GEOLOGICAL REPORT

SPECIALIST INPUT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED WATERBERG PHOTOVOLTAIC PLANT NEAR VAALWATER, LIMPOPO PROVINCE

Technical Report No: OGS2010-08-12-3

August 2010

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List of abbreviations and definitions

The study area:	The area as delineated on **Figure 1**
EIA:	Environmental Impact Assessment
PV:	Photovoltaic
EMP:	Environmental Management Plan
AMSL:	Above mean sea level
NGL:	Natural Ground Level
ECO:	Environmental Control Officer
Ma:	Million years ago
Mokolian:	The geological time period from 2050 to 900 Ma

1. INTRODUCTION

1.1. Background

Thupela Energy is in the process of carrying out the Environmental Impact Assessment (EIA) phase for the proposed Waterberg Photovoltaic Plant near Vaalwater in the Limpopo Province. The proposed activity is defined as the establishment of a photovoltaic plant including an array of photovoltaic panels and associated infrastructure, including:

- A switching station for the "turn in" into Eskom's existing Mink Power Line
- An extraction point and low volume water supply pipeline for the extraction of water from existing on-site boreholes
- Access roads within the site for the purposes of construction and limited maintenance
- Workshop, laydown and storage areas
- A Visitors Centre

The proposed activity is located on Portion 2 of the Farm Goedgevonden KR 104, which lies approximately 24 km north east of the town of Vaalwater in the Limpopo Province. No alternative site have been proposed as the identified site has been selected following an extensive site selection process.

1.2. Legislation

In terms of the EIA regulations published in terms of Section 24(5) of the National Environmental Management Act (NEMA, No 107 of 1998), the applicant requires environmental authorisation from the National Department of Environmental Affairs (DEA) (in consultation with the Limpopo Department of Economic Development, Environment and Tourism) for the undertaking of the proposed project. This specialist study fulfils the requirements under section 33 of the EIA regulations i.t.o. NEMA, published in Government Gazette R385 of 2006.

1.3. Terms of reference

Savannah Environmental (Pty) Ltd has been appointed by Thupela Energy (i.e. the applicant) to carry out the EIA process for the proposed activity. Specialist geological input is required in order to assess the environmental impacts on the geology and soil profile over the identified study area. Savannah Environmental (Pty) Ltd has appointed Outeniqua Geotechnical Services to conduct a specialist geological study of the study area.

The following broad scope of work has been given:

- Carry out a desk-top study of available information pertaining to the geology and soil types of the study area and the environmental impacts on the geological environment that are likely to be associated with the proposed activity. This was undertaken as part of the Scoping Phase.
- Conduct a site visit to collect visual data pertaining to the geology, soil types and potential soil degradation issues.

- Conduct a geological impact assessment and prepare a report on the findings, the results of which will be used to compile the EIA Report.

The following aspects are covered in this report:

- A description of the environment that may be affected by the activity (the study area);
- A description of the geology and soil types in the study area;
- Assess the potential environmental impacts that may arise from the establishment of the proposed facility on the soil profile and other geological features (with emphasis on erosion and soil degradation);
- Provide mitigating measures for the Environmental Management Plan (EMP) to manage and/or mitigate potential impacts.

In addition to this, a preliminary indication of the potential geotechnical constraints on the proposed project is provided. These constraints may impact on the engineering design of access roads and foundations, and include such issues as founding conditions and problem soils, groundwater problems, excavatability, sources of natural construction material, etc.

1.4. Limitations

Information provided in this specialist report has been based on information provided by Savannah Environmental (Pty) Ltd, published scientific literature and maps. The study area was visited briefly but no detailed soil investigation (trial pits, soil testing), geomorphological or geohydrological assessment or verification of the existing geological mapping was conducted. The information provided in this report is deemed adequate for the EIA process and preliminary planning phase but further geotechnical information may be required for the detailed design phase.

1.5. Authors credentials & declaration of independence

The author of this report, Iain Paton of Outeniqua Geotechnical Services cc (OGS), is a professional engineering geologist registered with the South African Council of Natural and Scientific Professions (Pr Sci Nat # 400236/07) with 12 years experience in the mining, petroleum and construction industries and is a member of the South African Institute of Engineering and Environmental Geologists. Iain Paton declares that he does not have any financial interest in the undertaking of the activity, other than remuneration for work performed in the compilation of this specialist report.

2. SITE DESCRIPTION

2.1. Location

The facility is proposed to be established on agricultural land on a portion of Portion 2 of the Farm Goedgevonden KR 104, located approximately 24 km east of Vaalwater within the Modimolle Local Municipality, Limpopo Province (see **Figure 1**). The study area can be accessed via the R33 from Modimolle to Lepahalale. Pretoria is the nearest major commercial centre, 200km to the south. The site falls outside of the boundary of the Waterberg Biosphere Reserve. The larger site covers an area of approximately 50 ha, with the development footprint for the proposed facility being approximately 20 ha, but not more than 30 ha. The location of the facility within the larger site will be informed by the outcomes of the EIA process.

