GEOLOGICAL REPORT

SPECIALIST INPUT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED AB's WIND ENERGY FACILITY NEAR INDWE, EASTERN CAPE PROVINCE, SOUTH AFRICA

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List of abbreviations and definitions

The study area:	The area as delineated on **Figure 1**
EIA:	Environmental Impact Assessment
WEF:	Wind Energy Facility
EMP:	Environmental Management Plan
AMSL:	Above mean sea level
Ma:	Million years
ECO:	Environmental Control Officer
Quaternary:	The geological time period from present to 2 Ma ago
Jurassic	The geological time period from 195 to 135 Ma ago
Triassic	The geological time period from 225 to 195 Ma ago

1. INTRODUCTION

1.1. Background

DNA Wind Farm (Pty) Ltd (a Rainmaker Energy Projects (Pty) Ltd subsidiary) is in the process of carrying out the Impact Assessment phase of the EIA for the proposed Wind Energy Facility (WEF) near Indwe in the Eastern Cape. The proposed activity is defined as the establishment of a wind energy facility and associated infrastructure. An area of approximately 980 hectares is being considered within which the facility is to be constructed. The proposed wind energy facility would include:

- Up to 24 wind turbines and foundations to support them;
- Underground cables between the turbines;
- 66 kV distribution line linking to the existing Eskom transmission grid
- A substation to facilitate the connections between the WEF and the existing power lines;
- Internal access roads between the turbines.
- An access road to the site from the main road/s within the area
- A workshop area for maintenance.

The proposed activity is located on the farm portions: Eenzaam (remaining extent), Begeer (remaining extent), Devon Bank (remaining extent), Noodshulp (remaining extent), Onverwagt (portion 2 and remaining extent), Houtnek (remaining extent) and Spytfontein (remaining extent).

No alternative areas have been proposed. The power line for the facility will connect to the existing Eskom grid.

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 (DNA Wind Farm (Pty) Ltd) requires authorisation from the National Department of Environmental Affairs (DEA) (in consultation with the Eastern Cape Department of Economic Development and Environmental Affairs (DEDEA)) for the undertaking of the proposed project.

1.3. Terms of reference

Savannah Environmental (Pty) Ltd has been 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 has appointed Outeniqua Geotechnical Services to conduct a specialist geological study of the site.

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.

- Conduct a brief 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 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 on the soil profile and other geological features (with emphasis on erosion and soil degradation);
- Provide mitigating measures for the EMP.

In addition to this, a basic assessment of the potential geotechnical constraints on the proposed project was conducted. 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 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 an independent professional engineering geologist (Pr Sci Nat # 400236/07) of 12 years experience in the mining, petroleum and construction industries. 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. OGS has no vested interest in the proposed activity and will not engage in conflicting activity associated with the project.

2. SITE DESCRIPTION

2.1. Location

The study area is located approximately 12km east-northeast of Indwe in the Eastern Cape, South Africa. Indwe is approximately 90km northeast of Queenstown (by road), which is the commercial centre for the region.

