

# **GEOLOGICAL IMPACT ASSESSMENT REPORT**

**SPECIALIST INPUT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT  
FOR THE PROPOSED TSITSIKAMMA COMMUNITY WIND ENERGY  
FACILITY ON A SITE NEAR HUMANSDORP, EASTERN CAPE PROVINCE,  
SOUTH AFRICA**

**5 August 2011 (Rev 0)**

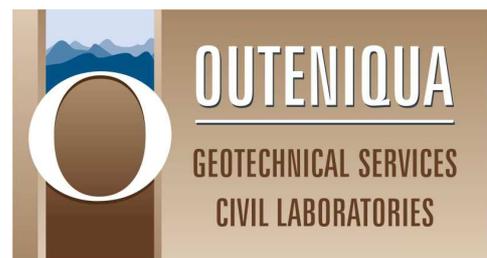
**Prepared for:**

**SAVANNAH ENVIRONMENTAL (PTY) LTD  
UNIT 606, EGLIN OFFICE PARK  
14 EGLIN RD, SUNNINGHILL, GAUTENG  
PO BOX 148, SUNNINGHILL, 2157  
SOUTH AFRICA  
TEL: +27 (0)11 2346621  
www.savannahsa.com**



**Prepared by:**

**OUTENIQUA GEOTECHNICAL SERVICES cc  
26 COVE ST, KNYSNA  
PO BOX 3186, GEORGE INDUSTRIAL, 6536  
SOUTH AFRICA  
TEL: +27 (0)44 3820502  
www.outeniqua.co.za**



## **List of abbreviations and definitions**

AMSL:	Above mean sea level
ECO:	Environmental Control Officer
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Plan
ER:	Engineer's representative
Ma:	Million years ago
NEMA:	National Environmental Management Act 107 of 1998
NGL:	Natural ground level
WEF:	Wind Energy Facility

## **1. INTRODUCTION**

### **1.1. Background**

Exxaro Resources Ltd and Watt Energy (Pty) Ltd is in the process of investigating the feasibility of the proposed Tsitsikamma Wind Energy Facility (WEF) on a site 20km west of Humansdorp in the Eastern Cape Province. The proposed activity is defined as the establishment of a Wind Energy Facility and associated infrastructure. The proposed facility includes:

- 29 wind turbines and foundations to support them;
- Electrical cabling between turbines;
- On-site substation to facilitate connection to the grid;
- 132 kV overhead power line linking to Eskom's existing Diep Rivier or Melkhout substations;
- Internal access roads;
- Maintenance and storage buildings.

### **1.2. Legislation**

In terms of the EIA regulations published in terms of Section 24(5) of the National Environmental Management Act (NEMA, No 107 of 1998), the applicant requires authorisation from the National Department of Environmental Affairs (DEA) in consultation with the Eastern Cape Provincial Department for the undertaking of the proposed project.

This specialist geological study is undertaken in accordance with Regulation 17 of the NEMA.

### **1.3. Terms of reference**

Savannah Environmental has been appointed by the developers to carry out the EIA process for the proposed activity. Specialist input is required in order to assess the environmental impacts on the geological environment (soil, rock and landforms) associated with the proposed activity. Savannah Environmental has appointed Outeniqua Geotechnical Services cc to conduct a specialist geological impact assessment.

The following scope of work has been given:

- Conduct a site visit to collect data pertaining to the physical and geological nature of the study area.
- Describe the geological environment and discuss the potential environmental impacts on the geological environment that may be associated with the proposed activity.
- Quantitatively assess the potential negative and positive impacts and provide mitigating measures for inclusion in the EMP.

### **1.4. Limitations**

Information provided in this specialist report has been based on information provided by the developer, Savannah Environmental (Pty) Ltd, published scientific literature and maps. The study

area was visited briefly but no detailed soil investigation or geological mapping was conducted. The information provided in this report is deemed adequate for the EIA process.