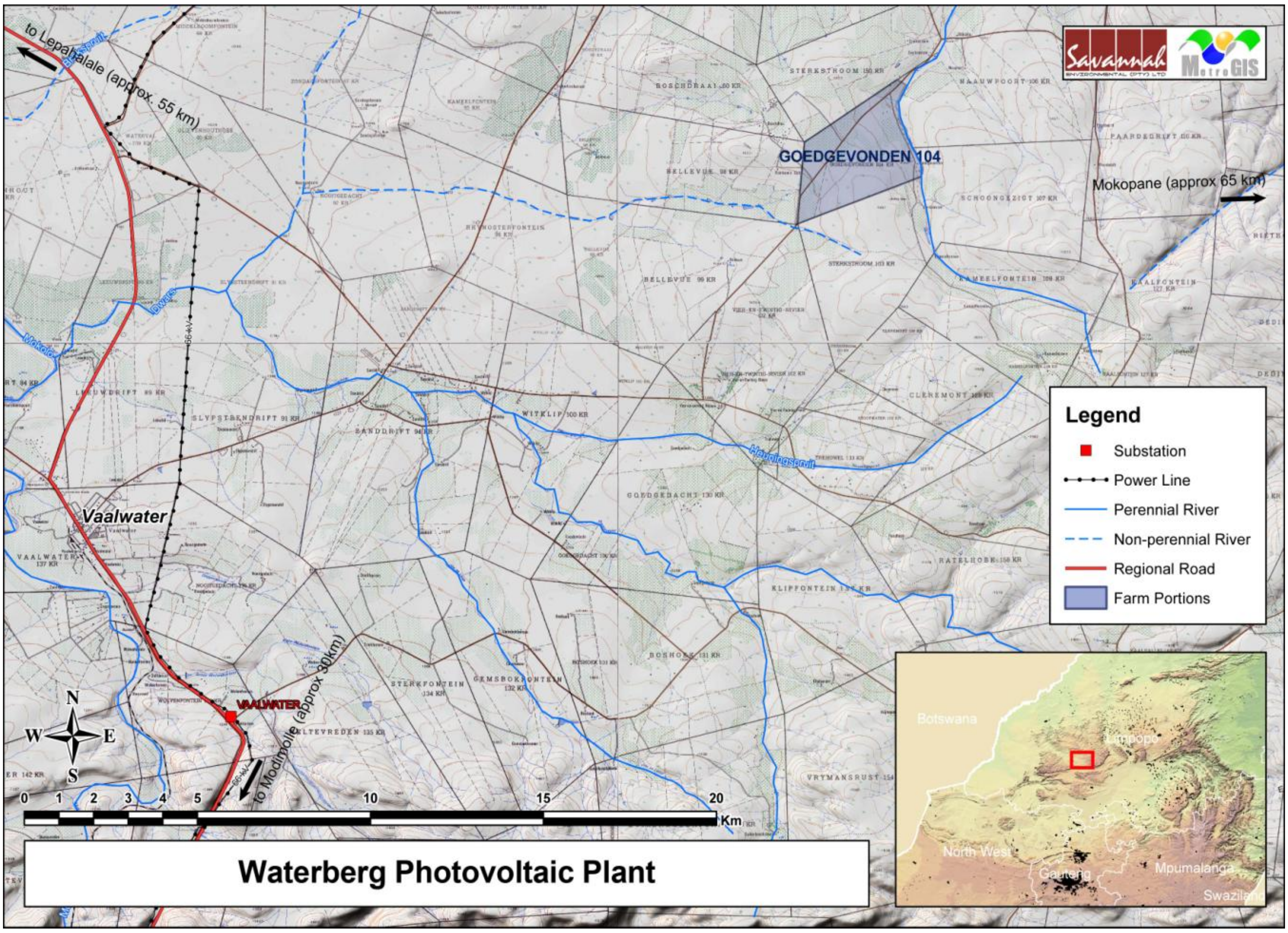

Figure 1: Locality map of Farm Goedgevonden KR 104 (blue shaded area)

2.2. Topography, climate & vegetation cover

The study area is located on the Waterberg massif which can best be described as an "inverted saucer" stretching from Modimolle and Mokopane in the east to Thabazimbi and Lephalale in the west. Within the central core is a vast basin plateau dissected by numerous rivers.

The topography of the study area slopes gently from southwest to northeast from 1400m to 1360m AMSL. A gravel road runs along the eastern border of the study area, parallel with the Melkrivier which drains the area.