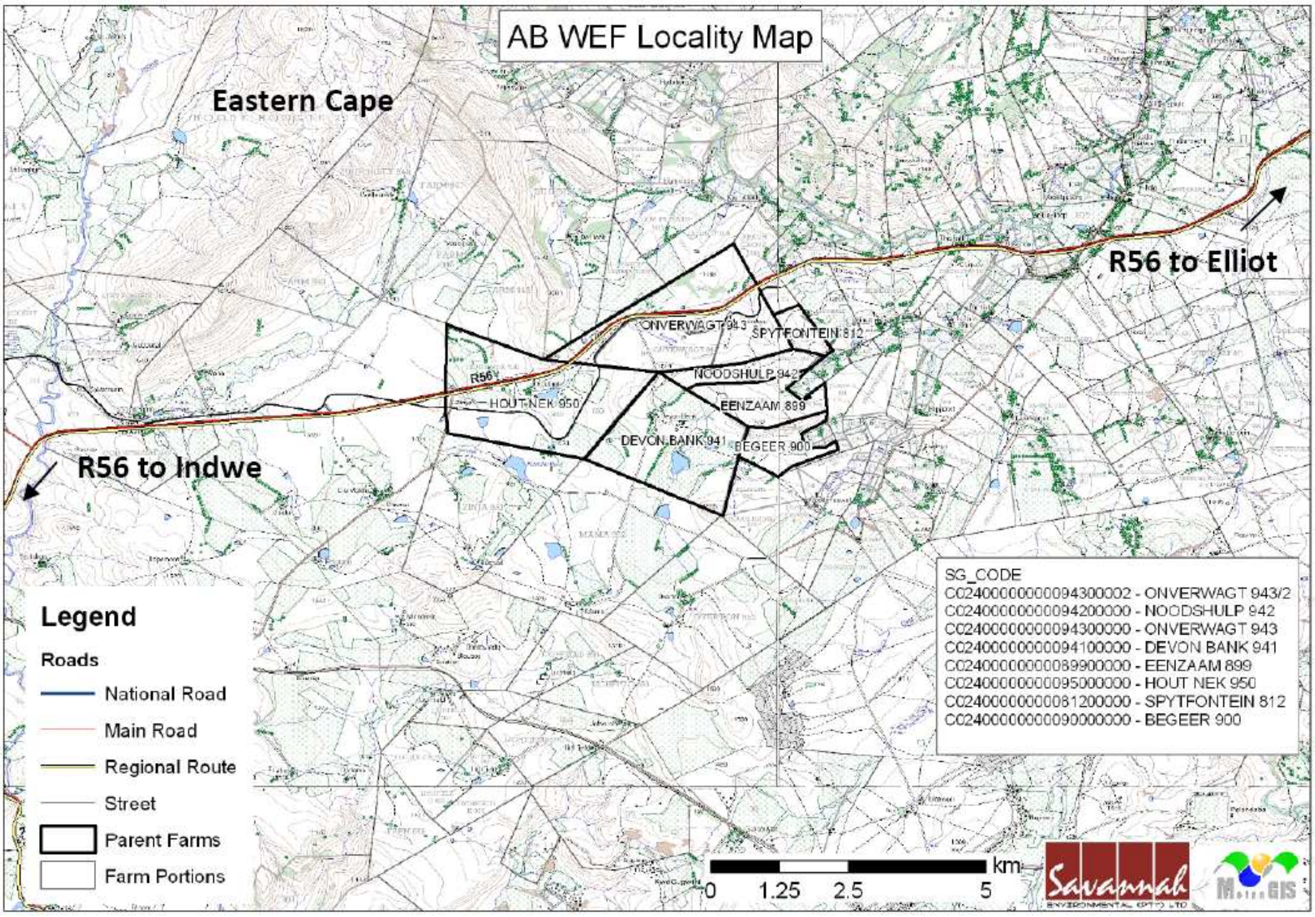


Figure 1: Locality map of study area (black lines)

2.2. Topography, climate & vegetation cover

The study area is spread across hilly terrain along the R56 between Indwe and Elliot. There are several prominent hills in the vicinity of the study area which rise to altitudes ranging from 1468m to 1621m AMSL. The total altitude range within the boundaries of the study area is 1400m to 1565m and the slope gradients range from low/moderate (2°) to steep (>45°), leading up to the peaks. The proposed location of the individual wind turbines is on the flatter upland portions of the study area (see **Figure 3**).

The climatic N-number for the area, which is 3.5, indicates that chemical weathering processes are dominant[5], but significant mechanical weathering does take place. The area has a predominantly summer rainfall and the average annual is moderate, around 628mm[7 & 8].

The present land-use of the area is agricultural pasture and there are several existing farm buildings on Devon Bank and Hout Nek.

The dominant vegetation type across the study area is indigenous Tsomo Grassland of the Sub-Escarpment Grassland Bioregion[8].

2.3. Geology & soil types

The study area is underlain by sedimentary rocks of the Molteno Formation in the southern portion, and Elliot Formation in the northern portion. The reason for this is that the sedimentary strata dip northwards at approximately 2-5°. The older Molteno Formation consists of gritstone, sandstone, mudstone, shale and subordinate coal seams, and the younger Elliot Formation comprises sandstone and mudstone. Both sedimentary formations are late Triassic age and have been intruded by transgressive dolerite sills of Jurassic age, at altitudes ranging between 1460m and 1500m. Several small dolerite dykes are also mapped within the study area.

The hardness of the various rock types also acts as a control on the development of the landscape. The hard, resistant dolerite has aided the preservation of some prominent hills in the area from the forces of erosion which attempt to level the landscape. The sandstone units within the Molteno and Elliot Formations are coarser grained, harder and less prone to weathering than the mudstones. Hard sandstone layers produce resistant ledges and cliffs and the mudstones typically crumble on steep slopes (slaking), producing concave cliff-faces and slopes. Natural drainage lines also tend to develop in weaker rocks types, fractures or fault lines.

