Supergroup observed near D1.



Figure 14: Surface materials consisting of angular sandy fine gravels (colluvium) with occasional rounded dolerite cobbles encountered near MBH22.



Figure 15: Well developed soil profile encountered in drainage channel north of MBH21; note lenses of angular coarse gravel suspended in sand-dominated soil profile.



Figure 16: Typical plateau landforms separating often wide drainages, photograph captured on road between Murraysburg and Richmond.



Figure 17: Surface texture of Murraysburg-Aberdeen/Nelspoort road that appears to be well-maintained, captured south of Murraysburg. Aggregate mainly comprises angular dolerite fragments that appears to be well-graded, with some shales and siltstone fragments (which have presumably been blended to achieve adequate binding of the surface).



Figure 18: Close-up of dolerite and mudstone fragments picked out of gravel road.



Figure 19: Example of typical woolsack weathering of dolerite outcrops, encountered across the Study Area.

13. APPENDIX D: SPECIALIST DECLARATION

(Last page)

forestry, fisheries
& the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

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SPECIALIST DECLARATION FORM – AUGUST 2023

Specialist Declaration form for assessments undertaken for 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)

REPORT TITLE

Basic Assessment for the proposed development of the Padloper Solar PV Facility 6 (i.e., Padloper PV 6), the proposed development of 132 kV Electrical Grid Infrastructure between the proposed Padloper PV 4 and the proposed Padloper PV 6 (i.e., Padloper EGI 6), and their associated infrastructure, near Murraysburg in the Western Cape Province

Kindly note the following:

1. This form must always be used for assessment that are in support of 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 August 2023. 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.dffe.gov.za/documents/forms.
3. An electronic copy of the signed declaration form must be appended to all Draft and Final Reports submitted to the department for consideration.
4. The specialist must be aware of and comply with '*the Procedures for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the act, when applying for environmental authorisation - GN 320/2020)*', where applicable.

1. SPECIALIST INFORMATION

Title of Specialist Assessment	Basic Assessment
Specialist Company Name	GEOSS SA (Pty) Ltd
Specialist Name	Shane Teek
Specialist Identity Number	[redacted]
Specialist Qualifications:	M.ENG (Geotechnical Specialist); BSc Hons Hydrogeology
Professional affiliation/registration:	SACNASP: 126397
Physical address:	[redacted]
Postal address:	
Postal address	
Telephone	
Cell phone	
E-mail	

2. DECLARATION BY THE SPECIALIST

I, Shane Teek declare that –

- I act as the independent specialist in this application;
- I am aware of the procedures and requirements for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (NEMA), 1998, as amended, when applying for environmental authorisation which were promulgated in Government Notice No. 320 of 20 March 2020 (i.e. "the Protocols") and in Government Notice No. 1150 of 30 October 2020.
- 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 NEMA Act.



Signature of the Specialist

GEOSS SA (Pty) Ltd

Name of Company:

14 Aug 2023

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, _ Shane Teekl_____, 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 SA (Pty) Ltd

Name of Company

14 August 2023

Date

Click or tap here to enter text.

Signature of the Commissioner of Oaths

14 August 2023

Click or tap to enter a date.

Date

forestry, fisheries
& the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

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1. SPECIALIST INFORMATION

Title of Specialist Assessment	Basic Assessment
Specialist Company Name	GEOSS SA (Pty) Ltd
Specialist Name	Dale Barrow
Specialist Identity Number	[redacted]
Specialist Qualifications:	MSc Geohydrology- Principal Geohydrologist
Professional affiliation/registration:	SACNASP: 400289/13
Physical address:	[redacted]
Postal address:	
Postal address	
Telephone	
Cell phone	
E-mail	

2. DECLARATION BY THE SPECIALIST

I, Dale Barrow declare that –

- I act as the independent specialist in this application;
- I am aware of the procedures and requirements for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (NEMA), 1998, as amended, when applying for environmental authorisation which were promulgated in Government Notice No. 320 of 20 March 2020 (i.e. "the Protocols") and in Government Notice No. 1150 of 30 October 2020.
- 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 NEMA Act.



Signature of the Specialist

GEOSS South Africa (Pty) Ltd

Name of Company:

14 Aug 2023

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, _ Dale Leith Barrow_____, 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 (Pty) Ltd

Name of Company

14 August 2023

Date

Click or tap here to enter text.

Signature of the Commissioner of Oaths

14 Aug 2023

Date

forestry, fisheries
& the environment

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Title of Specialist Assessment	Basic Assessment
Specialist Company Name	GEOSS South Africa (Pty) Ltd
Specialist Name	Hardwig Luttig
Specialist Identity Number	[redacted]
Specialist Qualifications:	Geotechnical Specialist: MEng
Professional affiliation/registration:	
Physical address:	[redacted]
Postal address:	
Postal address	
Telephone	
Cell phone	
E-mail	

2. DECLARATION BY THE SPECIALIST

I, Hartwig Luttig declare that –

- I act as the independent specialist in this application;
- I am aware of the procedures and requirements for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (NEMA), 1998, as amended, when applying for environmental authorisation which were promulgated in Government Notice No. 320 of 20 March 2020 (i.e. "the Protocols") and in Government Notice No. 1150 of 30 October 2020.
- 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 NEMA Act.



Signature of the Specialist

GEOSS SA (Pty) Ltd

Name of Company:

14 Aug 2023

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, _ Hartwig Luttig_____, 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 SA (Pty) Ltd

Name of Company

14 August 2023

Date

Click or tap here to enter text.

Signature of the Commissioner of Oaths

14 August 2023

Date