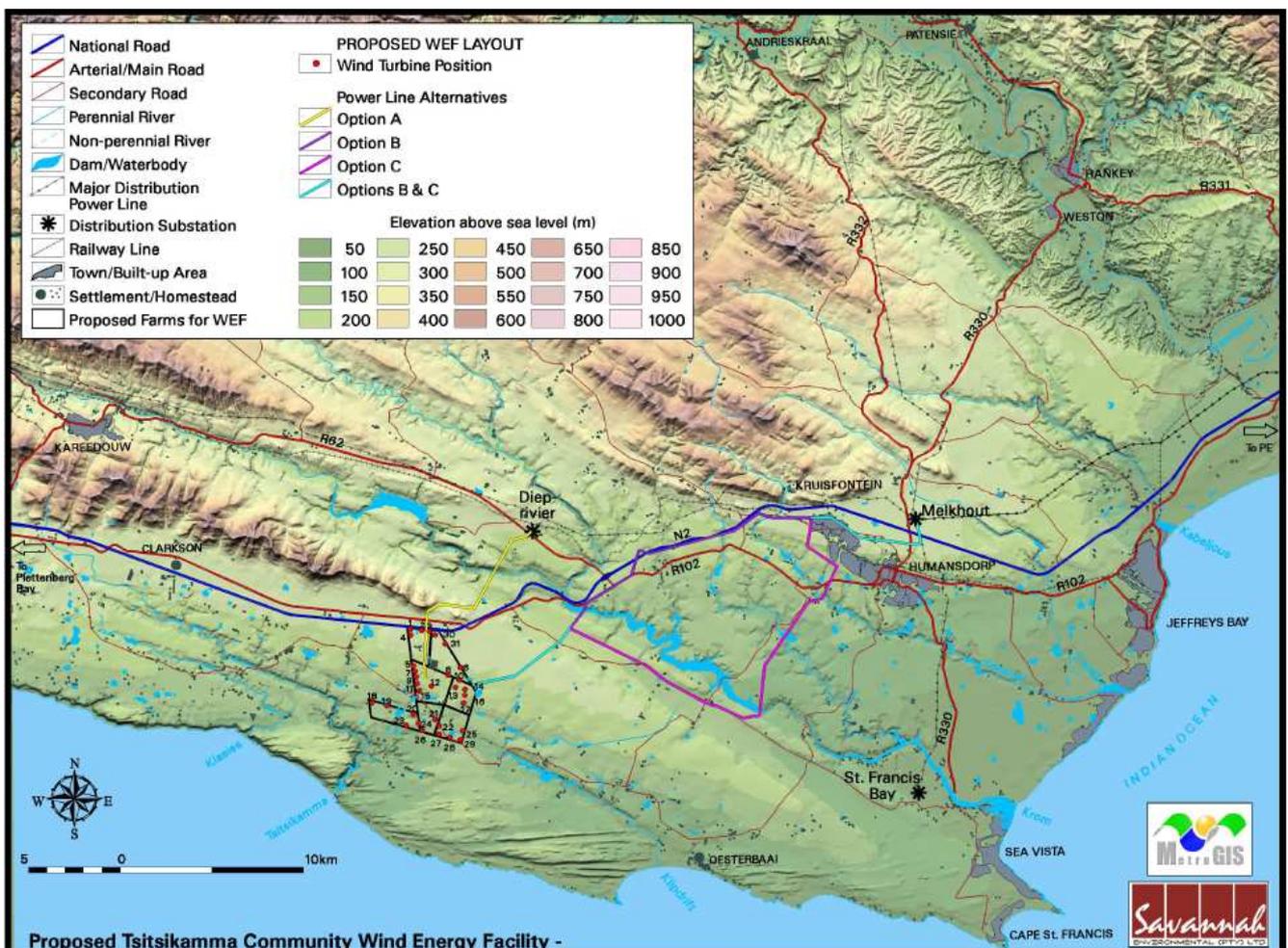
### 1.5. Authors credentials & declaration of independence

The author of this report, Iain Paton of Outeniqua Geotechnical Services cc (OGS), is a professional engineering geologist registered with the South African Council for Natural and Scientific Professions (Pr Sci Nat # 400236/07) with 12 years experience in the mining, energy and construction industries. Iain Paton is a member of the South African Institute of Engineering and Environmental Geologists (SAIEG) and the Geotechnical Division of the South African Institute of Civil Engineering (SAICE). 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 report.

## 2. SITE DESCRIPTION

### 2.1. Location

The site is located approximately 20km west of Humansdorp in the Eastern Cape on Portions 3 - 9 of Farm Wittekleibosch 787. Humansdorp is approximately 90km west of Port Elizabeth, which is the nearest major commercial centre. Access to the study area is via the N2 and the Oyster Bay gravel road (see **Figure 1**).