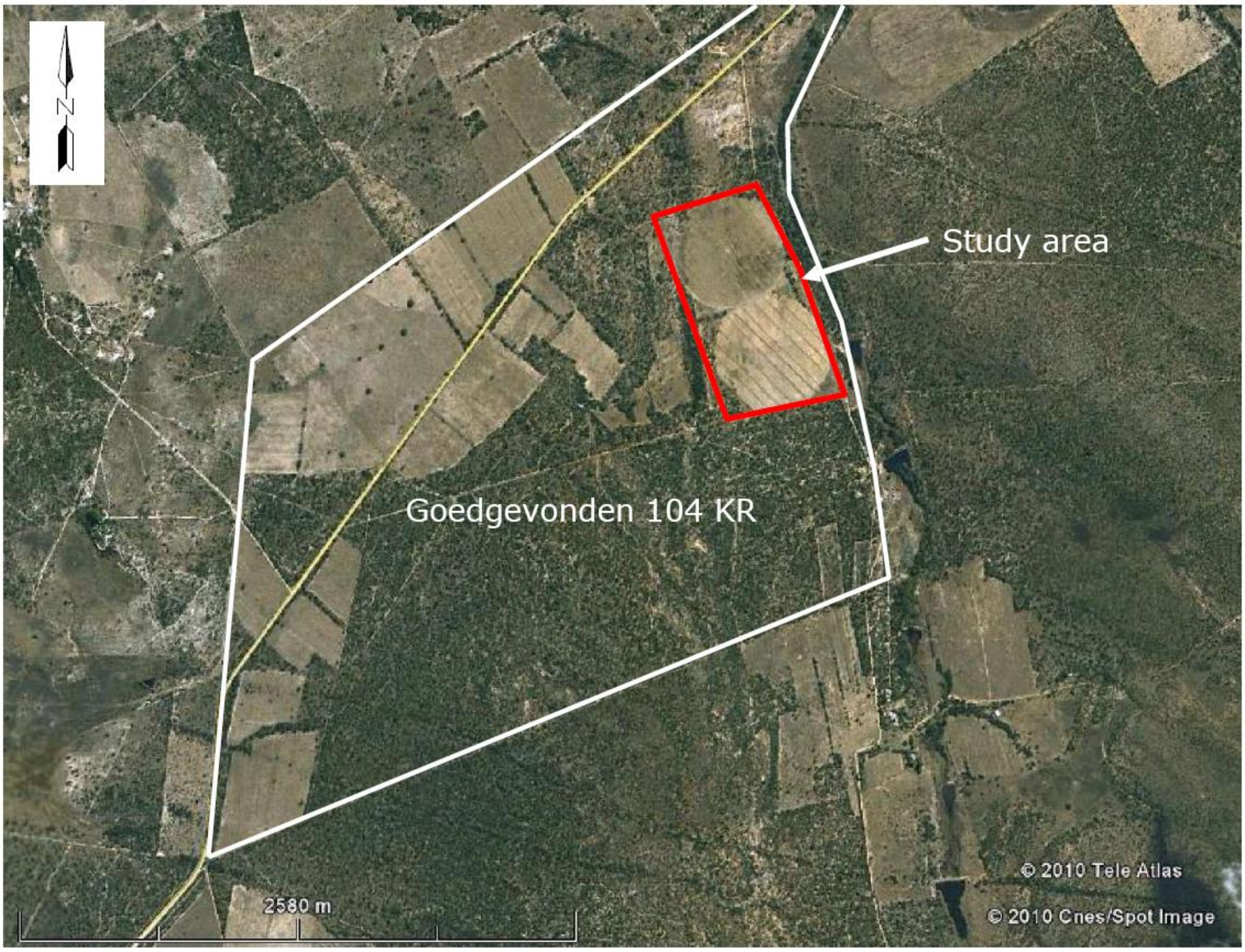

Figure 2: Aerial photo of the study area (red line) within the Farm Goedgevonden KR104 (white lines)

The Weinert Climatic N-number[7] for the area, which is between 4 and 5, indicates that the climate is semi-humid and chemical and mechanical weathering processes are at play, the former being slightly dominant. Mean annual precipitation for this region is approximately 500-700mm, falling mainly in October to April.[2]

The study area is cultivated ground which has been almost completely cleared of natural bushveld vegetation and is presently covered with grass. Anti-erosion berms have been constructed across the fields parallel to the contours. These berms are visible in the circular cultivated fields in **Figure 2**.

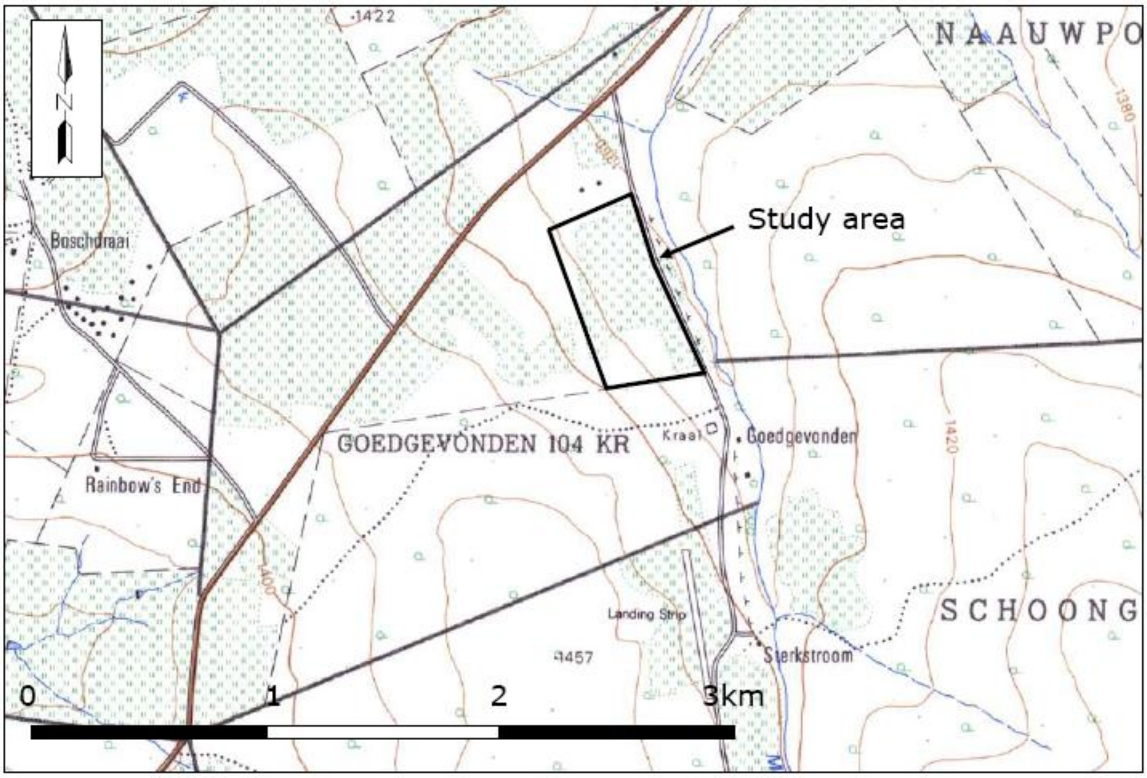

Figure 2: Topographical map of the study area

2.3. Geology & soil types

The plateau that makes up the Waterberg consists of a thick sequence of sandstone and conglomerate, dated at 1900Ma. According to the 1:250 000 Geological Map published by the Council for Geoscience (see **Figure 3**), the bedrock geology of the study area is Cleremont Formation of the Kransberg Subgroup, Waterberg Group (Mokolian Stage of the Precambrian era) which predominantly consists of coarse grained sandstone.

