GEOLOGICAL REPORT

SPECIALIST INPUT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED POFADDER SOLAR THERMAL FACILITY NEAR POFADDER, NORTHERN CAPE PROVINCE, SOUTH AFRICA

Technical Report No: OGS2010-09-14-1

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List of abbreviations and definitions

The study area:	The area as delineated on **Figure 1**
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Plan
AMSL:	Above mean sea level
NGL:	Natural Ground Level
Ma:	Million years before present
CSP:	Concentrating solar power
PV:	Photovoltaic
ECO:	Environmental Control Officer
ER:	Engineer's representative

1. INTRODUCTION

1.1. Background information and location

KaXu CSP is in the process of carrying out an EIA for the proposed Pofadder Solar Thermal Facility located on the farm Scuit-Klip 92 Portion 4, which is approximately 30km northeast of Pofadder in the Northern Cape. The study area is accessed via the N14, 170km from Upington, which is the nearest major commercial centre.

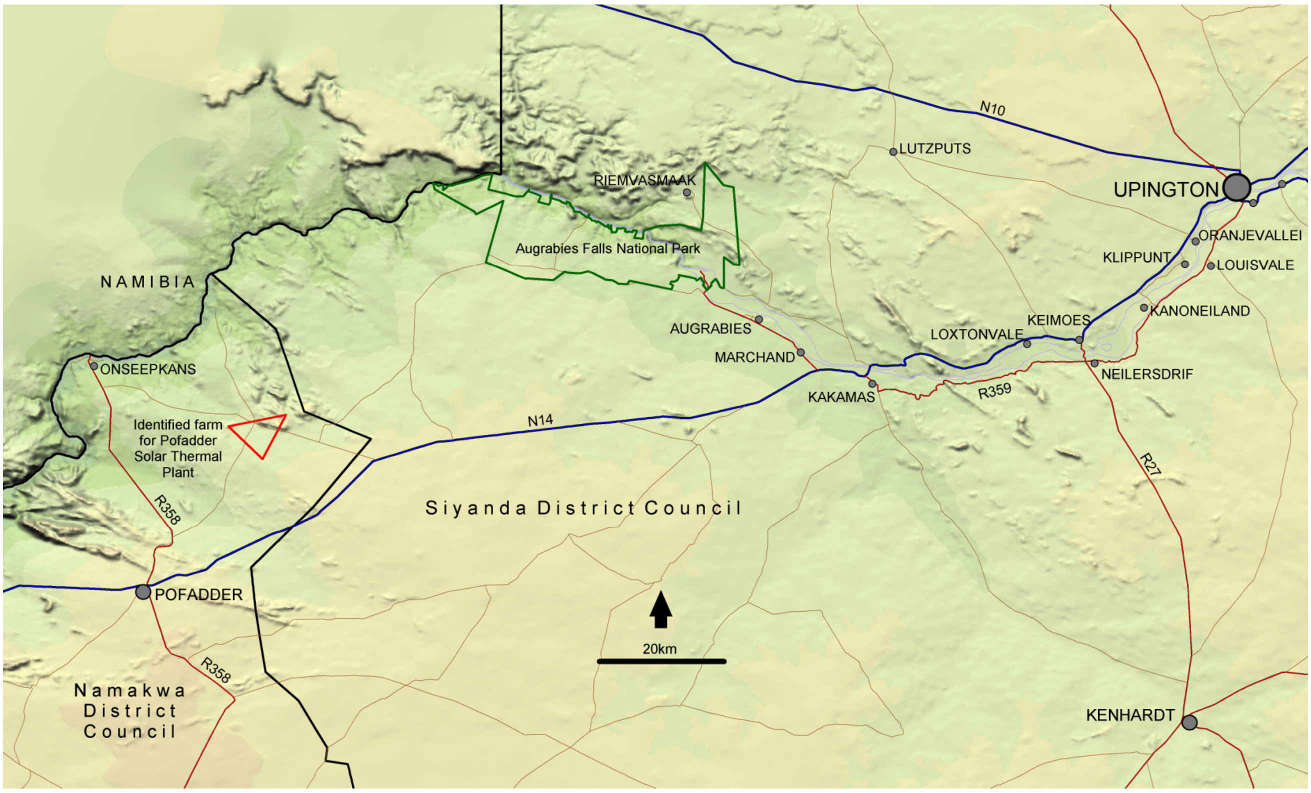


Figure 1: Locality map of study area

The proposed facility is expected to have a development footprint of approximately 1200ha within the broader site of 3300ha. The development footprint is the area which will be disturbed during the operational phase.

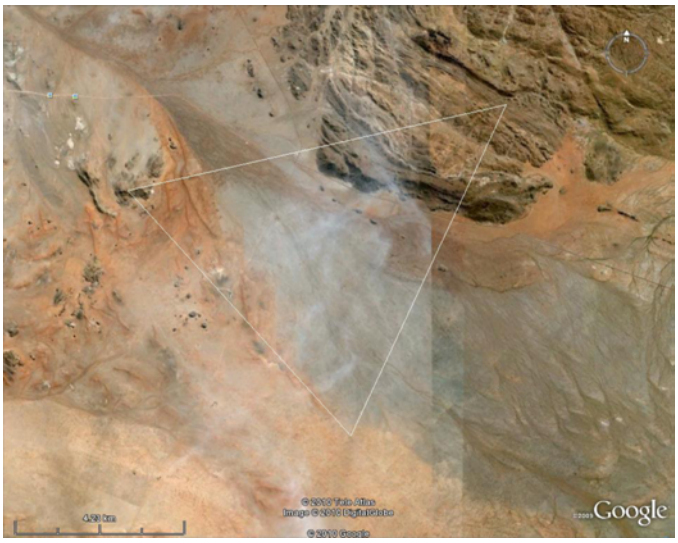


Figure 2: Aerial photo of the study area (white lines)

1.2. Description of the proposed activity

The proposed solar thermal facility will have a maximum generating capacity of 310 MW which will be achieved using the following (in any combination or multiple):

- 50 MW Heliostat Field (300 ha) & Power Tower (0.5 ha);
- 2x100 MW Solar Trough Fields (200 ha each) & Trough Power Islands (30 ha each);
- 10 MW PV Plants (60 ha).

The ancillary infrastructural requirements for the CSP components will include:

A steam turbine & generator
Concentrating solar power facilities require water as the heat transfer medium for the generation of high temperature steam which is used to drive a conventional turbine and generator. This turbine and generator will be housed within a 2-storey building on-site per unit installed.

A generator transformer and a small substation outside the building per unit
This infrastructure would form part of the power island.

Energy storage plant and vessels
An auxiliary steam boiler (i.e. fossil fuel boiler / generator) will be included on the power island and will be fired by diesel fuel or LPG. The boiler will be able to provide steam to the process, freeze protection heat exchangers, steam turbine seal system, and other critical plant components while the solar plant is offline or during night time or cloud covered days, or when the grid connection is not available.