Soils produced in humid climatic areas are dominantly formed by chemical weathering of the main mineral components of the parent rock, with lesser degrees of mechanical weathering. Soils types are closely linked to the parent rock type and the topography of the area in which they are formed. Coarser soils formed by mechanical weathering of rock outcrops on steep slopes will accumulate as talus gravel deposits whereas the finer particles will generally be transported down-slope and deposited in more distal areas (hillwash). Brittle shales and mudstones weather mechanically to produce fine gravels, whereas sandstones and dolerites generally produce coarser gravels as the parent rock tends to be more thickly bedded or massive. The soil types in the study area are likely to be dominated by transported soils, such as thin silty sandy gravels which are expected on the steep slopes (talus) and are underlain by rock, and thicker gravelly silty sands on the flatter areas (hillwash) and drainage lines/alluvial banks (alluvium).

A residual soil horizon of weathered mudrock, sandstone or dolerite may underlie the transported soils in flatter or low-lying areas where surface water can permeate. Chemical weathering of residual mudrocks will tend to produce clayey soils and the thickness of these soils is largely dependent on the historical moisture regimes of the soil. Significantly thicker accumulations of Quaternary alluvium (gravels, sand and silt) have been mapped in the lower-lying areas associated with ephemeral streams and rivers at lower altitudes ranging from 1440m to 1380m in the study area. A significant portion of the study area will have shallow rock or rock outcropping at surface and this will tend to be concentrated at higher altitudes and near steep slopes.

Observations made at the proposed sites of the individual turbines, which are planned along the ridgelines and flatter upland areas, suggest that shallow rock exists over most of the site and the transported soil horizon is thin, but weathering of this rock can produce thicker residual soils in some areas. Weathered dolerite (soft rock) has been extracted from a borrow pit along the main access road for gravel wearing course purposes.

