APPENDIX E

GUIDELINE FOR SEDIMENT AND SOIL MANAGEMENT AND EROSION CONTROL

1. Defining the Geomorphological Environment

According to the 1:250 000 Geological map (3118 Calvinia) published by the Council for Geosciences the area comprises numerous young cover deposits of mostly marine origin underlain by metamorphic bedrock of the Namaqualand Metamorphic Province. Generally the wide range of Tertiary (5 to 2 million years old) to Recent (Holocene from the end of the Pleistocene (8 000 years ago to present time) deposits covering the coastal plain includes thin cover sands where underlying bedrock is difficult to deduce to limited outcrop and exposure. Raised beaches along the coast are related to marine transgression linked to Tertiary and Pleistocene sea-floor spreading, glaciations and crustal warping.

Marine terrace deposits (raised beaches) are common along the coastline and are unlikely to occur within the wind energy facility site.

Isolated and patchy calcrete material is mapped in the south-eastern part of the study area, west of the Skilpadvlei farmstead. These calcrete deposits are related to dorbank (indurated hard rock pedogenic material) of the surrounding calcareous soils and represent advanced calcretisation of the red sand, clay, gravel and scree that occurs in the area. The calcrete is usually about 1 m thick but can reach thicknesses if up to 6 m in places.

Isolated duricrusts of silcrete and ferricrete also occur in the SchaapVlei area and appear to be related to the sub-surface palaeo (ancient) drainage system along which enhanced ground water movement took place. This layer frequently crops out at between the 65 m and 70 m contour levels. The duricrust formation is described as being related to three main mechanisms of enhanced groundwater circulation:

- Palaeo land surfaces or permeable terrace gravels
- Palaeo drainage systems
- Major fault structures

Calcareous and gypsoferous soils are mapped in the extreme southern (north of Cliff Point) and north-western (south of the Weskus Mynbou landing strip and Skaapvlei) part of the study area. These surficial deposits generally comprise hard red calcareous soil known as dorbank. These materials have been interpreted as remnants of the overlying terrace deposits of the Quagga’s Kop Formation, which frequently exhibit similar degrees of calcretisation.

Fine-grained, red-coloured aeolian (formed by wind) sands cover the coastal plain throughout the region, including large parts of the study area. These wind-blown sands frequently form low-relief, mobile bedforms that are blown over underlying harder calcareous soils. The dunes are able to form up and down the slopes of hills and valleys to reveal micro "climbing falling" dune morphologies.

Patches of the dune sand overlie various other bedrock and surficial deposits and stretch right up to the coast where they spill over the sea cliff onto white beach and dune sand. The red colour of the dune sand is a function of oxidising arid conditions. The sand bedforms are generally blown inland by the prevailing southerly and south-westerly winds and it is suggested that the red aeolian sand was derived from the palaeo Olifants River mouth, which would have occurred south-east of its present location during Palaeogene/Neogene regression.

2. Defining the geological constraints

The study area generally comprises weathered metamorphic rocks of the Namaqualand Metamorphic Province at depth. These bedrock conditions are overlain by unconsolidated aeolian sand with variable pedogenic influences dominated by calcareous material with minor amounts of ferruginous and siliceous material in places. The calcareous material ranges from competent dorbank (hardpan) grading to more friable glaebular calcrete and calcretised sand, whilst the ferricrete and silcrete tends to grade into one another and are composed of sand, grit, talus and conglomerate.

Engineering geological constraints that must be considered during planning from an engineering perspective include the following:

» Where clayey material occurs close to surface this material may be expansive and should be tested to determine any heave characteristics. Heaving clays will result in structural damage to foundations during fluctuating moisture conditions if not taken into account by the project engineers during foundation design.
» The unconsolidated aeolian sand would be erodible by both wind and water. These cover sands should, therefore, be protected by vegetation cover and excavation gradients of not steeper than 1:3 should be created to facilitate such growth.
» Where cover sands are exposed to flowing water and high wind speeds the risk of soil erosion could be considered high.
» The sands in the study area may contain a collapsible fabric and should be tested to ascertain any inherent collapse potential. This implies structural damage to foundations where such soil movements have not been allowed for in the foundation design.
» Differential settlement concerns should be borne in mind where structures are founded on material of variable consistency such as very loose aeolian sand and well cemented calcareous dorbank (hardpan). Ground conditions in such environments

should be checked by project engineers during construction to ensure risks such as these are eliminated/ reduced.