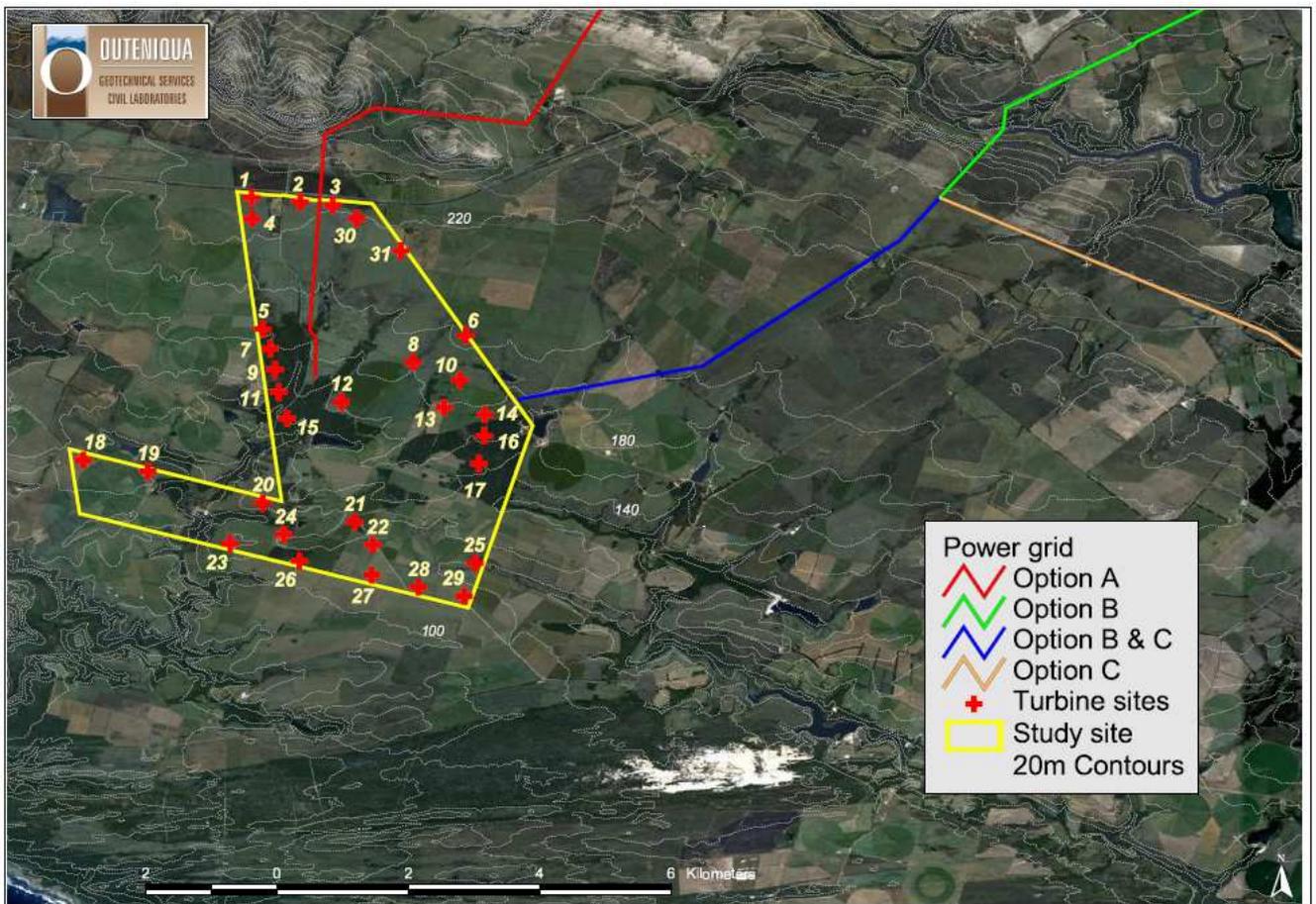
**Figure 1:** Locality map of the site

## 2.2. Topography, climate, & vegetation cover

The proposed site is located on the southern foothills of the Cape Fold Belt mountains on gently undulating agricultural pasture, predominantly used for dairy farming. The average gradient slopes in a southerly direction from an altitude of approximately 225m amsl near the northern boundary (along the N2 highway) to an altitude of approximately 115m amsl along the southern boundary.

The proposed site falls within the coastal temperate climatic region of South Africa which is characterised by frontal weather, leading to changeable, often overcast and moderate conditions. Seasonal variation in temperatures is generally mild, but snow can occur at high altitudes on Cape mountain ranges. Midday temperatures typically range between 15 and 25°C<sup>2</sup> and mean annual precipitation is 500-800mm.<sup>4</sup> The Weinert Climatic N-number<sup>7</sup> for the area, which is approximately 2, indicates that the climate is semi-humid, often wet and chemical weathering processes are dominant.

Vegetation on the site is largely transformed due to cultivation and significant alien invasion has occurred in areas that are not cultivated (specifically on Portion 5 & 6).