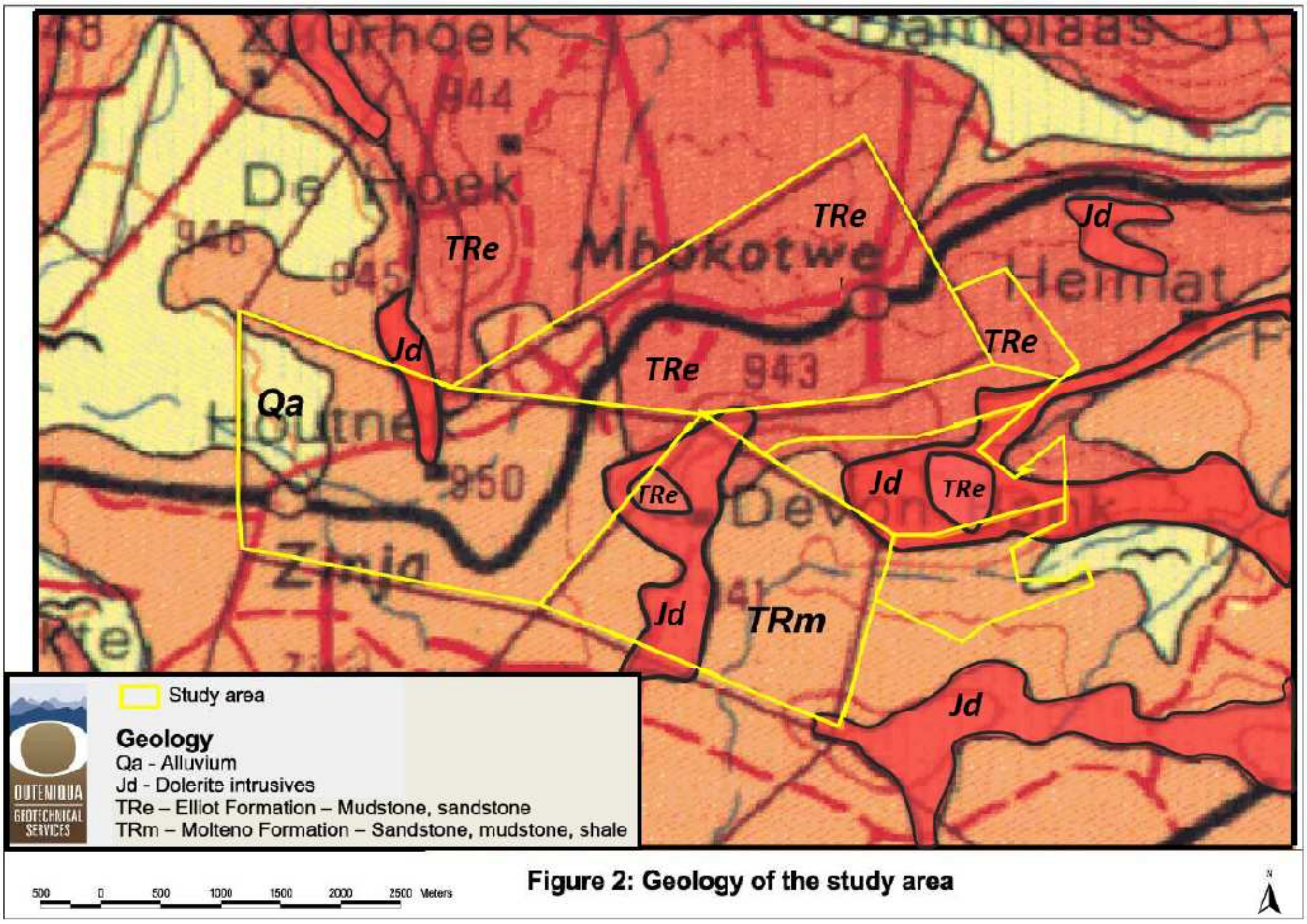


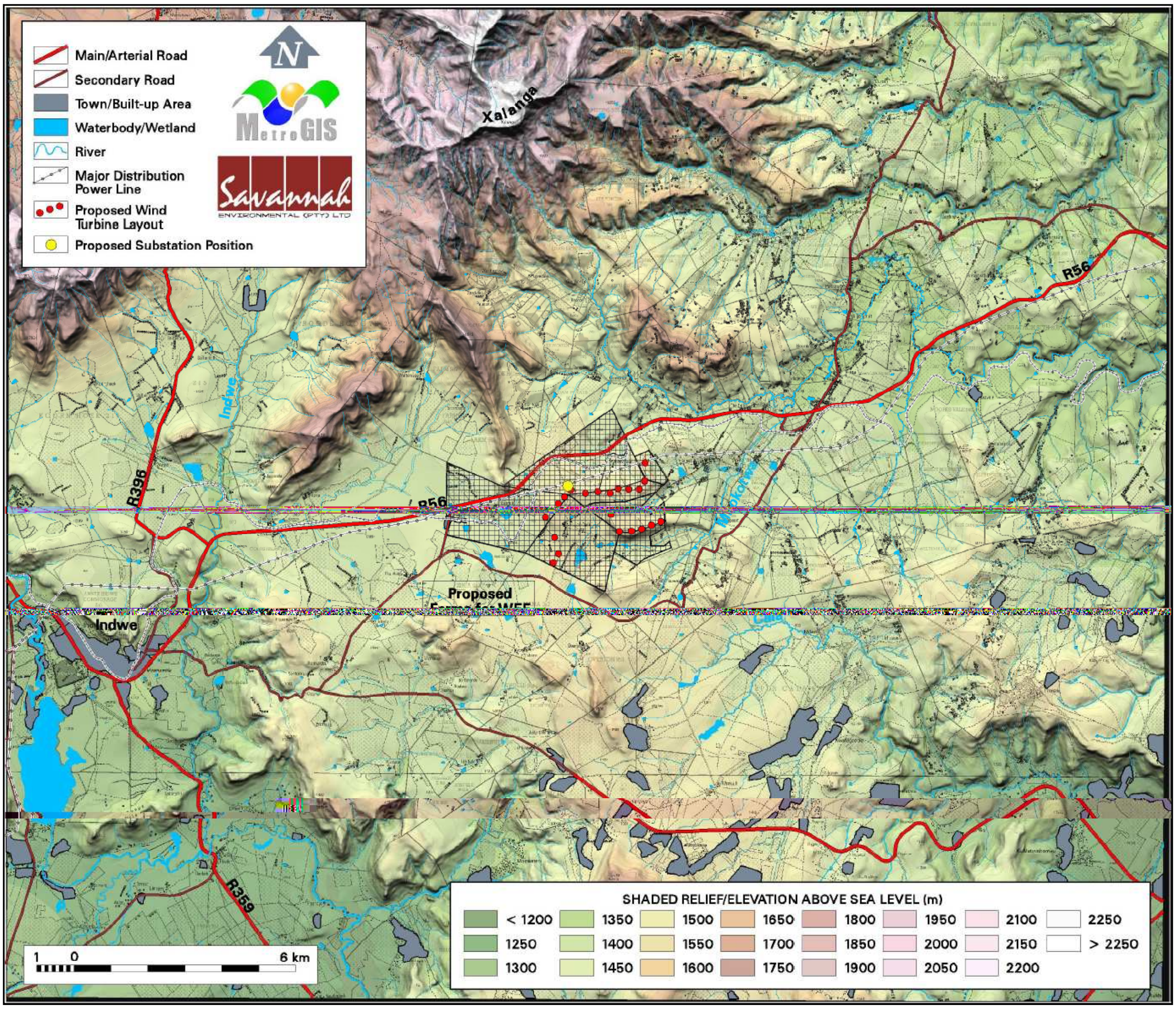
Figure 2: Geological map of the study area.