» Compressible soil and associated reduced bearing pressures within the aeolian environment. Engineers will, therefore, have to engineer improved ground conditions to ensure adequate bearing pressures are created to facilitate construction of all infrastructure associated with this project.
» Compressible soil when wet and associated reduced bearing capacities of clayey material after wet periods. Where such clayey conditions occur adequate stormwater drainage will need to be installed to encourage water away from the area of interest.
» Shallow well-cemented dorbank (considered highly likely) and less weathered bedrock (considered highly unlikely) with associated excavation concerns where deeper foundations/trenches are required. Where such excavation concerns are encountered stronger excavation equipment and even blasting may be required to facilitate deep trench excavation.
» Shallow perched water tables in flatter areas especially after periods of heavy or prolonged precipitation. Adequate stormwater planning will be required to ensure that such flooding scenarios are reduced/eliminated during the design stage of the project.
» Poor surface drainage and damp conditions where flat grades prevail.
» Unstable excavation sidewalls where excavation trenches are opened where (a) shallow perched water tables prevail or (b) where deep excavations are opened within unconsolidated aeolian sand.
» Karst topography and sinkholes cannot be excluded where thicker accumulations of calcareous material occur. Karstic weathering phenomena are well documented where groundwater ingress occurs into thick calcareous deposits such as occurring in the study area (considered unlikely in the study area due to low rainfall values).

Many of the above criteria should be proven during invasive field investigation techniques, including disturbed soil sample analysis. The suitability of material for construction applications such as turbine foundations and pavement layerworks should also be established during such detailed engineering geological investigation. Additional tests that should be carried out during the specialist investigation include the establishment of the erosion potential of the material occurring across the site (i.e. dispersiveness), the suitability of the material for construction applications, *in situ* bearing capacities and the chemical potential of the groundwater (perched) occurring across the site to impact negatively on reinforced concrete structures.

Engineering geological test procedures that should be undertaken during the above specialist investigation should include the following:

» Foundation Indicator for turbine and substation foundations (including hydrometer test)
» Road Indicator for road pavement layerworks

- MOD CBR for both foundation and pavement design
- SCS Double Hydrometer to establish dispersive potential of the soil
- Corrosive test of groundwater (if encountered) to establish impact on reinforced concrete

Suitable construction material for road surfaces must be identified for use.

3. Soil horizons

The majority of the soil within the Namaqualand Strandveld area (which stretches along the coast between the Olifants River and the Orange River) is a mixture of soil which originated from the interior and from the ocean. The strong southerly wind along the coast has, over time, blown away the finer soil particles, leaving behind the coarser soil particles.

In general, soil types change with distance inland – white soils are associated with the coastal dunes, with yellow and red soils being more prominent inland.

The soil type affects the plant groups which grow in an area. The **white soil** near to the coast is looser and more mobile, supporting only plants which can withstand these conditions. This is generally the easiest area to rehabilitate as plants which are found in this area are adapted to the dunes which are continually altered by the wind.

The **yellow soils** which occur further inland are more stable, and therefore plant species which require more stable conditions are found in these areas, although those plants which are found on the white dune sands can also occur here.

The **red soils** which are found even further inland are the most stable and oldest soils in the area. Some plant species which occur in these areas are very sensitive and are easily disturbed, making rehabilitation very difficult.

The following soil horizons are relevant in soil management:

- **Topsoil:**

The top-most soil layer (0-25 cm) in undisturbed areas. This soil layer is important as it contains nutrients, organic material, seeds, communities of micro-organisms, fungi and soil fauna. All the contents of the topsoil layer is necessary for soil processes such as nutrient cycling, and support growth of new plants. The biologically active upper layer of soil is fundamental in the development of soils and the sustainability of the entire ecosystem. Funi, algae, cyanobacteria and non-vascular plants form a 'living crust' on the soil surface that influences the retenetion of resources (principally nutrients and water), as well as reducing the potential for soil erosion.

In general, the greatest concentration of seeds (i.e. up to 90% of the seedbank) is found in the top 5-10 cm of topsoil within the Namaqualand area. Soil nutrients and other biological elements also have a higher concentration in the top 5 – 10 cm of soil, but can occur up to 25 cm.