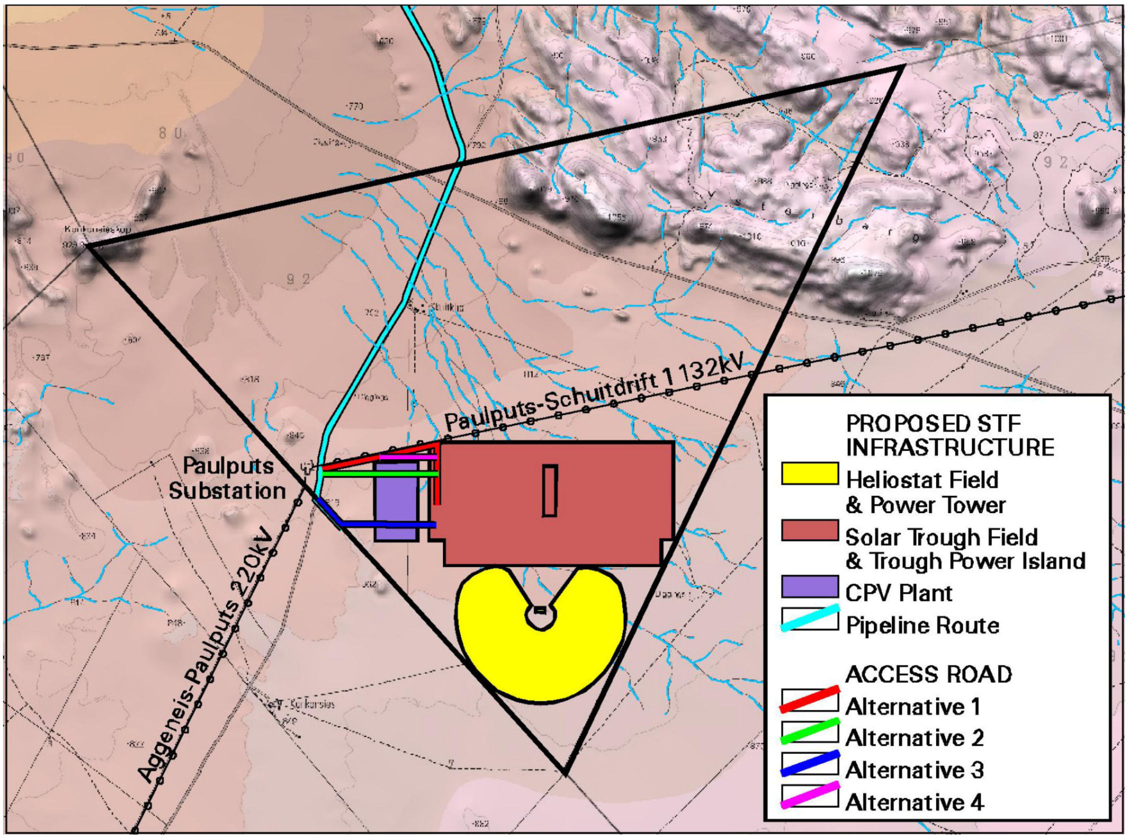
Power line
The generated power will be evacuated into the Eskom electricity grid via a power line into the existing Paulputs Transmission Substation situated adjacent to the site.

Water extraction, treatment, and pipelines
An extraction point 30 km north of the site on the Orange (Gariep) River and a pipeline to a settlement dam located approximately north of the site. From there it will be pumped via pipeline to the facility.

Blow down ponds
Blow down ponds will be established to receive wastewater from the generation process.

Access roads
An access road to the site will be established from the existing gravel road which runs through the site to Paulputs Transmission Substation. Between the heliostats/troughs/photovoltaic panels there will be a gravel access tracks that would be used for maintenance purposes during the operational phase.

Workshop, office, and storage areas
These areas would be located within the boundaries of the overall site.



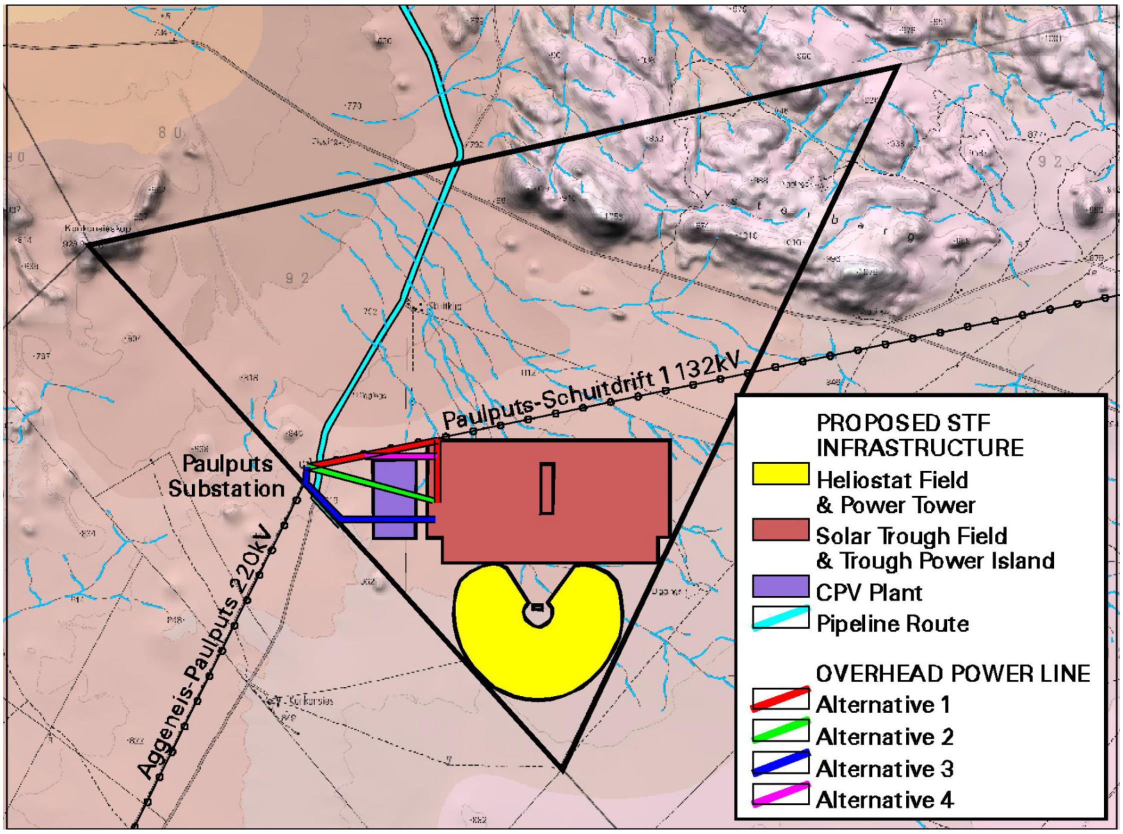


Figure 3: Maps showing layout of proposed facility and associated infrastructure

1.3. Applicable 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 Provincial Department) 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.