Outcrops of dark to light red orange or light brown, profusely cross-bedded sandstone occur only in the northwestern corner of the site. On the remaining majority of the site, this sandstone bedrock is covered by dark red orange to light brown, fine to medium grained, silty sand which is more than 1m thick (see **Figure 4**).

Surficial soil permeability is expected to be moderate to high with a perched water table potentially developing on weathered sandstone at a depth exceeding 1m over most of the site.

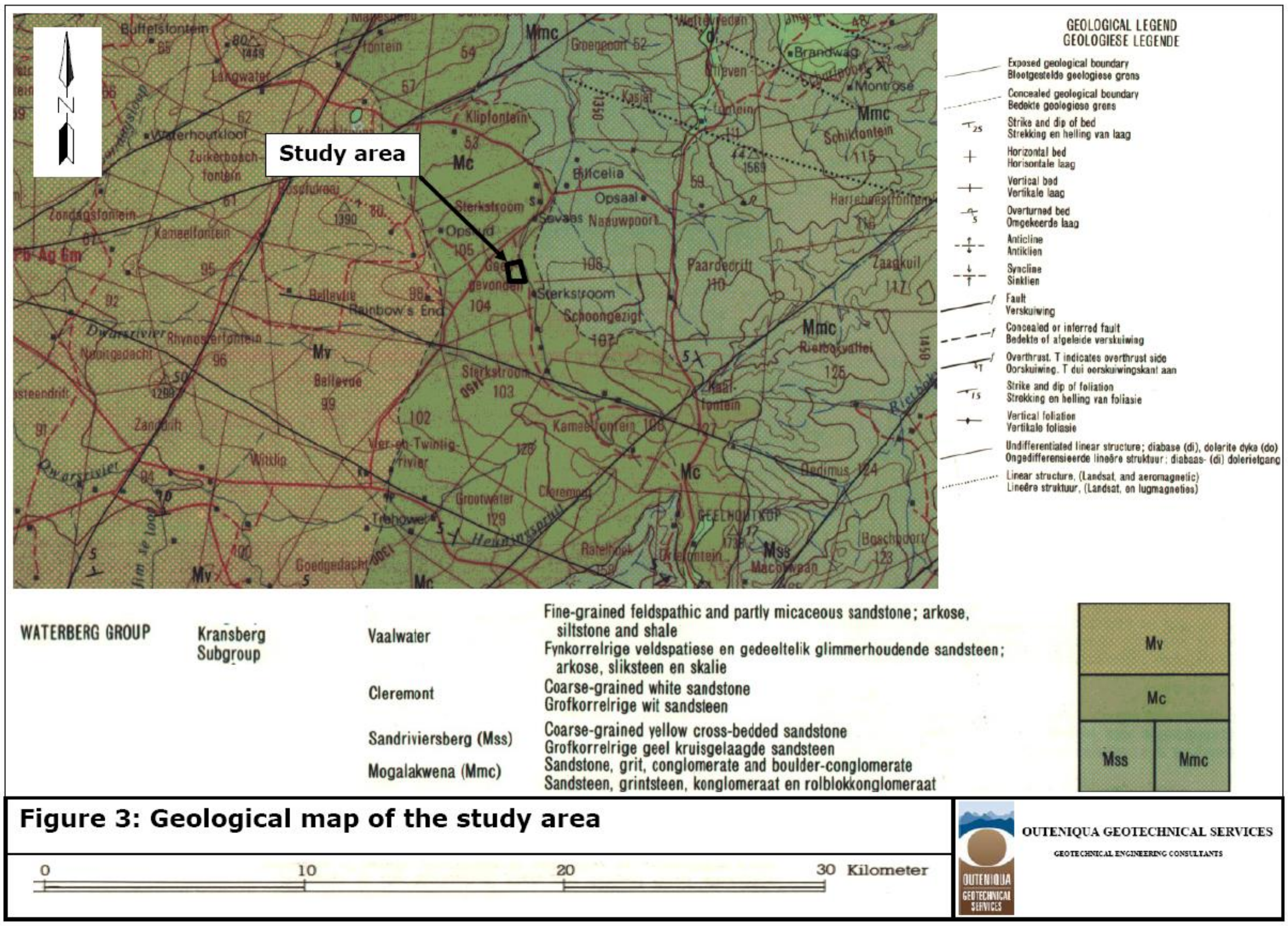

Figure 3: Geological map of the study area.