» **Subsoil:**
Soil generally deeper than 25 cm. The subsoil contains lower levels of nutrients, but the soil texture is still suitable for plant growth. Generally, white dune sand has a subsoil layer which can be up to 2 m deep, whereas the subsoil layer in red soils is only approximately 50 cm.

» **Overburden:**
All the soil below the subsoil layer, generally characterised by a fine soil texture which is sometimes high in clay and salt content which makes plant growth difficult. Such soils comprise a sterile growth medium, devoid of nutrients, and depending on the clay content, are of high salinity and often phytotoxic (Desmet, 1996). Even shallow-lying overburden soils are largely depleted of nutrients. These soils constitute an unsuitable medium for the establishment of plants.

4. Soil Management

Where excavation is required during the construction phase, soil management practises are required to be adhered to in order to limit soil loss and encourage rehabilitation efforts post-construction. The two most important aspects to consider when removing topsoil are the depth of soil to remove as topsoil, and the conditions for storing topsoil.

4.1. The correct handling of topsoil

Topsoil must be retained on site in order to be used to site rehabilitation. The correct handling of the topsoil layer is in most cases the key to rehabilitation success. Local and international studies indicate that the correct handling of topsoil is vital in conserving the seed bank and nutrients which occur within this layer, and thereby ensure rehabilitation success.

It is important that the correct depth of topsoil is excavated in order to ensure good plant growth. If excavation is too shallow, then an important growth medium for new seedlings could be lost. If excavation is too deep, this could lead to the dilution of the seed and nutrient rich topsoil with deeper sterile soil. The mixture of topsoil with the deeper sterile soil hinders the germination of seeds which are buried too deep in the soil layer. Mixture of soil layers also leads to the dilution of nutrient levels which are at highest concentration within the topsoil, resulting in lower levels of nutrients available for new seedlings.

Studies on the Namaqualand coast indicate that the top 5 – 10 cm of soil contains 90% of the seed bank. However, there are difficulties in mechanically removing such shallow layers of soil. In addition, the biologically active and nutrient enriched layer extends well beyond this depth. Since the soils in semi-arid areas contain very little organic matter and there is little stratification in the sandy soils, delineating the topsoil layer is not always an easy task. There is a trade-off between losing too much of the nutrient enriched, biologically active soil, and diluting and irretrievably burying much of the seed bank.

4.2. Storage of topsoil

Topsoil must stored separately from other soil in heaps until construction in an area is complete. Ideally, removed topsoil should be re-applied immediately. This requires planning and co-ordination and transportation of the material. The next best option is to minimise the duration of topsoil storage. storing topsoil for long periods leads to seed bank depletion following germination during storage, and anoxic conditions develop inside large stockpile heaps.

Even in small stockpiles, it is likely that a high proportion of micro-organisms, fungi and soil biota are killed. Associated with the loss of biological communities is a significant depletion in soil nutrients. The length of time that the topsoil is stored is also important as the viability of the seeds, the activity of the biological elements and the nutrients present in the soil reduces with time. This is due to the creation of anaerobic conditions which occur within the topsoil heaps which results in the decomposition of biological material. Both at inland and coastal Namaqualand sites, experience has shown that any relocation of stockpiling of topsil has reduced the concentrations of a range of nutrients. These reductions appear to increase further over the first few months of stockpiling. Experience therefore points to optimum storage less than 1 month in duration and the maximum topsoil height not exceeding 1 m in order to preserve micro-organisms within the topsoil, which can be lost due to compaction and lack of oxygen. A storage period for topsoil of less than 3 months is recognised internationally as best practice. Topsoil should not be stripped or stockpiled when wet, as compaction will occur.

Overburden must not be mixed with topsoil stockpiles. All stockpiles must be positioned away from drainage lines. Sediment fencing should be erected downslope of all stockpiles to intercept any sediment and upslope runoff should be diverted away from stockpiles.

4.3. Prevention of wind erosion

After replacement of the topsoil layer during rehabilitation, it is important to ensure that this area is protected against wind erosion such that the topsoil is not blown away. Strong and regular winds are considered to be the greatest hindrance to successful rehabilitation in this area. In undisturbed areas, fully-grown plants provide protection to seedlings and sensitive species against the strong winds. In a disturbed area, however, there is nothing to reduce the wind speed, resulting in new seedlings and relocated plants being easily buried or blown away. The strong winds also result in erosion and the loss of valuable topsoil, which makes rehabilitation even more difficult. There have been instances along the west coast where the entire topsoil layer has been lost within two days of replacement as a result of erosion by strong winds. The use of wind nets has been shown to be an effective method of minimising the loss of soil through wind erosion. It is therefore important that wind nets are erected as soon as the topsoil is replaced in an area. If correctly implemented, the use of wind nets in rehabilitation areas can assist in reducing the wind speed and protect new plant growth.