1.4. Terms of reference

Savannah Environmental (Pty) Ltd was appointed by 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 study area. Savannah Environmental (Pty) Ltd appointed Outeniqua Geotechnical Services to conduct a specialist geological study of the study area.

The following broad scope of work was 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.
- Conduct a brief site visit to collect visual data pertaining to the geology, soil types, and potential soil degradation issues.
- Prepare a report on the findings of the study including an assessment of the potential impacts.

The following aspects are covered in this report:

- A description of the proposed activity;
- 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;
- An assessment of the potential environmental impacts on the soil profile and other geological features (with emphasis on erosion and soil degradation);
- Guidelines for mitigating measures to be included in the EMP.
- A preliminary indication of potential geotechnical constraints on the proposed project that may affect the civil engineering design.

1.5. Limitations

Information provided in this specialist report was based on information provided by !KaXu CSP, Savannah Environmental[11], 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.

1.6. 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. DESCRIPTION OF THE ENVIRONMENT

2.1. Topography, climate, & vegetation cover

The majority of the study area is characterised by a lowland area with a very low slope gradient ranging from 780 to 860m AMSL. An upland area of high relief is located in the north-eastern portion of the study area where altitudes reach a maximum of 1056m AMSL. The lowland area occupies the central portion of the study area forms part of a natural drainage line which flows ephemerally in a north-westerly direction towards the Orange River.

The Weinert Climatic N-number[7] for the area, which is between 40 and 50, indicates that the climate is extremely arid and mechanical weathering processes are dominant. Mean annual precipitation for this region is 119mm (1956-1986) and mean annual evaporation (A-Pan) is 3705mm for the same period.[3]

Vegetation cover is very thin and dominated by grassland and small thorn bushes along natural drainage lines. The Vegetation Map of SA indicates that the vegetation type over the lowland area is Bushmanland Arid Grassland and the upland area in the north-eastern portion is characterised by Lower Gariep Broken Veld.[6]

2.3. Geology & soil types

The study area is located within the Namaqualand Metamorphic Belt which comprises very old and very highly deformed sedimentary (Khesian Group) and igneous (Namaquan Group) rocks of the Mokolian Erathem (2100-1200Ma) that form part of the Southern African Basement Complex rocks.[9] The rocks have undergone both regional and contact metamorphism and the culminating deformation phase has been dated at about 1000Ma.[4]

The upland area in the north-eastern portion of the study area is underlain by Koenap Formation meta-pelitic rocks (Kkn in **Figure 4**), the Polisiehoek gneiss (Npo in **Figure 4**) and the Skuitklip granite suite (Nsku in **Figure 4**). The Koenap Formation comprises metamorphosed fine grained, immature rocks of sedimentary origin and the Polisiehoek gneisses are highly metamorphosed granitoid rocks of intrusive igneous origin. Deposits of aeolian red sands, scree and gravelly sands occur on the western slopes of this upland area ($Q\text{-}s_2$ in **Figure 4**).

The lowland areas of the study area (i.e. the alluvial basin) are dominantly underlain by Quaternary soils of reworked residual and transported (aeolian) origin. The central area is dominated by reworked residual coarse grained, pink feldspathic gravels weathered from the Skuitklip granite suite (Q-r_2 in **Figure 4**). A certain amount of alluvial reworking of this soil has occurred. The development of pedogenic calcrete below the soil cover is expected on residual weathered granite. Also in this area, Koenap Formation kinzigite protrudes through the Quaternary cover and the outcrops resemble piles of black boulders. The thickness of the soil cover in the basin area is estimated to be less than 2m, based on soil maps.[10]

The western portion is dominated by red aeolian sands (Q-s_1 in **Figure 4**) which form lenticular dune cordons (see also **Figure 3**). Protruding through this aeolian sand cover is Oupvlakte Formation granulites (Kop in **Figure 4**) and Gemsbokvlakte gneiss (Ngv in **Figure 4**).

Rock outcrops in the central basin lowland area are limited to a few sporadic low koppies. In the north-eastern corner or the triangle, rock outcrops form prominent hills leading up to Skuitklipkop (1036m).

The basement rocks are intensely deformed due to a shear zone that runs along the western boundary of the study area. This shear zone is considered inactive, based on available seismic data.

Mining activity within the study area is limited to granite dimension stone which has been quarried in the northeastern corner of the study area (see symbol MA in **Figure 4**). Other resources exploited in the nearby vicinity include deposits of phosphate, nickel & copper. The Namaqualand area is well known as a mineral-rich area. A small calcrete borrow pit was noted along the gravel road to the Paulputs Transmission Substation.