**Figure 2:** Aerial photo of site showing contours and proposed infrastructure

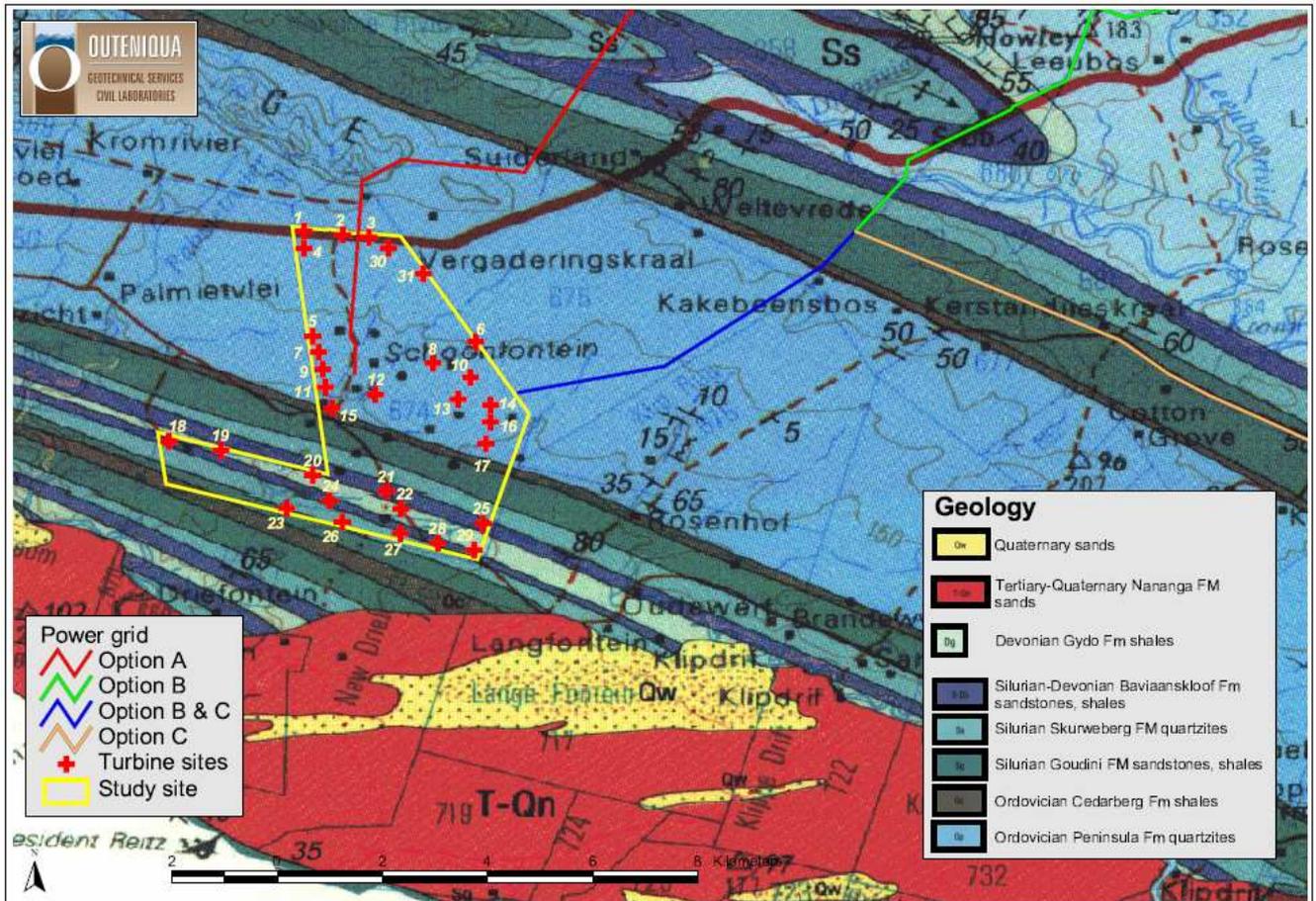
### 2.3. Geology & soil types

The entire site is located on the African Erosion Surface which is a palaeo-planation underlain by rocks of the Palaeozoic Cape Supergroup (see **Figure 3**) which consists of the basal Table Mountain Group (including the Peninsula Formation quartzite, Cederberg Formation shale, Goudini Formation sandstone, Skurweberg Formation quartzite, and Baviaanskloof Formation sandstone) and the overlying Bokkeveld Group (represented by the Gydo Formation shales). The northern half of the site is underlain by the older Peninsula Formation quartzites and the southern half of the site is underlain by younger formations, the majority of which are less resistant to weathering.

The Cape rocks are folded along northwest-southeast trending axes which is a result of compressional deformation during the Cape Folding Event which occurred approximately 310million years ago.<sup>15</sup> There are no significant geological faults in the immediate vicinity of the site and the region is considered to be seismically inactive.<sup>14</sup>

Outcrops of hard quartzitic sandstone of the Peninsula Formation were noted along the existing gravel road in the vicinity of turbine No. 15. Other quartzite rock outcrops of the Skurweberg Formation were noted in the vicinity of turbine No.25. These two formations are the most resistant to weathering of all the underlying rock formations. Outcrops of other, less resistant formations are unlikely due to the deep weathering of these softer rocks.

The typical soil profiles associated with these geological formations are characterised by fine grained topsoils (silty clayey sands) overlying a moderately to deeply weathered residual soil horizon consisting of silts and clays on shales/siltstones or clayey sands over sandstones. A thinner, coarser granular soil cover is expected on the harder, more resistant quartzites (such as those of the Peninsula and Skurweberg formations). The fine grained transported soil cover (which is often loose and prone to erosion) on the high-lying areas of the site is likely to be relatively thin because erosion has been the dominant process and therefore the transported soils will be concentrated along valleys and natural drainage lines.



**Figure 3:** Geological map of the study area.

## 2.4. Hydrology

The study area drains into the catchment areas of the Klipdrif and Tsitsikamma Rivers to the east and west of the study area, respectively. The structural geology exerts a control over the alignment of major rivers in the area, which tend to follow softer rock formations along this NW-SE trend.

Infiltration of rainwater is likely to be low due to the presence of near-surface rock or low permeability soils and therefore a significant percentage of rainfall will end up as surface run-off. The presence of well-defined drainage lines are an indication of significant proportion of surface run-off.

## 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 natural soil cover, bedrock geology and other geological landforms. Important or prominent geological features or landforms that contribute to the aesthetic scenery or geological interest in the area also considered in the impact study. Features such as middens, addits, fossil sites, etc. which are important from archaeological, palaeontological or heritage perspective are not covered in this report. The geohydrological environment is also not covered in this study.

The proposed activity may potentially cause a negative direct impact on degradation of soil, rock and/or landforms. The proposed activity could also result in negative indirect impacts, such as increased siltation in waterways downstream from the site or dust pollution in the area surrounding the site. The severity or significance of the various impacts is related to the nature and extent of the activity.

Potential direct positive impacts could include a reduction in soil erosion along poorly constructed and poorly maintained existing roads which could be improved to accommodate run-off in a more controlled manner (i.e. better drainage). Potential indirect positive impacts relating to the geological environment could include a reduction in the demand for non-renewable energy sources (such as coal). and the impacts are dominantly related to the construction phase with insignificant additional impacts in the post construction and decommissioning phases.

### **3.1. Soil degradation**

Soil degradation is the negative alteration of the natural soil profile, usually directly or indirectly related to human activity. Soil degradation due to construction activity will negatively affect soil formation, natural weathering processes, moisture levels and soil stability. This will, in turn, affect biological processes operating in the soil. Soil degradation includes erosion (i.e. due to water and wind), soil removal, mixing, wetting, compaction, pollution, salinisation, crusting, and acidification.

Soil erosion is a natural process whereby the ground level is lowered by wind or water action and may occur as a result of *inter alia* chemical processes and/or physical transport on the land surface<sup>1</sup>. 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 a local and regional scale (i.e. on and off site) and as a potential threat to global agricultural potential. 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 variables<sup>8</sup>, such as mode of transport (i.e. wind or water).

Erosion of soil due to water run-off is generally considered as more important due to the magnitude of the potential impact over a relatively short period of time which can be very difficult to control. Erosion by water occurs when the force exerted on the soil by flowing water exceeds the internal shear strength of the soil and the soil fails and becomes mobilised into suspension. Erosion potential is typically increased in areas where soil is loosened and vegetation cover is stripped (e.g. construction sites). Erosion sensitivity can be broadly mapped according to the severity of the potential erosion if land disturbing activities occur and this is generally related to the geology, soil types and the topography. Generally speaking, unconsolidated or partly consolidated fine-grained soils of low plasticity along drainage lines and on moderate to steep slopes or at the base of steep slopes are most vulnerable to severe levels of erosion due to water run-off. These areas are typically called "highly sensitive" areas.