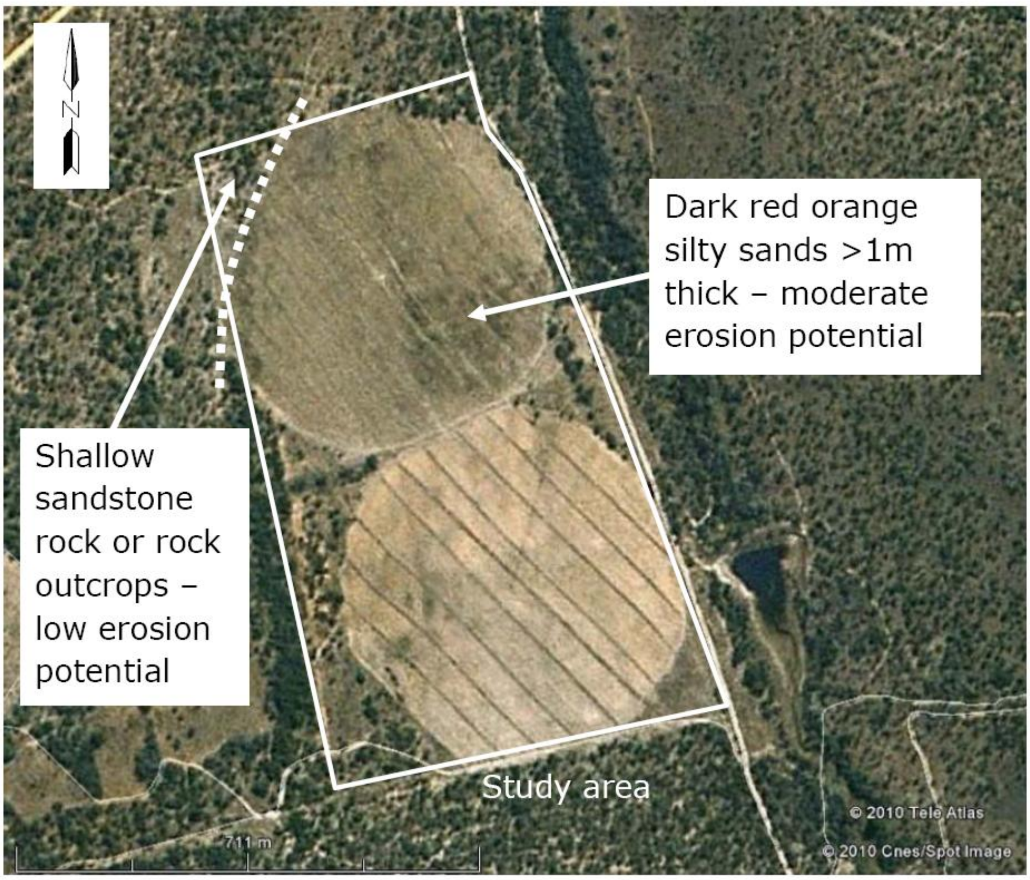

Figure 4: Soil types and erosion sensitivity map of the study area.

2.4. Hydrology

Surface runoff is the water flow that occurs when soil is infiltrated to full capacity and excess water from rain or other sources flows over the land. This run-off is a major contributing factor influencing potential erosion. Infiltration into the sandy soils on this site is likely to be high but will be restricted, to a certain extent, by the silt content which is variable. Sandy soils with high silt content are not be as permeable as sandy soils with low silt content.

The hydrology of the study area will play an important role in the erosion potential. Rainfall, if not intercepted by vegetation or artificial surfaces, falls on the earth where it may evaporate, infiltrate, lie in depression storage, or end up as surface run-off. The permeability of the ground influences the percentage of rainfall which infiltrates. Where soil cover is thin or impermeable, infiltration will tend to be lower and vice versa. Surface run-off is generally inversely proportional to infiltration, ceteris paribus. Rainfall intensity, infiltration, and slope gradient influence the volume, velocity, and energy of surface run-off. The energy of the hydraulic system and the soil texture and consistency are the main determining factors of the erosion potential. The presence of vegetation and other erosion inhibitors tend to reduce the energy of the hydraulic system as well as providing an anchoring effect on the soil mass.

In this particular area, the soils are moderate to highly permeable, the slope gradients are low and the vegetation cover is fairly well established which means that run-off is likely to be low. However, if vegetation is removed, serious erosion can occur during heavy downpours.

3. GEOLOGICAL IMPACT ASSESSMENT

The geological impact assessment aims to assess the impact that the proposed development will have on the geological environment which includes the parent rock and the natural soil profile. Important or prominent geological features (geosites) that contribute to the aesthetic scenery or geological interest in the area, such as fossil sites, prominent rock outcrops or features are also considered in the impact study. Geological features, such as caves, addits, middens, worship rocks, etc. which are important from an historical, cultural, archaeological or religious heritage standpoint are not assessed in this report as they are generally covered in the Heritage Impact Assessment. Geohydrological assessments also do not form part of this study.

At this stage, there are no known important or prominent geological features and the parent rock is unlikely to be detrimentally affected by the proposed activity, as no deep excavations are planned. Therefore, the impact on the natural soil profile is the primary focus of this study as it is important for the sustainability of the surrounding ecosystems.

3.1. Soil degradation

Soil degradation is the removal, alteration, or damage to soil and soil forming processes, usually due to human activity. The stripping of vegetation or disturbance to the natural ground level over disturbance areas will negatively affect soil formation, natural weathering processes, moisture levels, soil stability, humus levels, and biological activity. Soil degradation includes erosion (due to water and wind), salinisation, acidification, water-logging, pollution, soil mining and burial, compaction, and crusting[9].

Soil erosion is a natural process whereby the ground level is gradually lowered by wind or water action and may occur as a result of inter alia chemical or mechanical processes and/or physical transport on the land surface. Soil erosion that has been induced or increased by human activity is termed "accelerated erosion" and is an integral element of global soil degradation. Accelerated soil erosion is generally considered the most important geological impact in any development due to its potential impact on a local and regional scale (i.e. on and off site) and as a potential threat to agricultural production and self sufficiency. Soil erodibility is the susceptibility of soil to erosion and is a complex variable, not only because it depends on soil chemistry, texture and characteristics, but because it varies with time and other conditions[9]. In general, erodibility potential is increased where low-plasticity, fine grained soils occur. The Erosion Index for South Africa[10] indicates that the area where the study site is located has a moderate to low-moderate susceptibility to erosion. The erodibility index is determined by combining the effects of slope, geology and soil type, rainfall intensity and land use.

