GEOLOGICAL REPORT

SPECIALIST INPUT FOR THE SCOPING PHASE OF THE ENVIRONMENTAL IMPACT ASSESSMENT

PROPOSED TSITSIKAMMA COMMUNITY WIND ENERGY FACILITY, EASTERN CAPE PROVINCE

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List of abbreviations and definitions

AMSL:	Above mean sea level
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Plan
Ma:	Million years
Palaeozoic:	The geological period from 550-250Ma
Pleistocene:	The geological period from 2.5Ma -12000a
Pliocene:	The geological period from 5.3-2.5Ma
Quaternary:	The geological period from 2.5Ma to present
Study area:	The area as delineated on **Figure 1**
Tertiary:	The geological period from 550-250Ma
WEF:	Wind Energy Facility

1. INTRODUCTION

1.1. Background

Exxaro Resources and Watt Energy (Pty) Ltd are in the process of investigating the feasibility of a proposed Wind Energy Facility (WEF) on a site in the Tsitsikamma area in the Eastern Cape Province. The proposed activity is defined as the establishment of a WEF and associated infrastructure, including the following:

- Wind turbines with a maximum capacity of 100MW and concrete foundations to support them;
- Underground cabling between the turbines;
- A substation and associated 132kV power line to facilitate the connections between the WEF and the existing Melkhout Substation;
- Internal access roads to each turbine;
- A workshop building for maintenance and control.

1.2. Terms of reference

Savannah Environmental (Pty) Ltd has been appointed by Exxaro Resources and Watt Energy (Pty) Ltd to undertake the EIA process for the proposed activity. As part of the Scoping Phase, specialist geological input is required in order to identify the geology of the site and determine potential environmental impacts on the geological environment within the study area, with particular focus on soil erosion. Savannah Environmental has appointed Outeniqua Geotechnical Services to conduct a specialist geological report for the Scoping Phase.

The following broad scope of work has been given:

- Carry out a desk-top study of available information pertaining to the geology, soil types and physical aspects of the study area;
- Prepare a brief report which describes the location, physical characteristics, geology and potential environmental impacts on the geological environment that are likely to be associated with the proposed activity.

1.3. Limitations

Information provided in this specialist report has been based on information provided by the developer, published scientific literature and maps. The study area was not visited and no detailed geotechnical investigation (trial pits, soil testing) or verification of the existing geological mapping was conducted. The information provided in this report is deemed adequate for the Scoping Phase of the EIA process.

1.4. 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 construction, mining and energy 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 Institution of Civil Engineering (SAICE).

OGS shareholders and employees have 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 proposed wind energy facility is located near Humansdorp on the farms: Portions 19 and 22 of Zalverige Valley 660, Portions 3, 4 and 5 of Vergaaderingskraal 675, Portion 1 of Ou Driefontein 721, Portion 2 of New Driefontein 720, Portions 3 - 9 of Wittekleibosch 787, Farm 818, Remainder of Farm 678 and Portion 3 of Kliprug 676.

The study area is accessed via the N2 between Port Elizabeth and Plettenberg Bay and then the R102 (see Figure 1).

Figure 1: Locality and topography map of study area (blue shaded farm portions)

2.2. Topography, climate & vegetation cover

The study area is located on the gently undulating remnant of the African Erosion Surface which developed during between the late Jurassic (145Ma) until the end of the early Miocene at approximately 15Ma.[10] The end result of this prolonged erosion event resulted in advanced planation throughout the sub-continent resulting in the development of a deep-weathered profile.[11] Concomitant and subsequent continental uplift has promoted the incision of rivers into this surface, resulting in several steep-sided river valleys which flow in a southerly direction towards the coast. The study area ultimately drains into the Tsitsikamma River on the western side and the Klipdrifrivier on the eastern side (See **Figure 2**).

Altitude ranges across the study area from 220m in the northern portion near the N2 highway to sea level in the southern portion.

The Köppen-Geiger Climate Map indicates that this area falls within the marine 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 the mountain ranges to the north of the study area. Midday temperatures typically range between 15 and 25°C and mean annual precipitation between 600-850mm.[2] The Weinert Climatic N-number[7] for the area, which is approximately 2, indicates that the climate is semi-humid and chemical weathering processes is dominant.

The indigenous vegetation has been highly altered for agricultural purposes and presently consists of croplands and grazing over most of the study area, with some indigenous vegetation likely in the southern coastal area.