Specifically relating to the site in question, the geological map in **Figure 3** indicates that the northern half of the site is underlain by hard, resistant quartzite rock of the Peninsula Formation

and the remainder southern portion is underlain by a variety of generally softer rocks (with exception of the Skurweberg Fm which also consists of quartzite. The geological setting is not typically prone to erosion but minor erosion will occur in areas where run-off is concentrated, such as along roads (side channels) and along natural drainage lines where hydraulic energy is higher. **Table 2** summarises the site sensitivity in terms of water erosion.

**Table 2:** Water erosion sensitivity

Sensitivity Level	Area/Terrain	Comments/Recommendations
Moderate	Natural drainage lines	Natural erosion taking place at present. Special engineering measures required.
Low	Remainder of site	Minor natural erosion taking place at present. Normal erosion mitigating measures apply.

### 3.2. Degradation of bedrock, topography and landforms

Excavations for foundations, pipelines and access roads in areas where shallow bedrock occurs may have a negative impact on the bedrock and the natural topography. However, the excavations are likely to be restricted and to a depth of less than a few meters which will have minimal effect on the surroundings. Excavations for access roads in areas with steeper terrain may involve significant road cuttings which may result in unsightly scars on the hillside. Road cuttings can also lead to slope instability if not engineered properly, resulting in further degradation of the landscape. Degradation of the natural topography can also lead to changes in the hydrology and groundwater regime of the surroundings. Generally speaking the degradation to the site geology is not considered to be too problematic as the topographic relief is low to moderate.

### 3.3. Assessment of impacts

The environmental impact assessment aims to evaluate the impacts that the proposed activity will have on the geological environment and attempts to provide mitigating measures to minimise negative impacts.

Direct, indirect, and cumulative negative 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).

### 3.3.1. Direct impacts

An assessment of the individual potential direct impacts associated with the proposed activity is tabulated in **Table 3**.

**Table 3:** Potential direct impacts

<b><i>Nature: Removal and displacement of soil for roads, pipelines and structures.</i></b>		
	<b><i>Without mitigation</i></b>	<b><i>With mitigation</i></b>
<b><i>Extent</i></b>	Local (1)	Local (1)
<b><i>Duration</i></b>	Long term (4)	Short term (2)
<b><i>Magnitude</i></b>	Low (4)	Minor (2)
<b><i>Probability</i></b>	Definite (5)	Definite (5)
<b><i>Significance</i></b>	<b>Moderate (45)</b>	<b>Low (25)</b>
<b><i>Status</i></b>	Negative	Negative
<b><i>Reversibility</i></b>	Partially reversible	Partially reversible

<b>Irreplaceable loss of resources?</b>	Yes	Yes
<b>Can impacts be mitigated?</b>	Yes, to a certain extent.	
<b>Mitigation:</b>	<ul style="list-style-type: none"> <li>» Use existing roads where possible.</li> <li>» Design platforms, lay-down areas and roads according to contours to minimise cut and fill operations.</li> <li>» Restrict activity outside of authorised construction areas.</li> <li>» Rehabilitate soil after construction.</li> </ul>	
<b>Cumulative impacts:</b>	» The cumulative impact of soil removal in the area is considered low due to undeveloped nature of the area.	
<b>Residual impacts:</b>	» Minor negative – slow regeneration of topsoil.	

<b>Nature: Loosening, mixing, wetting &amp; compacting of in situ soil during earthworks.</b>		
	<b>Without mitigation</b>	<b>With mitigation</b>
<b>Extent</b>	Local (1)	Local (1)
<b>Duration</b>	Medium term (3)	Short term (2)
<b>Magnitude</b>	Low (4)	Minor (2)
<b>Probability</b>	Definite (5)	Definite (5)
<b>Significance</b>	<b>Moderate (40)</b>	<b>Low (25)</b>
<b>Status</b>	Negative	Negative
<b>Reversibility</b>	Irreversible	Reversible
<b>Irreplaceable loss of resources?</b>	Yes	Minor
<b>Can impacts be mitigated?</b>	Yes, to a certain extent	
<b>Mitigation:</b>	<ul style="list-style-type: none"> <li>» Use existing roads where possible.</li> <li>» Design platforms and roads according to contours to minimise cut and fill operations.</li> <li>» Restrict activity outside of construction areas.</li> <li>» Rehabilitate soil after construction.</li> </ul>	
<b>Cumulative impacts:</b>	» The cumulative impact of earthworks in the area is considered low due to the undeveloped nature of the area	
<b>Residual impacts:</b>	» Minor negative – slow regeneration of vegetation & soil.	

<b>Nature: Increased pollution of soil by contaminants (e.g. fuel, oil, chemicals, cement).</b>		
	<b>Without mitigation</b>	<b>With mitigation</b>
<b>Extent</b>	Local (1)	Local (1)
<b>Duration</b>	Medium term (2)	Very short term (1)
<b>Magnitude</b>	Low (4)	Minor (2)
<b>Probability</b>	Probable (3)	Probable (3)
<b>Significance</b>	<b>Low (21)</b>	<b>Low (12)</b>
<b>Status</b>	Negative	Negative
<b>Reversibility</b>	Partially reversible	Partially reversible

<b>Irreplaceable loss of resources?</b>	Yes	Minor
<b>Can impacts be mitigated?</b>	Yes, to a certain extent	
<b>Mitigation:</b>	<ul style="list-style-type: none"> <li>» Control use and disposal of potential contaminants or hazardous materials.</li> <li>» Remove contaminants and contaminated topsoil and replace topsoil in affected areas.</li> </ul>	
<b>Cumulative impacts:</b>	» The cumulative impact of soil pollution is considered low due to the undeveloped nature of the study area.	
<b>Residual impacts:</b>	» Minor negative – slow regeneration of soil processes in and under topsoil	