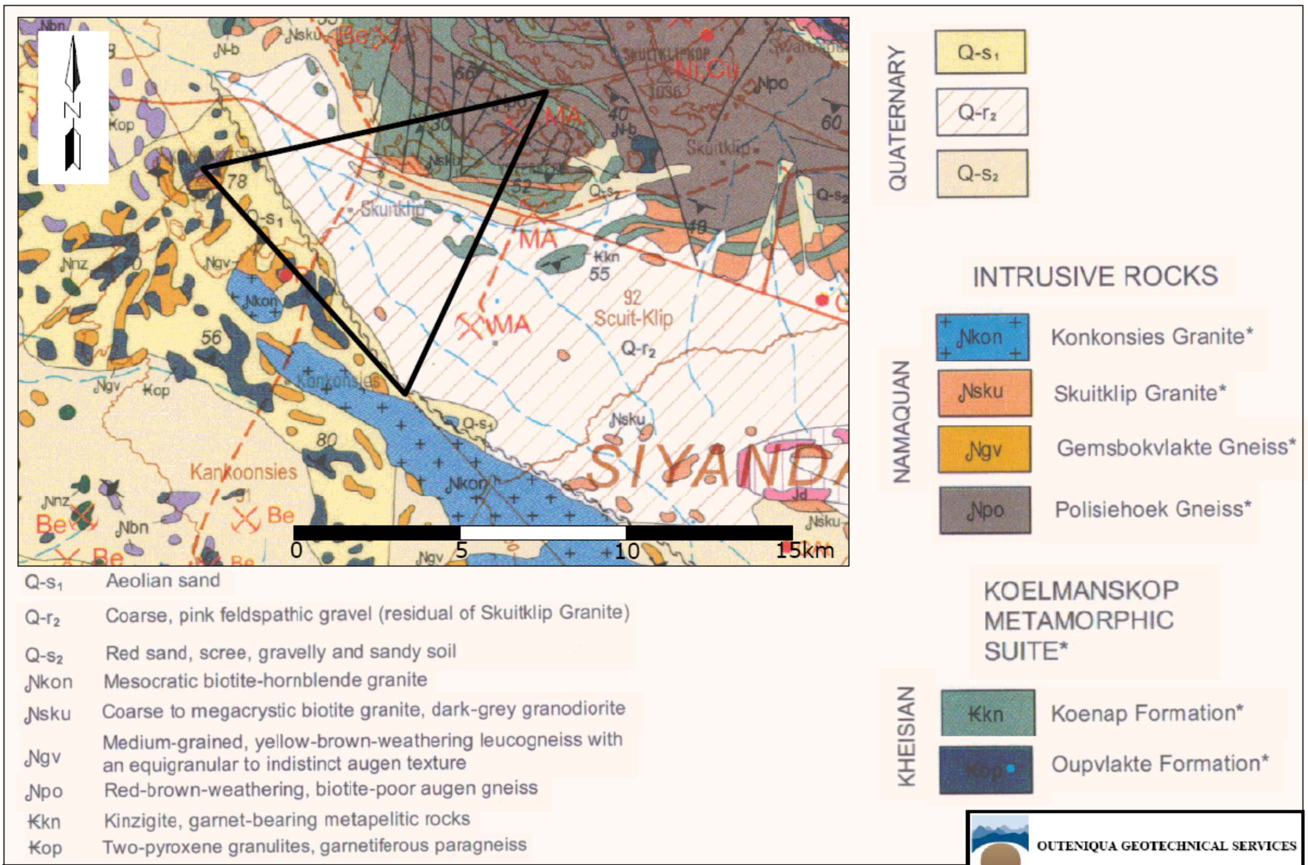


Figure 4: Geology of the study area

2.4. Hydrology

The study area falls within the D81E quaternary catchment[3] and is dominated by ephemeral rivers which flow in a north-westerly direction into the Orange (Gariep) River. Analysis of aerial photography indicates well-defined dendritic and braided ephemeral drainage patterns.

Expected infiltration of rainfall is high over most of the study area which is underlain by Quaternary sandy and gravelly soils (Qr_2, Qs_1, and Qs_2 in **Figure 4**). Where basement rocks protrude through Quaternary sand cover, ground infiltration will be relatively low and higher run-off can be expected due to lower permeability and steeper slopes.

The hydrology of the site plays an important role in the erosion potential. Rainfall, if not intercepted by vegetation or by 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 the 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 will tend to reduce the energy of the hydraulic system as well as providing an anchoring effect on the soil mass.

In this particular study area, the Quaternary soil cover is moderately to highly permeable and the slope gradients are low which means that under normal conditions, infiltration is high and run-off and subsequent erosion is likely to be low. However, the existence of a well-defined drainage pattern is an indication that exceptional heavy rainfall and run-off may occur, during which time, a significant proportion ends up as run-off, and this results in moderate erosion along the drainage lines.

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 bedrock and the overlying natural soil profile. The impact on the natural soil profile is generally considered most important as it is crucial for the sustainability of fauna and flora. Other important or prominent geological features (geosites) that contribute to the aesthetic scenery or academic interest in the area, such as prominent rock outcrops or features or fossil sites, are also considered in the impact study. Geological features, such as caves, addits, middens, worship rocks, etc. which are important from historical, cultural, archaeological or religious heritage standpoint are not assessed in this report as they are covered in the Heritage Impact Assessment. Geohydrological impact assessments also do not form part of this study.

3.1. Soil degradation

Soil degradation is the removal, alteration, or damage to soil and associated soil forming processes, usually related 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 density, soil chemistry, and biological activity. Soil degradation includes erosion (due to water and wind), salinisation, acidification, crusting, water-logging, pollution, soil excavation, removal or burial (as in the case of cut-and-fill operations) and soil compaction.

The proposed construction activity will include excavation, loosening, displacement and/or burial of soil, stockpiling, mixing, wetting, filling and compaction of soil and potential soil pollution with chemicals (such as fuel, oil and cement) and these activities carry potential negative direct impacts contributing to soil degradation and possibly accelerated erosion. These activities could also cause negative indirect impacts such as increased siltation in other areas away from the site causing negative impact on water sources and agriculture with potential socio-economic repercussions. The severity or significance of the various impacts is largely dependent on the nature and scope of the activity. There are no known positive impacts relating to the geological environment and the impacts are generally related to the construction phase only with very little additional impacts in the post construction and decommissioning phases.

Soil erosion is a natural process whereby the ground level is lowered by wind or water action and may occur because of inter alia chemical processes and/or physical transport on the land surface[1]. Soil erosion 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 the environment on a local and regional scale (i.e. on and off site) and as a potential threat to agricultural potential.

Soil erodibility potential is the likelihood that erosion will occur when soils are exposed to water (and/or wind) during or as a result of land-disturbing activities. This is a complex phenomenon, not only because it depends on soil chemistry, texture, and characteristics, but because it varies with time and other variables. However, the geology of the site, soil texture, and topography are the main considerations. The Erosion Index for South Africa[4] indicates that the area where the site is located has a moderate to low susceptibility to erosion, and this is primarily due to the very dry climate. However, exceptional heavy rainfall can occur and thus soil erosion concerns will be greatest along drainage lines where run-off is concentrated and hydraulic energy is potentially high. Areas where loose, unconsolidated sandy soils of low plasticity (i.e. Quaternary sandy soils) occur also tend to be more susceptible to erosion following heavy downpours, and this includes most of the proposed site. Localised occurrences of hard, resistant bedrock or calcrete duricrust will tend to limit erosion. In addition to this, areas where vegetation is limited or has been disturbed or damaged due to construction activity will be also more susceptible to erosion following heavy downpours. **Table 1** outlines the site-sensitivity in terms of erosion susceptibility.

Table 1: Erosion sensitivity

Sensitivity Level	Area/Terrain	Comments/Recommendations
High	Natural drainage lines/watercourses	Fine-grained alluvial and aeolian soil. Erosion is currently taking place - No-go areas without mitigating measures.
Moderate	Areas underlain by Quaternary sands (see **Figure 4**)	Erosion of loosened, exposed sand is likely to occur during heavy downpours or due to concentrated discharge of construction water. The presence of shallow calcrete or bedrock will have limiting effect. Normal mitigating measures apply.
Low	Areas underlain by calcrete and basement rocks (see **Figure 4**)	

The proposed development layout indicates that some infrastructure and roads are sited near or across small drainage lines. These areas tend to be more sensitive i.t.o. erodibility potential and special engineering designs such as culverts, river training, etc. may have to be considered to minimise impact on these watercourses and to prevent obstructions in the site drainage.

3.2. Degradation of bedrock

The proposed activity is unlikely to have any significant impact on bedrock due to the limited extent of excavations.

3.3. Degradation of geo-sites

Geo-sites are interesting or academically important geological exposures or features that require protection for obvious reasons and the environmental impact process needs to cater for these aspects, if they occur within the site. The occurrence of these sites is not always apparent unless the particular feature is well known (such as a prominent rock feature like the Maltese Cross in the Cederberg). Geo-sites that are less well-known or that have local significance are usually brought to light during the public participation process. There are no geo-sites that the author is aware of that warrant special attention for preservation.