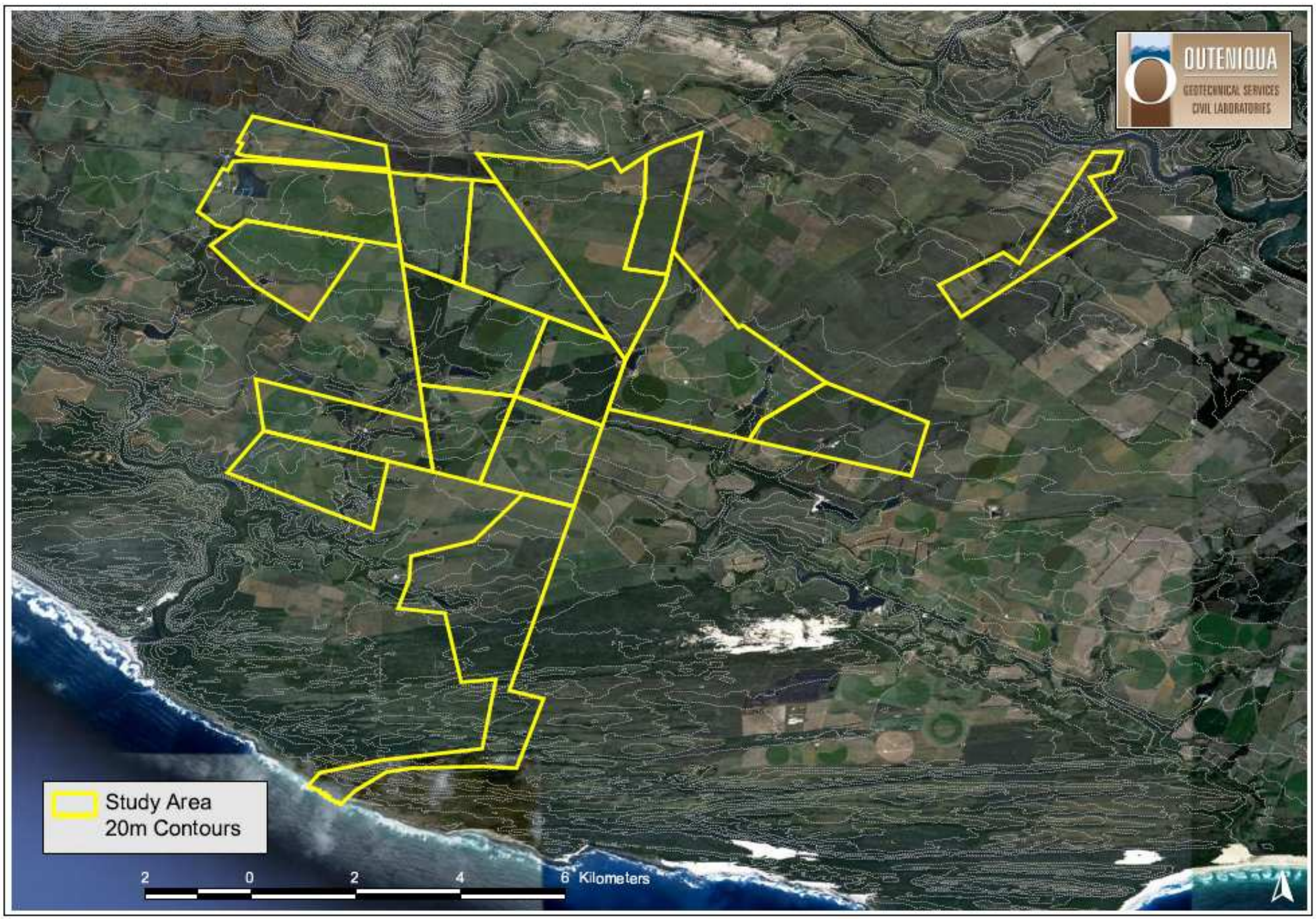

Figure 2: Aerial photo of the study area (yellow lines) with 20m contours

2.3. Geology & soil types

The northern portion of the study area is underlain by rocks of the Palaeozoic Cape Supergroup (blue, purple and green in **Figure 3**) which are unconformably overlain in the southern portion of the study area by Plio-Pleistocene (Tertiary-Quaternary) and Holocene (Quaternary) deposits of aeolian sands of the Nanaga Formation and Schelm Hoek Formations, respectively (red and yellow in **Figure 3**).[11]

The geological sequence of the older Table Mountain Group of the Cape Supergroup that is exposed in the study area consists of the basal Peninsula Formation quartzites, successively overlain by Cederberg Formation shales, Goudini Formation sandstone, Skurweberg Formation quartzites, and Baviaanskloof Formation sandstones. In localised areas, Gydo Formation shales (Bokkeveld Group of the Cape Supergroup) are exposed along the axis of synclines, resting on an unconformity between exposures of older Baviaanskloof Formation.