<b>Nature: Increased soil erosion by wind and water.</b>		
	<b>Without mitigation</b>	<b>With mitigation</b>
<b>Extent</b>	Local (1)	Local (1)
<b>Duration</b>	Medium term (3)	Very short term (1)
<b>Magnitude</b>	Low (4)	Minor (2)
<b>Probability</b>	Very probable (4)	Probable (3)
<b>Significance</b>	<b>Moderate (32)</b>	<b>Low (12)</b>
<b>Status</b>	Negative	Negative
<b>Reversibility</b>	Irreversible	Practically irreversible
<b>Irreplaceable loss of resources?</b>	Yes, minor	Yes, minor
<b>Can impacts be mitigated?</b>	Yes.	
<b>Mitigation:</b>	<ul style="list-style-type: none"> <li>» Minimise size of construction camps.</li> <li>» Restrict activity outside of construction areas.</li> <li>» Implement effective erosion control measures.</li> <li>» Carry out earthworks in phases across site to reduce the area of exposed ground at any one time.</li> <li>» Keep to existing roads, where practical, to minimise loosening of natural ground. Improve drainage along roads.</li> <li>» Protect and maintain denuded areas and material stockpiles to minimise erosion and instability</li> </ul>	
<b>Cumulative impacts:</b>	» The cumulative impact of soil erosion in the area is considered low due to the undeveloped nature of the area.	
<b>Residual impacts:</b>	» Minor localised erosion.	

<b>Nature: Reduction in soil erosion by water as a result of improved drainage and control of run-off.</b>		
	<b>Without mitigation</b>	<b>With mitigation</b>
<b>Extent</b>	Local (1)	n/a
<b>Duration</b>	Long term (4)	n/a
<b>Magnitude</b>	Low (4)	n/a
<b>Probability</b>	Very probable (4)	n/a
<b>Significance</b>	<b>Moderate (36)</b>	n/a

<b>Status</b>	Positive	
<b>Reversibility</b>	n/a	
<b>Irreplaceable loss of resources?</b>		
<b>Can impacts be mitigated?</b>		
<b>Mitigation:</b>		
<b>Cumulative impacts:</b>		
<b>Residual impacts:</b>		

### 3.3.2. Indirect impacts

An assessment of the potential indirect impacts associated with the proposed activity is tabulated in **Table 4**.

**Table 4:** Potential indirect impacts

<b>Nature: Increased siltation of drainage lines and watersources downstream from site.</b>		
	<b>Without mitigation</b>	<b>With mitigation</b>
<b>Extent</b>	Regional (3)	Local (1)
<b>Duration</b>	Long term (4)	Long term (4)
<b>Magnitude</b>	Minor (2)	Minor (2)
<b>Probability</b>	Probable (3)	Probable (3)
<b>Significance</b>	<b>Low (27)</b>	<b>Low (21)</b>
<b>Status</b>	Negative	Negative
<b>Reversibility</b>	Irreversible	Irreversible
<b>Irreplaceable loss of resources?</b>	Yes	Yes
<b>Can impacts be mitigated?</b>	Yes	
<b>Mitigation:</b>	<ul style="list-style-type: none"> <li>» Install anti-erosion measures such as silt fences, geosynthetic erosion protection and/or flow attenuation along watercourses below construction sites.</li> <li>» Strictly controlled activity near water courses/natural drainage lines as sediment transport is higher in these areas.</li> </ul>	
<b>Cumulative impacts:</b>	<ul style="list-style-type: none"> <li>» The cumulative impact of siltation in the area is considered low.</li> </ul>	
<b>Residual impacts:</b>	<ul style="list-style-type: none"> <li>» Minor localised movement of soil across site</li> </ul>	

<b>Nature: Increased dust pollution from construction sites affecting surroundings.</b>		
	<b>Without mitigation</b>	<b>With mitigation</b>
<b>Extent</b>	Regional (2)	Local (1)
<b>Duration</b>	Very short term (1)	Very short term (1)
<b>Magnitude</b>	Low (4)	Minor (2)
<b>Probability</b>	Highly probable (4)	Highly probable (4)

<b>Significance</b>	<b>Low (28)</b>	<b>Low (16)</b>
<b>Status</b>	Negative	Negative
<b>Reversibility</b>	Irreversible	Irreversible
<b>Irreplaceable loss of resources?</b>	Yes, low	Yes, minor
<b>Can impacts be mitigated?</b>	Yes	
<b>Mitigation:</b>	» Use suitable gravel wearing course on access roads » Apply straw bales or dampen dusty denuded areas.	
<b>Cumulative impacts:</b>	» The cumulative impact of dust in the area is considered low.	
<b>Residual impacts:</b>	» Minor localised movement of soil across site	

<b>Nature: Reduction in demand for non-renewable energy sources.</b>		
	<b>Without mitigation</b>	<b>With mitigation</b>
<b>Extent</b>	National (3)	n/a
<b>Duration</b>	Long term (4)	n/a
<b>Magnitude</b>	Moderate (6)	n/a
<b>Probability</b>	Very probable (4)	n/a
<b>Significance</b>	<b>Moderate (52)</b>	n/a
<b>Status</b>	Positive	
<b>Reversibility</b>		
<b>Irreplaceable loss of resources?</b>		
<b>Can impacts be mitigated?</b>		
<b>Mitigation:</b>		
<b>Cumulative impacts:</b>	» The cumulative positive impact on a national (and international) scale is considered very high.	
<b>Residual impacts:</b>		

### 3.3.3. Impact statement

The potential negative impacts on the geological environment are considered to have a low to moderate significance. With effective implementation of mitigating measures these impacts identified above can be reduced to a low significance.

The potential positive impacts on the geological environment are considered to have a moderate significance on a local scale but the cumulative impact of a reduction in demand and extraction/mining of non-renewable energy sources on a national scale is very significant.