2.4. Hydrology

The eastern half of the study area drains into the Mbokotwa River and the western half drains into the Indwe River, both of which lie in the Kei River primary catchment area which has a mean annual runoff 675-1300 million cubic meters[10]. The watershed is roughly parallel to the access road to the Devon Bank farmhouse from the R56. The ephemeral streams that traverse the study area are proximal tributaries of these rivers. There are numerous small man-made dams along these streams within the study area.

The hydrology of the study area 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 average size of the spaces or pores in a soil determines soil permeability, i.e. the rate at which water and air move from upper to lower soil layers. Soil permeability is also influenced by soil structure and how soil particles are organised and clumped together. Soils vary in their contents of clay (very fine particles), silt (fine particles), sand (medium size particles), and gravel (course to very course particles). The proportion of the different sizes and types of mineral particles determines the soil texture. The permeability of the soil 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 and slope gradient influence the 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, high velocity run-off concentrated along natural drainage lines is expected on steep slopes, with lower velocity sheet-wash or braided streams on the plateau areas, foothills or alluvial plains. The soil on the steep slopes is generally coarser grained and will be relatively permeable but the soil cover tends to be thin, thus restricting infiltration. The coarse nature of this soil means that it will be less susceptible to erosion. The flatter areas will tend to have thicker soil cover and but lower permeability due to finer soil texture. The hydraulic energy is generally lower on flatter slopes but the fine-grained nature of the soil in these areas means that a lower energy system can still cause erosion of finer grained soil particles.



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 historical, cultural, archaeological or religious heritage standpoint are not assessed in this report as they are covered in the Heritage Impact Assessment. Geohydrological or geomorphological assessments also do not form part of this study.

There are no known important or prominent geological features and the parent rock is unlikely to be detrimentally affected by the proposed activity, as there are no deep excavations planned. Therefore, the impact on the natural soil profile is the primary focus of this study as it is important for the sustainability of 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 impact on 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, compaction and crusting[9].

The proposed activity will more than likely include excavation or displacement of soil, stockpiling, mixing, wetting and compaction of soil and pollution and these activities carry potential negative direct impacts contributing to soil degradation. These activities could also cause negative indirect impacts such as increased siltation in other areas away from the site and loss of agricultural potential with obvious socio-economic effects (not discussed further in this report). The severity or significance of the various impacts is related to the nature and extent of the activity. There are no known positive impacts relating to the geological environment. Negative impacts can be mitigated to a large degree by effective implementation of appropriate environmental management measures.

Soil degradation is not always apparent during the period of activity and can occur at a later stage thus having delayed effects.

Soil erosion is the process of the lowering of the natural ground level by wind or water and may occur as a result of inter alia chemical processes and/or physical transport on the land surface. Erosion and degradation are commonly linked and are usually associated with human activity (accelerated soil erosion).

Erosion (and subsequent deposition/siltation) has long been considered as a threat to agricultural production and self sufficiency[9]. Soil erodability – the susceptibility of soil to erosion – 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].

The Erosion Index for South Africa[10] indicates that the site has a moderate to high susceptibility to erosion. The erodibility index is determined by combining the effects of slope and soil type, rainfall intensity and land use. Soil erosion concerns will be greatest at the foot of steep slopes where run-off velocity is high and soil types are typically fine-grained and unconsolidated. Erosion gulleys will tend to form along natural drainage lines where run-off is concentrated and where vegetation is limited or has been disturbed or damaged (e.g. overgrazing).