The Cape rocks are folded along northwest-southeast trending axes which result in a mirror-image repetition of formations on either side of the axial planes. The limbs of the folds dip between 35 and 80°. This folding is a result of compressional deformation during the Permo-Triassic collision of the Pan-African and African plates. Subsequent tensional forces during the Jurassic-Cretaceous breakup of Gondwana produced significant normal faulting in the Cape Supergroup, producing several large half-grabens into which Cretaceous sediments were deposited (i.e. Uitenhage Group) to the east and west of the study area. There are no significant geological faults in the immediate vicinity of the study area and the region is considered to be seismically stable.

Hard quartzite rock outcrops and gravelly talus soils are likely to occur in areas underlain by Peninsula and Skurweberg Formations. Slightly softer sandstone with clayey, sandy and gravelly soil overburden are expected in areas underlain by Goudini and Baviaanskloof Formations. Relatively soft shale and clayey, gravelly residual soil is expected in areas underlain by Cederberg and Gydo Formations.

The Tertiary-Quaternary aeolian deposits (red and yellow in **Figure 3**), which occur in the southern portion of the study area, consist of unconsolidated to semi-consolidated sands of several meters thick.

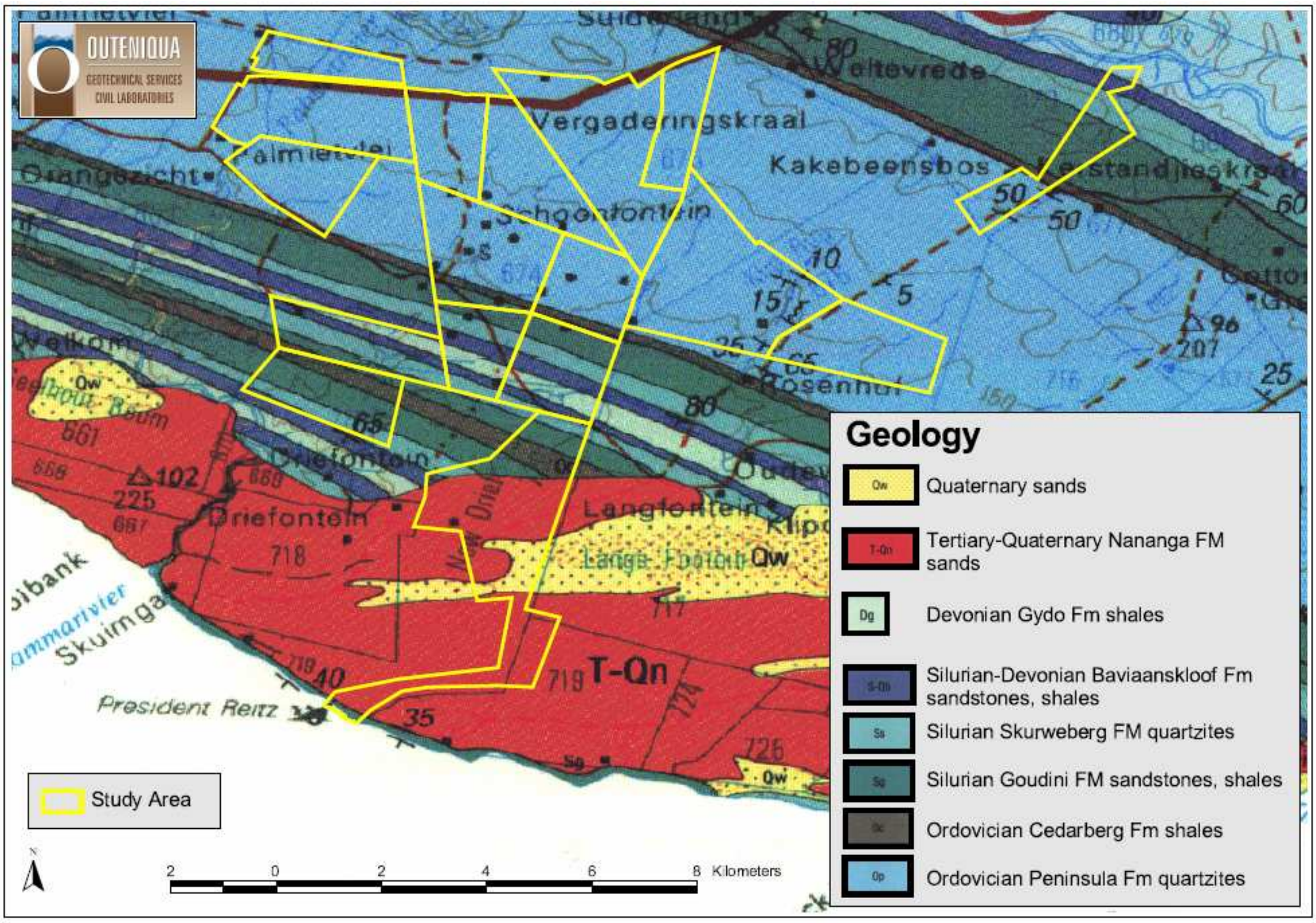

Figure 3: Geology of the study area.

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. Surface infiltration 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 surface drainage. The percentage run-off has implications for water erosion potential.

3. GEOLOGICAL SCOPING ASSESSMENT

The proposed activity may have certain impacts on the geological environment, and this needs to be assessed as an integral part of the broader EIA study. The geological environment includes the bedrock and the soil cover. Important or prominent geological features (geosites) that contribute to the aesthetic scenery or geological interest in the area, such prominent rock outcrops or features, must also be considered in the impact study. Heritage features, such as caves, addits, middens, fossil sites, etc. are not covered in this report as they are covered in the Heritage Impact Assessment. Geohydrological assessments also do not form part of this study.

3.1. Geo-sites

There are no known important or interesting geological phenomena that need to be addressed.

3.2. Rock degradation

Road cuttings into bedrock are anticipated due to the undulating terrain but there are no large-scale or deep excavations planned (such as quarries), and thus there is no significant rock degradation envisaged in the proposed activity which may affect groundwater tables or result in geological instability.