The proposed activity will include shallow excavation or displacement of soil, stockpiling, mixing, wetting and compaction of soil and pollution. These activities carry potential negative direct impacts contributing to soil degradation. These activities could also cause negative indirect impacts such as increased siltation into the Melkrivier to the east of the site causing negative impact on water sources and agriculture with socio-economic repercussions. The severity or significance of the potential impacts is related to the nature and extent of the proposed activity. There are no known positive impacts relating to the geological environment and the impacts are dominantly related to the construction phase with very little additional impacts in the post construction and decommissioning phases.

The soil erosion potential for the site is moderate due to the presence of erodible soils, but at present there is no sign of erosion taking place and this is largely due to the stabilising effect of the vegetation cover. Erosion will occur if vegetation is cleared and soil is loosened by construction activity. It is the aim of the environmental impact assessment to evaluate this impact and attempt to provide mitigating measures to manage the impact.

3.2. Degradation of parent rock

Apart from the impact on the overlying soil, excavations into bedrock may result in unsightly scars, resulting in potential visual impacts. However, it is unlikely that there will be any deep excavations into bedrock and therefore the impact is likely to be insignificant.

3.3. Assessment of impacts

The proposed activity involve minor earthworks associated with the construction of PV arrays, pipelines and foundations for structures such as a workshop, visitors centre, etc. Due to the very sandy nature of the soil at the study site, it is most likely that the buildings (i.e. the visitors centre) will be constructed with raft-type foundations. In this design no deep foundations are constructed, but instead a complete interconnected, re-enforced, 'raft' foundation is constructed on which the buildings can sit. If the sands should shift, the whole building will move with the raft, preventing cracking. The raft is positioned typically no more than 30 cm deep into the sand.

Concrete foundations will be constructed for the 'feet' of the PV panels. Foundation holes will be mechanically excavated to a depth of approximately 30 - 50 cm. The concrete foundation will be poured and will then be left up to a week to cure.

The most important geological issues are the direct impacts of soil degradation and erosion of topsoil from the area of activity. Other direct impacts would include the loss of agricultural potential of the area (not discussed in this report).

Indirect impacts could include increased siltation in nearby Melkrivier caused by an increase in erosion from the site and socio-economic impacts resulting from the loss of topsoil and lower agricultural potential.

Direct, indirect, and cumulative impacts are assessed in terms of the following criteria:

- The nature of the impact - what causes the impact, what will be impacted and how it will be impacted;
- The extent of the impact - whether it is local (limited to the immediate area or site of the development) or regional (on a scale of 1 to 5);
- The duration of the impact – whether it will be very short (less than 1 year), short (1-5 years), medium (5-15 years), long (>15 years) or permanent (on a scale of 1 to 5, respectively);
- The magnitude, quantified on a scale of 0-10, where 0 is small and will have no impact on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will have a slight impact on processes, 6 is moderate and will result in processes continuing, but in a modified way, 8 is high and processes are altered the extent that they temporarily cease, and 10 is very high and results in complete destruction of patterns and permanent cessation of processes;
- The probability of occurrence, which describes the likelihood of the impact actually occurring (on a scale of 1 to 5 – very improbable to definite);
- The significance, which is determined through a synthesis of the characteristics described above and is assessed as low, medium or high.
- The status, which is described as positive, negative or neutral;
- The degree to which the impact can be reversed;
- The degree to which the impact may cause the irreplaceable loss of resources;
- The degree to which the impact can be mitigated;
- The possibility of significant cumulative impacts of a number of individual areas of activity; and
- The possibility of residual impacts existing after mitigating measures have been put in place.

The significance is calculated by combining the criteria in the following formula:

$S = (E+D+M)P$

Where:
S = Significance weighting
E = Extent
D = Duration
M = Magnitude
P = Probability

The significance weightings for each potential impact are as follows:

<30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area);
30-60 points: Moderate (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated);
>60 points: High (i.e. where the impact will influence the decision to develop in the area).

3.3.1. Direct impacts

An assessment of the individual direct potential impacts associated with the proposed activity is outlined in Table 1.

Table 1: Assessment of potential direct impacts

Nature: Soil degradation – Removal of vegetation and topsoil under footprint of structures and access roads affecting soil formation processes on the site.		
	Without mitigation	**With mitigation**
Extent	Local (1)	N/A
Duration	Permanent (5)	N/A
Magnitude	Low (4)	N/A
Probability	Definite (5)	N/A
Significance	Moderate (50)	N/A
Status	Negative	
Reversibility	Irreversible	
Irreplaceable loss of resources?	Yes	
Can impacts be mitigated?	No	
Mitigation:	N/A	
Cumulative impacts:	The surrounding area is largely undeveloped agricultural land and there is no other development planned for the near future. The cumulative impact is therefore considered low at this stage.	
Residual impacts:	**N/A**	

Nature: Soil degradation – Pollution, salinisation, acidification, or water-logging of natural soil in construction areas affecting soil formation processes.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Short term (2)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	Moderate (30)	Low (21)
Status	Negative	Negative

Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	Minor	Insignificant
Can impacts be mitigated?	Yes	
Mitigation:	• Minimise disturbance areas by limiting construction act ivies to designated construction areas • Minimise activity within disturbance areas • Rehabilitate soil and vegetation • Stage earthworks in phases across site so that exposed areas are minimised • Keep to existing roads, where practical, to minimise impacts on undisturbed ground	
Cumulative impacts:	The surrounding area is undeveloped agricultural land and there is no other development planned in the near future. Therefore the cumulative impact is considered low at this stage.	
Residual impacts:	Minor negative – slow regeneration of vegetation & soil	