3.4. Assessment of impacts

Direct impacts are impacts on the environment that may occur as a direct result of activity within a specific area. Indirect impacts are impacts on the environment that may occur away from the site where the activity is occurring but are related to the activity. The cumulative impact is the combined, incremental effects over time of all development that has occurred or is going to occur within an area.

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.
- 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).

3.4.1. Direct impacts

The most important direct impact is soil degradation including erosion from the area of construction activity. An assessment of the individual direct potential impacts associated with the proposed activity is outlined in **Table 2**.

Table 2: Assessment of potential direct impacts

Nature: Soil and/or rock degradation – Removal of soil and/or rock for foundations and roads affecting soil-forming processes and/or local geology.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Medium term (3)
Magnitude	Low (4)	Minor (2)
Probability	Definite (4)	Definite (4)
Significance	**Moderate (40)**	**Low (24)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	Yes, low	Yes, low
Can impacts be mitigated?	Yes, to a certain extent.	
Mitigation:	• Topsoil can be replaced over foundations, where practical. • Keep to existing roads/tracks, where practical, to minimise impact on undisturbed ground. • Plan access roads carefully to minimise crossing of drainage lines.	
Cumulative impacts:	• The cumulative impact of topsoil removal and burial is considered low due to the limited extent of the activity and the dearth of development in the area.	
Residual impacts:	• Minor – slow regeneration of topsoil.	

Nature: Soil degradation – Site clearing, soil mixing, cut-and-fill operations, and compaction for construction platforms and road embankments affecting soil forming processes, resources, and erosion potential.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long term (4)	Medium term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Definite (4)	Definite (4)
Significance	**Moderate (44)**	**Moderate (32)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	Yes	Yes, minor
Can impacts be mitigated?	Yes, to a certain extent	
Mitigation:	• Plan access roads and platforms in order to minimise impact on drainage lines. • Minimise size of disturbance areas	

	• Restrict activity to within disturbance areas • Plan soil embankments with max slope of 1:2 to allow for rehabilitation and or use erosion control measures where necessary. • Keep to existing roads, where practical, to minimise impact on undisturbed ground.
Cumulative impacts:	• The cumulative impact of site clearing, soil mixing, etc. is considered low due to the limited extent of the activity and the dearth of development in the area.
Residual impacts:	• Minor – slow regeneration of topsoil.

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	Low (4)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Low (21)**
Status	Negative	Negative
Reversibility	Irreversible	Reversible
Irreplaceable loss of resources?	Yes	Yes, minor
Can impacts be mitigated?	Yes	
Mitigation:	• Chemicals, fuel, and cement only to be used in approved areas. • Rehabilitate soil and vegetation after construction. • Use spoil from excavations for backfilling, landscaping, or cart off site – no dumping on site.	
Cumulative impacts:	• Cumulative impact of soil pollution from all development in the area is considered low.	
Residual impacts:	• Minor negative – slow regeneration of vegetation & soil.	

Nature: Soil degradation – Stockpiling or dumping of soil and/or rock on site affecting soil formation processes.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Very short term (1)
Magnitude	Low (4)	Low (4)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	**Moderate (32)**	**Low (24)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	Yes, moderate	Yes, minor
Can impacts be mitigated?	Yes, to a certain extent	
Mitigation:	• Restrict temporary stockpiles to certain areas.	

	• No permanent dumping on site other than approved filling operations. • Rehabilitate soil and vegetation where practicable in areas of activity.
Cumulative impacts:	• The cumulative impact of stockpiling or dumping from all development in the area is considered low if mitigating measures are adopted.
Residual impacts:	• Minor negative – slow regeneration of topsoil

Nature: Soil degradation – Increased erosion due to construction activity.		
	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)	Probable (3)
Significance	**Moderate (40)**	**Low (18)**
Status	Negative	Negative
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Yes, moderate	Yes, minor
Can impacts be mitigated?	Yes	
Mitigation:	• Minimise aerial extent of construction/disturbance areas. • Minimise activity in high erosion-sensitive areas • Implement effective erosion control measures. • Stage construction in phases to minimise exposed ground where practicable. • Keep to existing roads, where practical, to minimise impact on undisturbed ground. • Ensure stable slopes of stockpiles/excavations to minimise slumping.	
Cumulative impacts:	• The cumulative impact of soil erosion from all development in the area is considered low if mitigating measures are adhered to.	
Residual impacts:	• Minor – Localised movement of sediment. Slow regeneration of soil processes	

3.4.2. Indirect impacts

The most important indirect impacts are the increased siltation downstream caused by an increase in erosion from the site with knock-on potential socio-economic impacts resulting from the degradation of agricultural land.

An assessment of the indirect potential impacts associated with the proposed activity is outlined in **Table 3** below.

Table 3: Assessment of potential indirect impacts

Nature: Soil degradation - Deposition down-slope affecting soil forming processes and siltation of watercourses 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?	Yes	Yes, minor
Can impacts be mitigated?	Yes, to a certain degree	
Mitigation:	• Minimise aerial extent of construction/disturbance areas as possible. • Minimise activity in high erosion-sensitive areas. • Implement effective erosion control measures. • Optimise the construction plan to minimise exposed ground where practicable. • Keep to existing roads, where practical, to minimise impact on undisturbed ground. • Ensure stable slopes of stockpiles/excavations to minimise slumping.	
Cumulative impacts:	The cumulative impact of siltation from all development in the area is considered low if mitigating measures are applied diligently.	
Residual impacts:	Minor localised movement of soil across site	

3.4.3. Impact statement

The possible presence of shallow, dense residual soil, calcrete, or basement rock may help to reduce the erosion potential but this is difficult to quantify without detailed geotechnical information. However, the direct impacts are likely to be moderate to low and the cumulative significance of all the potential impacts on the geological environment is considered low due to the limited scale of the development and the dearth of development in the immediate surrounding area. With effective implementation of mitigating measures the impacts identified above can be reduced to a low level.

3.4.4. Alternatives

There are four proposed alternative access roads within the site from the Paulputs Substation to the proposed facility and four proposed alternative power-lines connecting to the Paulputs Substation (see **Figure 5**). All the alternatives cross areas of high erosion sensitivity (drainage lines) and therefore the only variable is the size or extent of the disturbance area.

Access roads

Alternative 1 (See **Figure 5**) is preferred because it partially follows an existing power line and an Eskom maintenance track and therefore less undisturbed ground will be impacted. However, there are no other significant differences from a soil perspective between the alternatives.