3.3. Soil degradation

Soil degradation is the removal, alteration or damage to soil and soil-forming processes which can be due to natural processes, such as erosion, or human influence during construction activity. The preservation of the natural soil is important to maintain environmental *status quo*.

Potential negative impacts relating to soil degradation are anticipated for the proposed activity. Such impacts include excavation, displacement or importation of soil, stockpiling, mixing, wetting, compaction and pollution of soil, soil erosion and sedimentation of watercourses and storage dams.

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[1]. A geological terrain with a high erosion sensitivity is generally regarded as an area that is prone to severe erosion when the soils are exposed to rainwater (and to a lesser extent, wind) during or as a result of land-disturbing activities. Erosion sensitivity is generally higher in areas underlain by thick accumulations of unconsolidated, fine-grained soils of low-plasticity occur, such as colluvium or topsoil and Quaternary sand deposits (red and yellow areas in **Figure 3**).

Erosion potential is generally higher on steep slopes or at the base of steep slopes where hydraulic energy of run-off is increased. However, soil thickness and texture has a greater influence the erosion sensitivity of a particular terrain and thus the underlying geology is an overriding factor in determining erosion sensitivity.

The Erosion Index for South Africa[1] indicates that the site is located within an area that is ranked between 11 and 15 on a scale from 1 (highest potential) to 19 (lowest). This means that the erosion sensitivity is moderate to low. This indication is primarily based on terrain and geology.

No severe water erosion features are mapped on the 1:50 000 topography maps or are visible on the aerial photographs. However, moderate levels of erosion can be expected along drainage lines.

It is estimated that 80% of the study area is underlain by rock at a shallow depth or low-permeability residual soils with a low sensitivity to erosion. The remaining 20% of the study area is underlain by thick Tertiary-Quaternary aeolian sands which have a moderate erosion sensitivity. **Table 1** provides a summary of the expected erosion sensitivity of the different geological terrains. A more detailed site investigation (to be undertaken during the EIA phase of the project) will provide more accurate information which will facilitate the identification of areas where severe erosion has taken place or is likely to take place.