Nature: Soil degradation – Mixing, stockpiling and compaction of topsoil affecting soil formation processes.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Very short term (1)
Magnitude	Moderate (6)	Low (4)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	Moderate (40)	Low (24)
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	Yes	Yes, minor
Can impacts be mitigated?	Yes	
Mitigation:	• Minimise disturbance areas over which mixing, stockpiling occurs • Minimise activity within disturbance areas (prevent unnecessary excavations and stockpiling) • Re-use soil from excavations for landscaping or remove off site – don't leave stockpiles after construction on-site • Restrict number of access roads and minimise traffic • Rehabilitate soil and vegetation in areas of activity • Keep to existing roads, where practical, to minimise impact on undisturbed ground • Stage earthworks in phases to minimise exposed ground	
Cumulative impacts:	The surrounding area is undeveloped agricultural land and there is no other development planned in the near future. The cumulative impact is considered low at this stage.	
Residual impacts:	Minor negative – slow regeneration of soil processes in and under topsoil	

Nature: Soil degradation – Increased sheet, rill or gulley erosion and deposition down-slope due to the removal of vegetation and other activity in construction areas		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Medium term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Highly probable (4)	Highly probable (4)
Significance	Moderate (40)	Moderate (32)
Status	Negative	Negative

Reversibility	Practically irreversible	Practically irreversible
Irreplaceable loss of resources?	Moderate	Minor
Can impacts be mitigated?	Yes	
Mitigation:	• Restrict the size of disturbance areas • Minimise activity within designated disturbance areas • Implement effective erosion control measures, such as log terraces, erosion barriers/silt fences, etc. • Stage construction in phases to minimise exposed ground • Keep to existing roads, where practical, to minimise impact on undisturbed ground • Ensure stable slopes of stockpiles/excavations to minimise slumping	
Cumulative impacts:	The surrounding area is undeveloped agricultural land and there is no other development planned in the foreseeable future. The cumulative impact is considered low at this stage.	
Residual impacts:	Minor – Localised movement of sediment and slow regeneration of soil processes	

Nature: Degradation of parent rock – Excavations and or blasting causing degradation to local geology and instability.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Low (3)	Minor (2)
Probability	Improbable (2)	Improbable (2)
Significance	Low (18)	Low (16)
Status	Negative	Negative
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Insignificant	Insignificant
Can impacts be mitigated?	To a certain degree	
Mitigation:	• Restrict zone of disturbance and plan excavations carefully. • Keep to existing roads, where practical, to minimise impacts on undisturbed ground.	
Cumulative impacts:	The surrounding area is undeveloped agricultural land and there is no other development planned in the foreseeable future. The cumulative impact is considered low at this stage.	
Residual impacts:	Insignificant	

The direct impacts range from a moderate to low significance, but if mitigated successfully the impact will be reduced to an overall low significance.

3.3.2. Indirect impacts

An assessment of the potential indirect impacts associated with the proposed activity is outlined in **Table 2** below.

Table 2: Assessment of potential indirect impacts

Nature: Soil degradation – Deposition/siltation down-slope affecting soil forming processes and siltation of waterways and dams		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (4)	Probable (3)
Significance	Moderate (48)	Low (30)
Status	Negative	Negative
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Moderate	Minor
Can impacts be mitigated?	Yes	
Mitigation:	• Minimise size and distribution of disturbance areas • Minimise activity within disturbance areas (no unnecessary activity) • Install anti-erosion measures such as silt fences in disturbance areas	
Cumulative impacts:	The surrounding area is undeveloped agricultural land and there is no other development planned in the near future. The cumulative impact is therefore considered low at this stage.	
Residual impacts:	Minor localised movement of soil across site	

The indirect impacts will have a moderate significance but can be mitigated to have an overall low significance.

3.3.3. Cumulative impacts

The cumulative impact is considered low owing to the undeveloped nature of the immediate surrounding area.

3.3.4. Impact statement

The presence of shallow rock or low rock outcrops has a significant reducing effect on the erosion potential on the northwestern corner of the site and therefore this area has a low erosion potential. The rest of the site has a moderate erosion potential, but with effective implementation of mitigating measures the impacts can be reduced to a low level and therefore there is no compelling reason, from a geological perspective, why environmental authorisation for the proposed activity cannot be granted.

3.4. Mitigating measures

Negative impacts can be mitigated and/or managed to a large degree by the implementation of an appropriate and effective EMP.

The objectives, impacts, risks, and mitigating measures that are required for inclusion in the EMP are outlined in **Table 3** below:

OBJECTIVE: Soil/rock degradation and erosion control

The natural soil on the site needs to be preserved as far as possible to minimise impacts on the environment. Soil degradation including erosion (by wind and water) and subsequent deposition elsewhere is of a concern across the entire site which is underlain by fine grained soil which can be mobilised when disturbed, even on relatively low slope gradients (accelerated erosion). Uncontrolled run-off relating to construction activity (excessive wetting, etc.) will also lead to accelerated erosion. Degradation of the natural soil profile due to the proposed shallow excavation, stockpiling, compaction, pollution and other construction activities will affect soil forming processes and associated ecosystems. Degradation of parent rock is considered low as there are no deep excavations envisaged.

A set of strictly adhered mitigation measures are required to effectively limit the impact on the environment. The disturbance areas where human impact is likely are the focus of the mitigation measures laid out below.