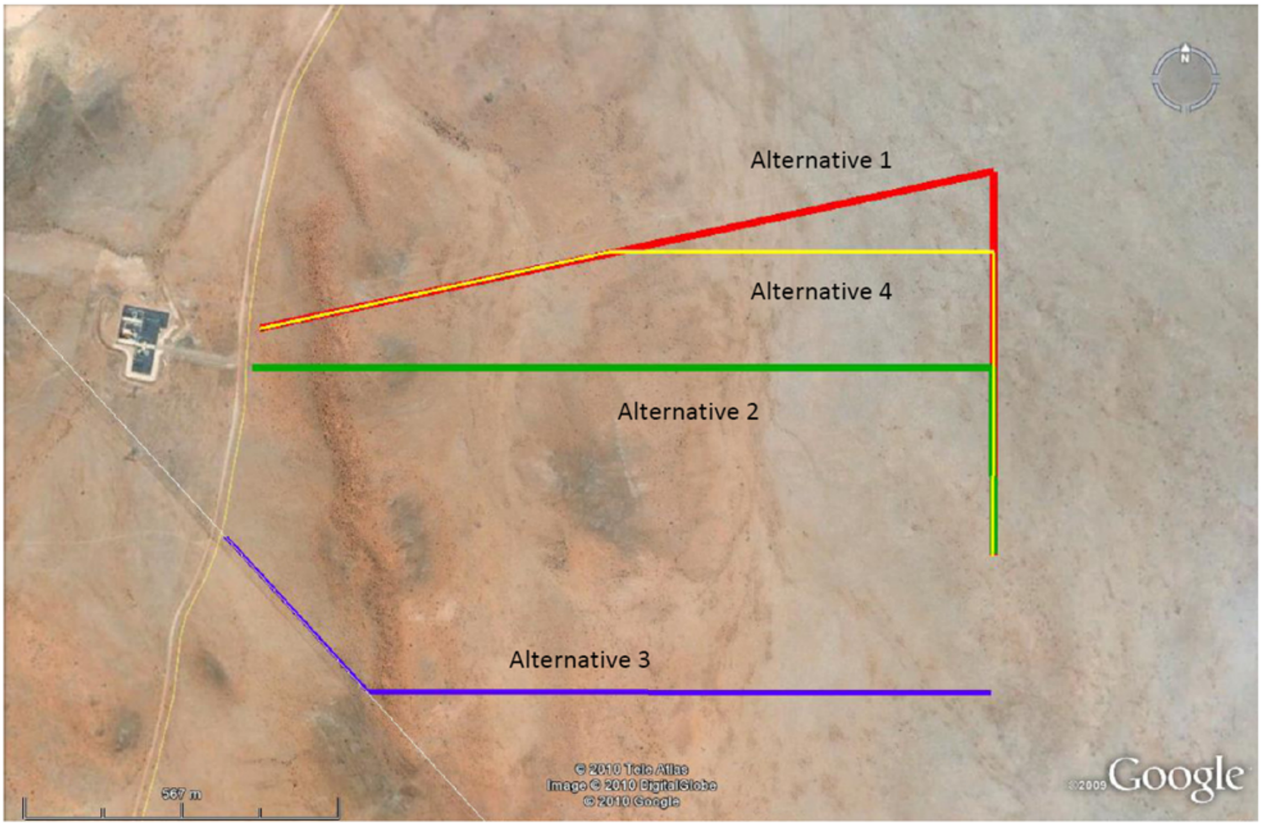


Figure 5: Alternative internal access roads

Power lines

The most suitable proposed power line would be one that runs along the preferred access road to minimise impact on undisturbed ground.

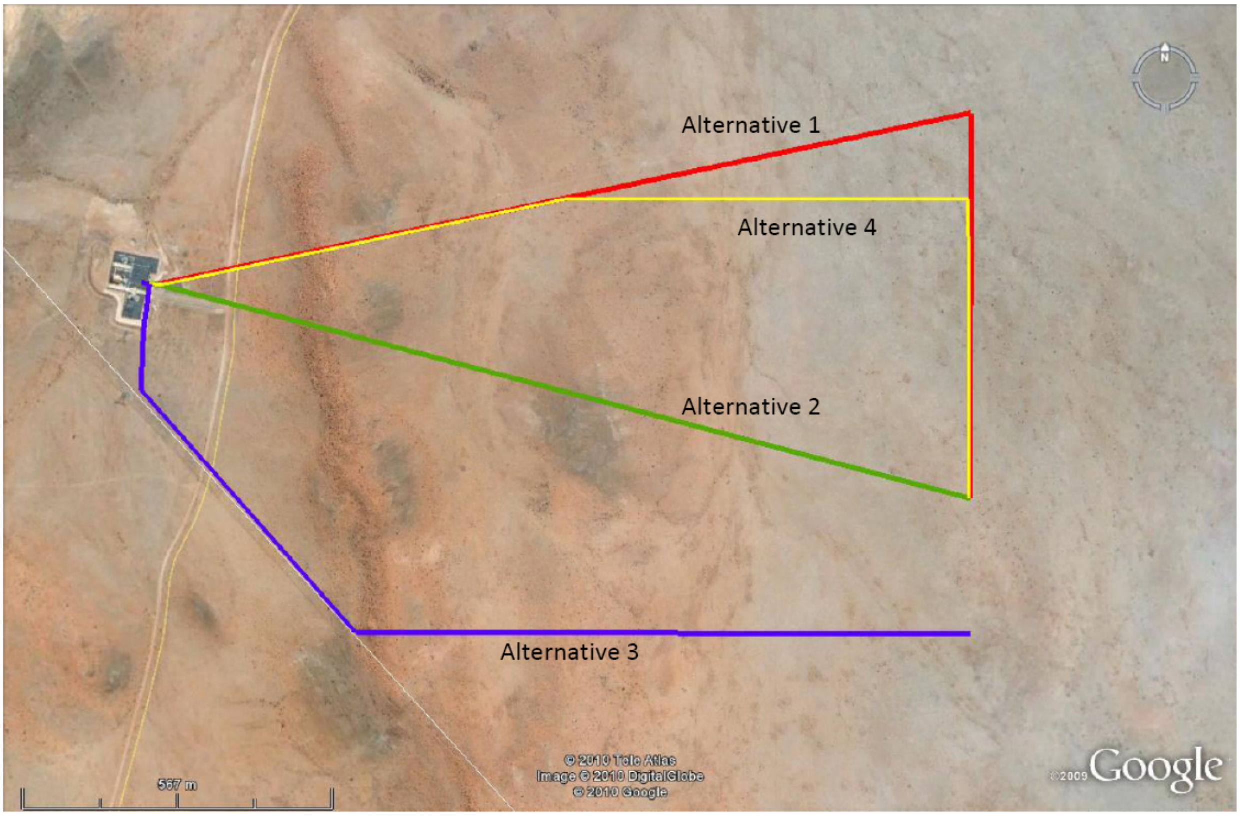


Figure 6: Alternative power lines

3.5. Environmental Management Plan (EMP) specification guidelines for earthworks

Negative impacts can be mitigated to a large degree by the implementation of an appropriate and effective EMP. The following specification guidelines relate specifically to the earthworks contract:

3.5.1. Earthworks

1. The excavations on site shall be done in accordance with SABS 1200 D or DB, as applicable.
2. Prior to earthworks (including site clearance) starting on the site, a search, and rescue operation for shall be undertaken as per the requirements set out in the EMP.
3. All earthworks shall be undertaken in such a manner to minimise the extent of any impacts caused by such activities.
4. Defined access routes to and from the area of operations as well as around the area of operation shall be detailed in the construction plan.
5. No equipment associated with the activity shall be allowed outside of these areas unless expressly permitted by the Site Manager.
6. Mechanical methods of rock breaking, including Montabert-type breakers, jackhammers, have dust impacts that must be addressed.
7. Residents shall be notified at least one week prior to these activities commencing, and their concerns if any, noted.
8. Chemical breaking shall require a method statement approved by the ER.