4.4. Overburden

The overburden is generally a sterile and, in most cases, a coloured material which has no organic or nutrient content which would support plant growth. The overburden generally becomes more salty and clayey with depth. The salt binds to the clay to form a chemical compound which hinders plant establishment.

The high salt and low nutrient content of the soil hinders the establishment of indigenous plants, expect for the salt-tolerant species such as *Atriplex lindeyi*, *Atriplex semibaccata* and *Lycium ferocissimum*.

5. Soil erosion

The site is considered to fall within an arid zone where the Weinert Number (N number) is greater than 5. The published literature indicates that the Namaqualand coastal zone has an N value in excess of 50, which implies that mechanical weathering is more prominent than chemical weathering in the region. The Weinert N number is a value calculated from climatic data that is used by engineers to establish the link associated with the variation in the performance of weathered rocks used in road construction when related to climatic conditions.

The N value is broadly split into areas where the N value is more or less than 5. The humid region of southern Africa is associated with areas where N is less than 5, while the more arid region occurs where N is greater than 5.

The above arid landscapes generally tend to be characterised by shallow soil conditions, which impact on weathering potential in the region. However, in the study area the above bedrock and weathering environments have been covered by reworked aeolian sands, which in turn have been modified by pedogenic (calcrete, ferricrete and silcrete) processes.

The published Erodibility Index for South Africa (published on the DEAT website) suggests that the Namaqualand coastline be considered low to moderate risk in terms of erosion potential (i.e. 11 to 15 out of a maximum of 19). However, significant erosion is known to occur along unsurfaced tracks and other exposed areas in the vicinity of the site.

Site-specific information must be acquired during the invasive engineering geological investigation to establish the various on-site parameters associated with soil erosion in the study area. This data will include:

- the mechanisms of erosion taking place
- the various soil environments within which the erosion takes place
- the significance of erosion should it continue unabated
- whether such erosion is natural or a function of anthropogenic disturbance.

Remedial actions must be established to ensure that existing erosion concerns are addressed with an erosion control strategy towards long-term rehabilitation. All development associated with the wind energy facility and associated infrastructure should be constructed with due cognisance of erosion risk to ensure that new erosion scars are not formed as a consequence of new development footprints.

The following generic points should be noted regarding the erosion risk in the study area:

- Soil loss will be greater during wet periods than dry months. Intense rainfall periods out of the wet season can also cause significant soil loss, however. The provision of erosion control measures for developments where construction occurs through the drier months of the year is equally important as those planned for developments during winter months.
- Soil loss from the site is related to the time that the soils are exposed, prior to rehabilitation/stabilisation. The time from commencement of construction to rehabilitation should be restricted to a minimum. Rehabilitation efforts should commence as soon as practical once construction activities are completed at a particular location.
- Construction staging and progressive rehabilitation of disturbed areas is important.
- The extent of the disturbance will influence the risk and consequences of erosion at the site.

General control measures are recommended in terms of a sediment control plan for the site. These recommendations relate to the planning and implementation stages of the proposed land development project and should be incorporated as part of the EMP:

- Diversion drains – these must be provided to divert run-off from upslope areas around sites of disturbance. Diversion drains should divert “clean” run-off (i.e. before it enters the construction site or areas such as the substation site) to natural drainage channels or lower-lying area. These structures should be designed to cater for peak flow.

» Stabilised Site Access – measures are required to prevent unnecessary erosion at construction sites. Recommendations to minimise such erosion potential include the following:
  - Access to building sites should be restricted to a single location
  - Construct a stabilised site access at the entrance to the construction site
  - Access roads to each turbine construction site should be kept to a minimum and be well delineated. Drivers must be informed of these access roads
  - Temporary access roads used during the construction process should be removed and the area rehabilitated upon completion of the construction phases

» Sediment fences may be utilised as a temporary measure during the construction phase in order to minimise sediment movement off site.