The erosion potential of the study area is closely related to the geology. A significant portion of the study area will be underlain by shallow rock or rock outcrops on surface. The presence of hard rock outcrops has obvious positive effects on the erosion potential as it will generally reduce the hydraulic energy. Areas where soil is thicker (typically in low-lying areas) are more critical. The distribution of unconsolidated alluvium is important, and particularly where this occurs on or at the base of slopes, as these areas will be more susceptible to erosion.

A preliminary indication is that 30% of the study area is susceptible to moderately high erosion, but these areas are located away from the proposed turbine positions. Sheet-wash, rill and gulley erosion silty sandy (loamy) topsoil related to poor agricultural practice and overgrazing is commonplace in many areas in the Eastern Cape but does not seem to be the case on these particular farm portions. No evidence of significant erosion is evident, but the removal of vegetation will contribute negatively to the erosion potential of the site. Gulley and sheet erosion will be the dominant processes, but significant wind erosion of disturbed areas can occur in fine-grained, dry or cohesionless soil (such as topsoil). Construction activity on slopes will tend to promote soil erosion and these areas will require more protection before, during and after construction.

Sensitivity Level	Area/Terrain	Comments/Recommendations
High	Natural drainage lines/watercourses	Thick fine-grained alluvial soil. Minor erosion is currently taking place - No-go areas without special mitigating measures
Moderate	High relief areas with slopes >1:4 and lowland areas immediately below steep slopes (foothills).	Erosion of loosened, exposed soil is likely to occur in these areas but the presence of shallow rock will have limiting effect.
Low	Upland areas of low relief.	Erosion potential reduced. Shallow rock also expected in most areas. Normal mitigating measures apply

Table 1: Erosion sensitivity

The proposed wind turbines and other structures are to be located on flatter upland areas where soil erosion potential is lower.

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. More importantly, deep or poorly planned excavations may potentially affect the stability of the surroundings, such as rock slides along road cuttings. It is a common misconception that excavations into bedrock do not affect ecosystems. Excavations into bedrock may affect the geohydrology of an area and can even contaminate groundwater. Blasting operations associated with excavations into rock have obvious environmental issues, chiefly including noise pollution, dust, vibrations and chemical hazards.

Fortunately, the proposed activity is unlikely to have significant impact in this regard because the proposed structures are unlikely to involve excavations deeper than 1-2m and, where required, access roads can probably be constructed without significant cuttings.

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 known geo-sites on the site.

In summary, there are no important or interesting geological phenomena known at this stage and the parent rock is unlikely to be detrimentally affected by the proposed activity, as there are no deep excavations planned. The negative impacts on the natural soil (soil degradation) are the primary focus of this study as it is important for the sustainability of ecosystems and agricultural land.

3.4. Assessment of impacts

The activity will tend to involve minor earthworks on localised, small construction footprints around each turbine or substation with interleading gravel access roads. No alternative sites have been proposed, but the structures can be shifted within the broader site to accommodate sensitive areas, if these occur where structures are planned.

The most important issues are the direct impacts of soil degradation and erosion of topsoil from the area of activity. This would affect the ecosystems operating in the topsoil and the plant and animal species that depend on it for growth and survival. Other direct impacts would include the loss of agricultural potential of the area. The significance of these impacts obviously depends on the present quality of the topsoil and the agricultural potential of the area.

Indirect impacts could include increased siltation in nearby streams and dams caused by an increase in erosion from the site and socio-economic impacts resulting from the loss of topsoil and lower agricultural potential. These are considered to be of low significance at this stage due to the localised and limited scale of activity proposed.

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.
- 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: Medium (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 impacts include soil degradation including erosion. The significance of the main direct impacts identified is considered low to moderate due to the localised and limited extent of the proposed activity, and the anticipated geology which appears to be generally favourable towards the proposed layout. No severe erosion currently exists on the site.

An assessment of the individual direct potential impacts associated with the proposed activity is outlined in Table 2.