3.5.2. Topsoil

1. Prior to construction, the topsoil areas to be disturbed should be stripped to a depth to be confirmed by the ER and set aside for spreading to all areas to be reinstated after the construction. Temporary topsoil stock piles must be covered with net or shade cloth to protect them at times when deemed necessary by the ER.
2. Once all grades have been finalised and prepared, topsoil should be spread evenly to all relevant areas to be re-vegetated.

3.5.3. Erosion and sedimentation control

1. During construction the contractor shall protect areas susceptible to erosion by installing necessary temporary and permanent drainage works as soon as possible and by taking other measures necessary to prevent the surface water from being concentrated in streams and from scouring the slopes, banks or other areas.
2. A method statement shall be developed and submitted to the ER to deal with erosion issues prior to bulk earthworks operations commencing.
3. Any erosion channels developed during the construction period or during the vegetation establishment period shall be backfilled and restored to a proper condition.
4. Stabilisation of cleared areas to prevent and control erosion shall be actively managed. The method of stabilisation shall determine in consultation with the ECO. Consideration shall be given to the following methods (or combination) where practicable:
    a) Brush cut packing
    b) Mulch or chip cover
    c) Straw stabilising

d) Watering
e) Planting/sodding
f) Hand seed-sowing
g) Hydroseeding
h) Soil binders and anti erosion compounds
i) Gabions & mattresses
j) Geofabric
k) Hessian cover
l) Log/ pole fencing

5. Traffic and movement over stabilised areas shall be restricted and controlled and damage to stabilised areas shall be repaired and maintained to the satisfaction of the ECO.
6. Anti-erosion compounds shall consist of all organic or inorganic material to bind soil particles together and shall be a proven product able to suppress dust and erosion. The application rate shall conform to the manufacturer's recommendations. The material used shall be approved by the ECO.

3.5.4. Blasting

1. A current and valid authorisation shall be obtained from the relevant authorities and copied to the ER prior to any blasting activity.
2. A method statement shall be required for any blasting related activities.
3. All laws and regulations applicable to blasting activities shall be adhered to at all times.
4. A qualified and registered blaster shall supervise all blasting and rock splitting operations at all times.
5. The contractor shall ensure that appropriate pre blast monitoring records are in place (i.e. photographic and inspection records of structures in close proximity to the blast area.)
6. The contractor shall take necessary precautions to prevent damage to special features and the general environment, which includes the removal of fly-rock. Environmental damage caused by blasting / drilling shall be repaired by the contractor to the satisfaction of the ER.
7. The contractor shall ensure that adequate warning is provided immediately prior to all blasting. All signals shall also be clearly given.
8. The contractor shall use blast mats or a suitable alternative for cover material during blasting as appropriate. Topsoil may not be used as blast cover.
9. During demolition the contractor shall ensure, where possible that trees in the area are not damaged.
10. Appropriate blast shaping techniques shall be employed to aid in the landscaping of blast areas, and a method statement to be approved by the ER, shall be required in this regard.
11. At least one week prior to blasting, the relevant occupants/owners of surrounding land shall be notified by the contractor and any concerns noted. Buildings within the potential damaging zone of the blast shall be surveyed preferably with the owner present and any cracks or latent defects pointed out and recorded either using photographs or video. Failing to do so shall render the contractor fully liable for any claim of whatsoever nature, which may arise. The contractor shall indemnify the employer in this regard.

3.5.5. Borrow pits and quarries

1. All borrow pit sites shall be clearly indicated on plan.

2. Prior to the onset of any quarrying or borrow pit activities the contractor shall establish from the ER whether authorisation has been obtained, both in terms of the Minerals and Petroleum Resources Development Act 28 of 2002 (via the compilation of an Environmental Management Programme Report) and in terms of the National Environmental Management Act (via the Environmental Impact Assessment process). No excavation or blasting activities shall commerce before the necessary authorizations are in place.
3. Borrow pits to be used must be approved by the ER and shall at all times be operated according to the regulations promulgated in terms of the Occupational Health & Safety Act (No 85 of 1993) and Noise Regulations of the Environment Conservation Act (No 73 of 1989).
4. Only a single lane access for construction vehicles shall be provided at borrow pit and quarry sites. New access roads require approval by the Site Engineer.
5. Stormwater and groundwater controls shall be implemented.
6. Machinery, fuels, and hazardous materials vulnerable to flooding shall be stored out of flood risk areas.
7. All loads shall be covered with a tarpaulin or similar to prevent dangers and nuisance to other road users if and where required.
8. Borrow pits shall be fenced to prevent unauthorized persons and vehicles from entering the area. Fences shall also be stock and game proof.
9. Rehabilitation and re-vegetation of borrow pits sites shall be according to a method statement to be approved by the ECO.
10. The contractor shall ensure that blasted faces of the pit shall be shape-blasted to the approval of the site manager.
11. Where required, dust and fly-rock prevention methods shall be detailed in a Method Statement to be approved by the site manager.
12. During the rehabilitation of borrow bits, the slope or the borrow pit shall be graded to blend with the natural terrain and be stabilized to prevent erosion.

3.5.6. Drilling and jack-hammering

1. The contractor shall submit a method statement detailing his proposals to prevent pollution during drilling operations. This shall be approved by the site manager prior to the onset of any drilling operations.
2. The contractor shall take all reasonable measures to limit dust generation because of drilling operations.
3. Noise and dust nuisances shall comply with the applicable standards.
4. The Contractor shall ensure that no pollution results from drilling operations, either because of oil and fuel drips, or from drilling fluid.
5. Drill coring with water or coolant lubricants shall require a method statement approved by the Site Manager.
6. Any areas or structures damaged by the drilling and associated activities shall be rehabilitated by the contractor to the satisfaction of the site manager.

3.5.7. Trenching

1. Trenching for services shall be undertaken in accordance with the engineering specifications (SABS 1200DE) with the environmental amplifications contain herein, where applicable.