### 3.4. Alternatives

There are no site alternatives under consideration. The do-nothing alternative will have no negative impact on the geological environment but will also not make any significant contribution to reducing the demand for non-renewable energy.

There are three alternative power line routes as follows:

- Alternative A – Power line routed to Dieprivier substation.
- Alternative B – Power line routed to Melkhout substation via the N2.
- Alternative C – Power line routed to Melkhout substation via Impofu dam.

The underlying geology is very similar for all three alternatives. Alternative A is preferred due to the shorter distance covered and the corresponding lower impact significance due to less infrastructure.

### **3.5. Environmental Management Plan (EMP) guidelines for earthworks**

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

#### **3.5.1. Earthworks**

1. Prior to earthworks (including site clearance) starting on the site, a plant search and rescue operation shall be undertaken as per the requirements set out in the EMP.
2. All earthworks shall be undertaken in such a manner so as to minimise the extent of any impacts caused by such activities.
3. Defined access routes to and from the area of operations as well as around the area of operation shall be detailed in a method statement for approval by the Site Manager.
4. No equipment associated with the activity shall be allowed outside of these areas unless expressly permitted by the Site Manager.
5. Mechanical methods of rock breaking, including Montabert-type breakers and jackhammers, have noise and dust impacts, and must be addressed in the EMP.
6. Residents shall be notified at least one week prior to these activities commencing, and their concerns addressed.
7. Chemical breaking shall require a method statement approved by the Engineer's Representative (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, shade cloth or straw bales to protect them.
2. Once all grades have been finalised and prepared, topsoil should be spread evenly to all affected 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 compacted and the areas 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 and provision shall be made for the following methods (or combination):
  - 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) Gabion bolsters & mattresses for flow attenuation
  - 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 (If required)**

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 allow for good quality vibration monitoring equipment and record keeping on site at all times during blasting operations.
7. The contractor shall ensure that emergency services are notified, in writing, a minimum of 24 hours prior to any blasting activities commencing on site.

8. 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 at the contractor's expense to the satisfaction of the ER.
9. The contractor shall ensure that adequate warning is provided immediately prior to all blasting. All signals shall also be clearly given.
10. The contractor shall use blast mats for cover material during blasting. Topsoil may not be used as blast cover.
11. During demolition the contractor shall ensure, where possible that trees in the area are not damaged.
12. 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.
13. At least one week prior to blasting, the relevant occupants/owners of surrounding land shall be notified by the contractor and any concerns addressed. 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 (If required)**

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 commence 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 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. Vehicles leaving borrow pits shall not deposit/shed mud, sand and debris onto any public road.
8. All loads shall be covered with a tarpaulin or similar to prevent dangers and nuisance to other road users.
9. Borrow pits shall be fenced to prevent unauthorized persons and vehicles from entering the area. Fences shall also be stock and game proof.
10. Rehabilitation and re-vegetation of borrow pits sites shall be according to a method statement to be approved by the ECO.
11. The contractor shall ensure that blasted faces of the pit shall be shape-blasted to the approval of the site manager.

12. Where required, dust and fly-rock prevention methods shall be detailed in a Method Statement to be approved by the site manager.
13. During the rehabilitation of borrow pits, 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 as a result of drilling operations.
3. Noise and dust nuisances shall comply with the applicable standards according to the Occupational Health and safety (Act No. 85 of 1993).
4. The Contractor shall ensure that no pollution results from drilling operations, either as a result of oil and fuel drips, or from drilling fluid.
5. All affected parties shall be informed at least one week prior to the onset of the proposed drilling/jackhammering operations, and their concerns addressed.
6. Drill coring with water or coolant lubricants shall require a method statement approved by the Site Manager.
7. 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 shall be kept to a minimum through the use of single trenches for multiple service provision.
2. 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.
3. Trench routes with permitted working areas shall be clearly defined and marked with painted stakes prior to excavation.
4. 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.
5. Trench lengths shall be kept as short as practically possible before backfilling and compacting.
6. Trenches shall be backfilled to the same level as (or slightly higher to allow for settlement) the surrounding land surface to minimise erosion. Excess soil shall be stockpiled in an area approved by the engineer.
7. Immediately after backfilling, trenches and associated disturbed working areas shall be planted with a suitable plant species and regularly watered. 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 and for any costs against the employer for damages resulting from dust.
2. The contractor shall take all reasonable measures to minimise the generation of dust as a result 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 shall be avoided under high wind conditions or when a visible dust plume is present.
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 shall be implemented at the discretion of the site manager.
7. Vehicle speeds shall not exceed 40km/h along dust roads or 20km/h when traversing unconsolidated and non-vegetated areas.
8. Appropriate dust suppression measures shall be used when dust generation is 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 shall be applied at a rate of one bale/ 10m<sup>2</sup> and harrowed into the top 100mm of top material for all completed earthworks.

### **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 5**.

**Table 5:** Summary of objectives of the EMP

OBJECTIVE: Minimise soil and rock degradation

The natural geological environment must be preserved as far as possible to minimise unforeseen impacts on the surrounding environment.