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, but minor**	
Can impacts be mitigated?	**No**	
Mitigation:	**N/A**	
Cumulative impacts:	**Numerous localised small footprints associated with structures but no significant cumulative impacts envisaged. Cumulative impacts can be minimised if construction is staged across the site.**	
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	**Low (4)**	**Low (4)**
Probability	**Probable (3)**	**Probable (3)**
Significance	**Low (24)**	**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.** • **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:	**Numerous localised small footprints associated with structures but no significant cumulative impacts envisaged. Cumulative impacts can be minimised if**	

	earthworks are staged so that exposed areas are minimised.
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	**Low (4)**	**Low (4)**
Probability	**Probable (3)**	**Probable (3)**
Significance	**Low (24)**	**Low (18)**
Status	**Negative**	**Negative**
Reversibility	**Partially reversible**	**Partially reversible**
Irreplaceable loss of resources?	**Yes**	**Minor**
Can impacts be mitigated?	**To a certain extent**	
Mitigation:	**• Prevent unnecessary excavations and stockpiling. • Restrict height of stockpiles to reduce compaction. • 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:	**Numerous localised small footprints associated with structures but no significant cumulative impacts envisaged.**	
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)**	**Very short term (1)**
Magnitude	**Moderate (6)**	**Low (4)**
Probability	**Highly probable (4)**	**Probable (3)**
Significance	**Moderate (40)**	**Low (18)**
Status	**Negative**	**Negative**
Reversibility	**Practically irreversible**	**Practically irreversible**
Irreplaceable loss of resources?	**Moderate**	**Minor**
Can impacts be mitigated?	**Yes**	
Mitigation:	**• Restrict zone of disturbance. • Implement effective erosion control measures. • Stage construction in phases to minimise exposed ground. • Keep to existing roads, where practical, to minimise impact on undisturbed ground.**	
Cumulative impacts:	**Numerous localised small footprints associated with structures but no significant cumulative impacts envisaged.**	

Residual impacts:	**Minor – Localised movement of sediment. Slow regeneration of soil processes**

Nature: Degradation of parent rock – Excavations causing degradation to local geology and instability.		
	Without mitigation	**With mitigation**
Extent	**Local (1)**	**Local (1)**
Duration	**Permanent (5)**	**Permanent (5)**
Magnitude	**Minor (2)**	**Minor (2)**
Probability	**Highly probable (4)**	**Probable (3)**
Significance	**Moderate (32)**	**Low (24)**
Status	**Negative**	**Negative**
Reversibility	**Irreversible**	**Irreversible**
Irreplaceable loss of resources?	**Yes, but insignificant**	**Yes, but insignificant**
Can impacts be mitigated?	**To a certain degree**	
Mitigation:	• **Restrict zone of disturbance and plan excavations carefully.** • **Plan any new access roads taking contour lines into consideration to minimise cutting and filling operations.** • **Keep to existing roads, where practical, to minimise impacts on undisturbed ground.**	
Cumulative impacts:	**Numerous localised small footprints associated with structures but no significant cumulative impacts envisaged.**	
Residual impacts:	**Minor – Some visual impact along access roads**	

Table 2: Assessment of potential direct impacts

3.4.2. Indirect impacts

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

Nature: Soil degradation - Deposition 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	**Highly Probable (4)**	**Probable (3)**
Significance	**Moderate (48)**	**Low (30)**
Status	**Negative**	**Negative**
Reversibility	**Irreversible**	**Irreversible**
Irreplaceable loss of resources?	**Moderate – depends on planning**	**Minor**
Can impacts be mitigated?	**To a certain degree**	
Mitigation:	**Install anti-erosion measures such as silt fences in disturbance areas.**	
Cumulative impacts:	**Numerous localised small footprints associated with structures and roads but no significant cumulative impacts envisaged if effective mitigation measures are in place.**	

Residual impacts:	Minor localised movement of soil across site

Table 3: Assessment of potential indirect impacts

3.4. Impact statement

The presence of shallow rock and rock outcrop in the areas where infrastructure is planned has a significant reducing effect on the erosion potential on the majority of the site. The cumulative significance of all the potential impacts on the geological environment is considered moderate without mitigating measures. With effective implementation of mitigating measures the impacts identified above can be reduced to a low level.

3.5. Mitigating measures

The objectives, impacts, risks and mitigating measures that are required for inclusion in the EMP are outlined in Table 4 below:

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 in areas 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 excavation, stockpiling, compaction, pollution and other construction activities will affect soil forming processes and associated ecosystems. Degradation of parent rock is unlikely as there are no deep excavations or deep road cutting/filling.