2. Trenching shall be kept to a minimum as is practically possible through the use of single trenches for multiple service provision.
3. The planning and selection of trench routes shall be undertaken in liaison with the ER and cognisance shall be given to minimising the potential for soil erosion.
4. Trench routes with permitted working areas shall be clearly defined and marked with painted stakes prior to excavation.
5. The stripping and separation of topsoil shall occur as stipulated by the ER. Soil shall be stockpiled for use as backfilling as directed by the ER.
6. Trench lengths shall be kept as short as practically possible before backfilling and compacting.
7. Trenches shall be backfilled to the same level as (or slightly higher to allow for settlement) the surrounding lard surface to minimise erosion. Excess soil shall be stockpiled in an area approved by the engineer.
8. Immediately after backfilling, trenches and associated disturbed working areas shall be re-vegetated with a suitable plant species where practicable. Where there is a particularly high erosion risk, a fabric such as Geojute (biodegradable) shall be used in addition to planting.

3.5.8. Dust

1. The contractor shall be solely responsible for the control of dust arising from the contractor's operations.
2. The contractor shall take all reasonable measures to minimise the generation of dust because of construction activities to the satisfaction of the site manager.
3. Removal of vegetation shall be avoided until such time as soil stripping is required and similarly exposed surfaces shall be re-vegetated or stabilised as soon as is practically possible.
4. Excavation, handling, and transport of erodible materials will, as far as practicable, be avoided under high wind conditions.
5. During high wind conditions the site manager will evaluate the situation and make recommendations as to whether dust damping measures are adequate, or whether working will cease altogether until the wind speed drops to an acceptable level.
6. Where possible, soil stockpiles shall be located in sheltered areas where they are not exposed to the erosive effects of the wind. Where erosion of stockpiles becomes a problem, erosion control measures will be implemented at the discretion of the site manager.
7. Vehicle speeds will not exceed 40km/h along dust roads or 20km/h when traversing unconsolidated and non-vegetated areas.
8. Appropriate dust suppression measures must be used when dust generation as unavoidable, e.g. dampening with water, particularly during prolonged periods of dry weather in summer. Such measures shall also include the use of temporary stabilising measures (e.g. chemical soil binders, straw, brush packs, clipping etc.)
9. Straw stabilisation must be applied at a sufficient rate and harrowed into the top 100mm of top material in high risk areas and where practical.

3.5.9. Imported materials and stockpiles

1. Imported materials shall be free of weeds, litter, and contaminants.
2. Sources of imported material shall be listed and approved by the ER on site.
3. The contractor shall provide samples to the ER for approval.
4. Stockpile areas shall be approved by the ER before any stockpiling commences.

3.5.10. Summary of objectives and performance monitoring

A summary of the project components, potential impacts, mitigating measures and performance monitoring is outlined in **Table 4.**

OBJECTIVE: Soil and 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 or uncontrolled discharge from bowsers, storage ponds/tanks, etc.) will also lead to accelerated erosion. Degradation of the natural soil profile due to 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.

Table 4: Summary of objectives of the EMP

Project components	CSP Parabolic troughs, heliostats, power tower, etc.
	Access roads
	Substation and overhead power lines
	Offices and workshops
	Underground pipelines
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, mixing, 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 size of disturbance areas
	To minimise destructive activity within disturbance areas
	To minimise soil degradation (excavation, 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 areas of high erosion risk. Only special works to be undertaken in these areas to be authorised by ECO and Engineer	ECO/EPC Contractor	Before and during construction
Identify disturbance areas for general construction work and restrict construction activity to these areas.	ECO/EPC Contractor	Before and during construction
Prevent unnecessary destructive activity within disturbance areas.	ECO/ EPC Contractor	Before and during construction
Access roads to be carefully planned and constructed to minimise the impacted area and prevent unnecessary degradation of soil. Special attention to be given to roads that cross drainage lines.	ECO/ EPC Contractor	Before and during construction
Dust control on construction site: Wetting of denuded areas if required by climatic conditions, e.g. high winds or spreading straw bales in sensitive, high risk areas.	EPC Contractor	During construction
Minimise removal of vegetation which aids soil stability.	EPC Contractor	During construction
Rehabilitate disturbance areas as soon as an area is vacated.	EPC Contractor	During and after construction
Soil conservation: Stockpile topsoil for re-use in rehabilitation phase. Protect stockpile from erosion.	EPC Contractor	Before and during construction
Erosion control measures: Run-off control and attenuation on slopes (sand bags, logs), silt fences, stormwater channels and catch-pits, shade nets, soil binding, geofabrics, hydro seeding or mulching over denuded areas.	EPC Contractor	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	EPC Contractor	Before construction and maintenance over duration of contract
Control depth of excavations and stability of cut faces/sidewalls	EPC Contractor	Before construction and maintenance over duration of contract

Performance Indicator	• No activity outside disturbance areas • Acceptable level of activity within disturbance areas, as determined by ECO • Acceptable level of soil erosion around site, as determined by ECO • Acceptable level of increased siltation in drainage lines, as determined by ECO • Acceptable level of soil degradation, as determined by ECO • Acceptable state of excavations, as determined by ECO • No activity in restricted areas
Monitoring	• Fortnightly 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

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 the proposed development. A basic assessment of the main geotechnical constraints that may affect the civil engineering design is given in **Table 5**.

Table 5: Geotechnical constraints on the proposed development

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.	High	Unconsolidated Quaternary sands 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.	Medium	Recommend found 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-high	Transported sands: 50-80kPa, depending on level of consolidation. Rock: >250kPa* (*check calcrete for thickness, consistency) Power tower ideally be founded on rock.
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 clay activity expected. Ground moistures very low.

Geotechnical Constraint	Effect on the proposed development	Severity	Comment & recommendations
Excavations	Boulders or rock affecting excavations	Low-medium	Shallow excavations will be soft/easy. Deeper excavations below 1m may hit rock. This is to be confirmed in geotechnical site investigation.
	Unstable excavations requiring shoring	High	Sidewalls of excavations exceeding 1m in unconsolidated sandy soils will be unstable. Temporary slopes to be battered to 1:2 or shored with temporary support.
Slope stability	Geological instability causing damage to structures founded on slopes	Low	No unstable slopes in proposed development footprint.
Seismic activity	Structures at risk of damage due to seismicity	Low-medium	Expected seismic intensity of VI on Modified Mercalli Scale and peak horizontal ground acceleration is 50-100cm/s^2 with a 10% chance of being exceeded in 100 years.
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	
Availability of local construction material	Large distances to nearest quarry for sources of suitable construction material negatively affect construction costs	Medium	Nearest major centre is Upington (170km). 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	Isolated small-scale diggings on the site which are unlikely to affect the proposed activity.

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 majority of the proposed development area is underlain by Quaternary sands and the soil erosion potential is highest along natural drainage lines, whereas the rest of the site is considered moderate to low. Impacts on soil 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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