<b>Project component/s</b>	<ul style="list-style-type: none"> <li>• Wind turbines</li> <li>• Access roads</li> <li>• Substation linking the facility to the electricity grid</li> </ul>
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	<ul style="list-style-type: none"> <li>• Underground pipelines and cabling</li> <li>• Overhead power lines</li> </ul>
<b>Potential Impact</b>	<ul style="list-style-type: none"> <li>• Soil and rock removal</li> <li>• Soil mixing, wetting, stockpiling, compaction</li> <li>• Soil pollution</li> <li>• Soil erosion</li> <li>• Siltation of drainage lines</li> <li>• Dust pollution</li> </ul>
<b>Activity/risk source</b>	<ul style="list-style-type: none"> <li>• Construction activity – earthworks &amp; transportation across site</li> <li>• Chemical pollutants</li> <li>• Rainfall - water erosion of disturbed areas</li> <li>• Wind - erosion of disturbed areas</li> </ul>
<b>Mitigation: Target/Objective</b>	<ul style="list-style-type: none"> <li>• To minimise destructive activity within construction areas &amp; prevent unnecessary activity outside of construction areas</li> <li>• To minimise soil degradation (removal, excavation, mixing, wetting, compaction, pollution, erosion, etc.)</li> <li>• To minimise siltation of drainage lines</li> <li>• To minimise dust pollution</li> </ul>

<b>Mitigation: Action/control</b>	<b>Responsibility</b>	<b>Timeframe</b>
Identify areas of high erosion risk (drainage lines/watercourses). Only special works to be undertaken in these areas to be authorised by ECO and Engineer's representative (ER)	ECO/ER/Contractor	Before and during construction
Identify construction areas for general construction work and restrict construction activity to these areas.	ECO/ER/Contractor	Before and during construction
Prevent unnecessary destructive activity within construction areas (prevent over-excavations and double handling)	ECO/ER/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 and roads on steep slopes (to prevent unnecessary cutting and filling operations).	ECO/ER/Contractor	Before and during construction
Dust control on construction site: Wetting or covering of cleared areas.	Contractor	During construction
Minimise removal of vegetation which aids soil stability.	ECO/Contractor	During construction
Rehabilitate disturbance areas as soon as an area is vacated.	Contractor	During and after construction
Soil conservation: Stockpile topsoil for re-use in rehabilitation phase. Protect stockpile from erosion.	Contractor	Before and during construction
Erosion control measures: Run-off control and attenuation on slopes (sand bags, logs), silt fences, stormwater channels and catch-pits, shade nets, soil binding, geofabrics, hydroseeding or mulching over cleared 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	ECO/ER/Contractor	Before construction and maintenance over duration of contract

Mitigation: Action/control	Responsibility	Timeframe
Control depth of excavations and stability of cut faces/sidewalls	ECO/ER/Contractor	Before construction and maintenance over duration of contract

<b>Performance Indicator</b>	<ul style="list-style-type: none"> <li>» Only authorised activity outside disturbance areas</li> <li>» No activity in no-go areas</li> <li>» Acceptable level of activity within disturbance areas, as determined by ECO</li> <li>» Acceptable level of soil erosion around site, as determined by ECO</li> <li>» Acceptable level of increased siltation in drainage lines, as determined by ECO</li> <li>» Acceptable level of soil degradation, as determined by ECO</li> <li>» Acceptable state of excavations, as determined by ER &amp; ECO</li> </ul>
<b>Monitoring</b>	<ul style="list-style-type: none"> <li>» Fortnightly inspections of the site</li> <li>» Fortnightly inspections of sediment control devices</li> <li>» Fortnightly inspections of surroundings, including drainage lines</li> <li>» Immediate reporting of ineffective sediment control systems</li> <li>» An incident reporting system will record non-conformances</li> </ul>

## 4. GEOTECHNICAL ASPECTS

### 4.1 Foundations for wind turbines

The design of foundations for wind turbines primarily concerns the resistance to overturning forces induced by wind loading and the foundation type is largely dependent on geotechnical conditions.

The simplest form of foundation is the spread footing on competent rock or engineered fill. This is essentially a gravity foundation that relies upon the weight of the soil overburden and concrete to provide sufficient vertical force to counteract horizontal forces during extreme wind loading. These footings are typically suited to a relatively shallow founding medium of a few meters and a trench is excavated to reach this level. The typical geometry of a spread footing for a wind turbine is 15-20m in diameter/width and 2-3m thick, resulting in an excavation of some 600m<sup>3</sup> of material.

Rock socketed piers are used where a competent rock layer exists at relatively shallow depths and rely primarily upon end bearing and secondarily upon side wall friction and sufficient lateral earth pressures.

Piled foundations are used in areas where competent founding mediums are found at greater depths.

Rock anchored footings are used where hard competent rock is found at surface or at very shallow depths and the footing is attached to the rock with steel anchors.

The majority of the turbines on the proposed site are underlain by shallow quartzitic sandstone or feldspathic sandstone which should have good bearing capacity. Some of the turbines are

underlain by shale which may be deeply weathered and have poor bearing capacity. A comprehensive geotechnical investigation will have to be undertaken by the developer in order to determine the geotechnical characteristics of the rock in order to allow the engineer to design the foundations.

#### **4.2. Internal access roads and crane platforms**

Access roads are required onto site and between turbines for the construction and maintenance of components. The access roads are typically surfaced with a gravel wearing course and the roads need to be wide enough to accommodate trucks with restricted turning capabilities. Maximum road curvatures, camber and gradients are strictly adhered to in the design process. The natural gradients of the site are low to moderate and some cut and fill operations will be required for the construction of internal access roads.

Stable platforms are required at each turbine site for the operation of cranes to be used in the construction process. The footprint of the platform is typically 1000m<sup>2</sup>. This crane pad is typically constructed on a cut and/or filled levelled platform upon which imported gravel layers are placed and compacted.

#### **4.3. Underground services**

Excavations for underground services are likely to encounter rock. Hydraulic tools may be required to excavate through hard rock.

### **5. CONCLUSIONS**

If suitable mitigating measures are applied, the proposed development will have a low to moderate potential *negative* impact on the geological environment. The proposed development will have also make a significant contribution to the cumulative *positive* impact on the geological environment in terms of a reduction in demand (and exploitation) for non-renewable energy sources. This is particularly important in a national and international context.

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