Project components	PV array modules
	Access roads
	Dining and kitchen facilities, visitors centre, crèche, offices, workshops and security buildings
	Underground and overhead pipes and power cabling
Potential Impact	Soil and rock degradation
	Soil erosion
	Increased deposition of soil into drainage systems
	Increased run-off over the site
Activities/risk sources	Construction activity – Removal of vegetation, excavation, stockpiling, compaction and pollution of soil
	Rainfall - water erosion of disturbed areas
	Wind erosion of disturbed areas
	Concentrated discharge of water from construction activity
Mitigation: Target/Objective	To minimise extent of disturbance areas
	To minimise activity within disturbance areas
	To minimise soil degradation (mixing, wetting, compaction, etc.)
	To minimise soil erosion
	To minimise deposition of soil into drainage lines
	To minimise instability of embankments/excavations

Mitigation: Action/control	Responsibility	Timeframe
Identify disturbance areas and restrict construction activity to these areas.	ECO/Contractor	Before and during construction

Restrict construction activity within disturbance areas.	ECO/Contractor	Before and during construction
Access roads to be carefully planned and constructed to minimise the impacted area and prevent unnecessary excavation, placement, and compaction of soil.	Engineer/ECO/ Contractor	Before and during construction
Dust control on construction site: Wetting of denuded areas.	Contractor	During construction
Minimise removal of vegetation which adds stability to soil.	ECO/Contractor	During construction
Rehabilitate disturbance areas as soon as an area is vacated.	Contractor	During and after construction
Soil conservation: Stockpile topsoil for re-use in rehabilitation phase. Protect stockpile from erosion.	Contractor	Before and during construction
Erosion control measures: Run-off attenuation on slopes (sand bags, logs), silt fences, stormwater catch-pits, shade nets or temporary mulching over denuded areas.	Contractor/ECO	Erection: Before construction Maintenance: Duration of contract
Where access roads cross natural drainage lines, culverts must be designed to allow free flow. Regular maintenance must be carried out.	Engineer/ECO/ Contractor	Before construction and maintenance over duration of contract
Control depth of excavations and stability of cut faces/sidewalls.	Engineer/ECO/ Contractor	Before construction and maintenance over duration of contract

Performance Indicator	• No activity outside disturbance areas • Acceptable level of activity within disturbance areas • Acceptable level of soil erosion around site • Acceptable level of increased siltation in drainage lines • Acceptable level of soil degradation • Acceptable state of excavations • No activity in restricted areas
Monitoring	• Regular inspections of the site • Fortnightly inspections of sediment control devices • Fortnightly inspections of surroundings, including drainage lines • Immediate reporting of ineffective sediment control systems

	• An incident reporting system will record non-conformances

Table 3: EMP guidelines

4. GEOTECHNICAL CONSTRAINTS

A basic preliminary assessment of the geotechnical nature of the study area affords the opportunity to identify any potential fatal flaws with the proposed site, in terms of the suitability of the site for development. A basic assessment of the main geotechnical constraints that may impact on the civil engineering design is given in **Table 4**.

Geotechnical Constraint	Effect on the proposed development	Severity	Comment & recommendations
Collapsible & compressible soil	Soil horizons with a potentially collapsible and/or compressible fabric hazardous to foundations.	Medium	Unconsolidated transported soils are potentially compressible and collapsible under load. Conventional compaction of soil will be adequate for light structures.
Differential settlement (DS)	Foundations placed across different soil types or rock may settle differentially.	Low-Medium	Recommend sound individual structures on same soil types.
Bearing capacity	Soils with low in situ bearing capacity resulting in high settlements of structures if not engineered properly	Medium	Transported sands: 50-80kPa, depending on level of consolidation.
Saturated soils, groundwater problems, perched or permanent water tables	Seepage from sidewalls of excavations affecting stability or dewatering of trenches necessary.	Low	No groundwater problems expected in shallow excavations.
Active soil	Heaving clays affecting foundation stability	Low	No active clay expected.
Excavations	Boulders or rock affecting excavations	Low	Difficult excavations (rock) expected in northwest corner only.
	Unstable excavations requiring shoring	Low-medium	Sidewalls of excavations exceeding 1m in unconsolidated sandy soils will be unstable. Temporary slopes to be battered to 1:2.
Slope stability	Geological instability causing damage to structures founded on slopes	Low	No unstable slopes in development footprint.
Seismic activity	Structures at risk of damage due to seismicity	Low	Limpopo Province is a potentially active seismic area but this is unlikely to affect development.
Flood potential or storm water damage	Low lying areas affected by poor drainage.	Low	Site is well drained.
	Steep slopes affected by uncontrolled run-off	Low	No steep slopes which could be unstable.
Unconsolidated fill	Unconsolidated fill material affecting foundations	Low	Minor fill along berms and pipelines

Geotechnical Constraint	Effect on the proposed development	Severity	Comment & recommendations
Availability of local construction material	Large distances to nearest quarry for sources of suitable construction material negatively affect construction costs	High	Nearest *major* centre is Pretoria (200km). Potential local sources of construction material (on site) are restricted to selected fill (sand).
Mining Activity	Past, present or future mining activity which may affect development of the site	Low	No known mining activity

Table 4: Geotechnical constraints on the proposed development

The above classification highlights some basic potential constraints, none of which are considered insurmountable. A detailed geotechnical investigation should be undertaken before the engineering design phase to provide more information. Geotechnical supervision or input is recommended during construction.

5. CONCLUSIONS

The site is underlain by transported silty sands and the soil erosion potential for the site is moderate. However, the topography is favourable and the vegetation is aiding the stability of the soil and as a result there is no sign of significant erosion on the site. This will change during construction and the envisaged impacts will carry a moderate significance which can be mitigated to a resultant low significance through effective implementation of the EMP.

A basic assessment of the potential geotechnical constraints on the project indicates no insurmountable problems or "fatal flaws" which have may have an impact on the design and construction processes.

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