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	Wind energy turbines
	Access roads
	Substation
	Offices and workshops
	Underground and overhead cabling and power lines
Potential Impact	Erosion and degradation of soil and rock
	Damage to vegetation by erosion or siltation
	Increased deposition of soil into drainage systems
	Increased run-off over the site
Activities/risk sources	Rainfall and wind erosion of disturbed areas
	Excavation, stockpiling and compaction of soil

	Concentrated discharge of water from construction activity
Mitigation: Target/Objective	To minimise erosion of soil from site during construction
	To minimise deposition of soil into drainage lines
	To minimise damage to vegetation by erosion or deposition
	To minimise damage to rock, soil and vegetation by construction activity

Mitigation: Action/control	Responsibility	Timeframe
Identify disturbance areas and restrict construction activity to these 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
Rehabilitate disturbance areas as soon as an area is vacated.	Contractor	During and after construction
Strictly control vibration pollution from compaction plant or excavation plant.	Contractor	During construction
Plant search and rescue: Remove native plant species from disturbance areas for re-use in the rehabilitation phase.	Contractor/ECO	Before construction
Soil conservation: Stockpile topsoil for re-use in rehabilitation phase. Maintain stockpile shape and size and protect 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	• Acceptable level of soil erosion around site, as determined by the ECO • Acceptable level of increased siltation in drainage lines, as determined by the ECO • Acceptable level of soil degradation, as determined by the ECO • Acceptable state of excavations, as determined by the ECO • 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 4: EMP guidelines

4. GEOTECHNICAL ASPECTS

A basic 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 are outlined in Table 5.

Geotechnical Constraint	Effect on the proposed development	Severity	Comment & recommendations
Collapsible & compressible soil	Soil horizons with a potentially collapsible or compressible fabric unsuitable for foundations.	Low-medium	Unconsolidated transported soils are potentially compressible and collapsible under load. Dynamic compaction of soil will be necessary or found on rock.
Differential settlement (DS)	Foundations placed across different soil types or rock may settle differentially.	Medium-High	Depth to bedrock or dense soil horizons (residual or consolidated) will vary across the site. Recommend found individual structures on adequately dense soil or rock.
Bearing capacity	Soils with low in situ bearing capacity resulting in high settlements of structures if not compacted or engineered properly	Medium-High	Transported sands: 50-80kPa, depending on level of consolidation. Residual soils: 50-250kPa, depending on moisture, structure and consistency. Rock: >250kPa, depending on lithology, structure and state of weathering.
Saturated soils, groundwater problems, perched or permanent water tables	Seepage from sidewalls of excavations affecting stability or dewatering of trenches necessary.	Low	Groundwater problems are unlikely to affect shallow excavations. Perched water tables may exist on residual soils or underlying rock in low-lying areas.
Active soil	Heaving clays affecting foundation stability	Medium	Active clay anticipated in residual weathered mudstones or dolerite.

Geotechnical Constraint	Effect on the proposed development	Severity	Comment & recommendations
Excavations	Boulders or rock affecting excavations	Medium	Difficult excavations expected below 0.5m in most upland areas.
	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-medium	Micro-instability associated with steep slopes (soil creep, crumbling). Macro-stability of rock formations unlikely to be a problem.
Seismic activity	Structures at risk of damage due to seismicity	Low-Medium	Eastern Cape is a potentially active seismic area. Seismic intensity of VI (MMS) and peak ground acceleration of less than $50cm/s^2$ with a 90% chance of not being exceeded within 50 years.
Flood potential or storm water damage	Low lying areas affected by poor drainage.	Low	Most of the site is well drained.
	Steep slopes affected by uncontrolled run-off	Low-medium	Minor natural steep slopes on the site
Unconsolidated fill	Unconsolidated fill material affecting foundations	Low	Minor fill associated with existing farm buildings and dams
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 Queenstown (100km). Potential local sources of construction material are restricted to selected fill (Sabunga-weathered dolerite).
Mining Activity	Past, present or future mining activity which may affect development of the site	Low	No known mining activity (developer should confirm this with land owner)

Table 5: Geotechnical constraints

The above classification highlights some basic potential constraints, none of which are considered insurmountable. A detailed geotechnical investigation should be undertaken by the project developer before the engineering design phase to provide more information to inform the design of the facility and structures and roads.

5. CONCLUSIONS

This report describes the physical and geological characteristics of the study area and provides an indication of the soil types that can be expected. This is in order to assess the impact on the geological environment which needs to be evaluated as part of the environmental impact assessment process. The most important impacts include soil degradation including erosion. The significance of the main direct impacts that have been identified is considered low to moderate due to the localised and limited extent of the proposed activity and the anticipated geology which appears to be generally favourable towards the proposed layout. No severe erosion exists on the site.

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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