Erosion sensitivity level	Land facet, terrain unit or geological formation	Comments
High	Drainage lines	High erosion sensitivity – no-go areas
Moderate	Tertiary-Quaternary aeolian deposits	Special mitigating measures apply
Low	Cape Supergroup	Normal mitigating measures apply

Table 1: Erosion sensitivity according to geological terrain units

3.4. Preliminary assessment of potential impacts

The proposed activity will involve earthworks for foundations for structures (turbines, substations, workshops, etc.), access roads and underground services.

The most important issues are the direct impacts of soil degradation and specifically, soil erosion in the area of activity.

The main direct potential impacts are identified and tabulated in **Table 2** below.

Impact:	Nature:	Extent:
Soil removal	Removal of soil due to excavations for foundations, underground services and access roads	Local
Soil alteration	Alteration of soil texture, density, structure and chemistry due to soil loosening, mixing, wetting, stockpiling and compaction	Local
Soil pollution	Pollution of *in situ* soil due to spillage of hazardous substances such as fuel, oil and cement	Local
Soil erosion	Loss of soil by water or wind erosion	Local

Table 2: Main direct impacts

Indirect potential impacts include increased deposition downstream (siltation) or downwind (dust) caused by accelerated water or wind erosion from the site.

The main indirect potential impacts are identified and tabulated in **Table 3** below.

Impact:	Nature:	Extent:
Siltation downstream/ dust downwind	Alteration of soil processes due to abnormal siltation arising from accelerated erosion	Regional

Table 3: Main indirect impacts

Other impacts may come to light as the study proceeds into the EIA phase.

The potential significance of the impacts that have been identified is likely to be low to moderate due to the localised extent of the activity within the study area and the low to moderate erosion potential. The limited scale of earthworks also generally points towards a short critical period where soils are loosened and exposed to erosion, and this can be managed successfully.

The vicinity of the study area is largely undeveloped and the impacts that this proposed development will contribute to the overall cumulative impact on soil degradation is considered to be low.

More in-depth analysis of these impacts should be carried with a site reconnaissance for the EIA phase of the project.

3.5. Mitigation of impacts

Construction activity will have negative impacts on the natural soil profile but this is generally restricted to the construction site footprint located within the boundary of the study area (only a portion of the study area will be utilised) and the activity within this footprint (the disturbance area) can be regulated to mitigate the impacts successfully. The following mitigation measures should be considered for the framework for the Environmental Management Plan (EMP):

- Construction activities should be kept to restricted areas and activities should be kept to a minimum as far as possible (limit unnecessary earthworks, double handling, etc.);
- Excavation processes should be monitored to prevent over-excavation and the correct placement of soil in controlled stockpiles (slope stability must be ensured);
- Rehabilitation of disturbed areas should be undertaken as soon as possible and properly monitored;
- Correct use of hazardous substances should be controlled;
- The wetting of soil and the discharge of construction grey water across natural soil should be controlled;
- Erosion control measures (e.g.: silt fences, sand bags, flow attenuation devices, etc.) should be installed where necessary and maintained;
- Where significant pedestrian and / or vehicular traffic is predicted during construction, such areas should be surfaced with a temporary gravel wearing course to reduce erosion of the *in situ* soil and to prevent dust;

- The handling of natural construction materials, such as filling soil and gravels will require dust management, particularly near sensitive areas;
- Rehabilitation will involve the replacement of suitable and adequate topsoil and the encouragement of indigenous local vegetation to stabilise the soil.

4. PLAN OF STUDY FOR EIA

The following methodology will be adopted for the EIA phase study:

- Conduct a site visit to confirm the physical and geological information used in this report and to collect visual information pertaining to the soil types and their geotechnical engineering properties;
- Assess the present state of erosion, identify critical areas in terms of erosion;
- Prepare a specialist report detailing the environmental issues and potential impacts pertaining to soil degradation and erosion;
- Assess the potential direct and indirect impacts using a weighting system that assigns a value to the categories (extent, duration, magnitude, probability) and arrives at a total which depicts the significance of the particular impact;
- Assess the contribution of the proposed activity in the cumulative impact of the development in the area;
- Comparatively assess any feasible alternatives (if any);
- Provide mitigating measures to input into the Environmental Management Plan (EMP).

5. CONCLUSIONS

The scoping level study has identified the geology of the site and expected soil types. The degradation of the natural soil, and specifically soil erosion, are the main environmental impacts that the proposed activity may have on the geological environment. The erodibility potential is considered to be low-moderate over most of the study area but high erosion sensitivity is anticipated along natural drainage lines where hydraulic energy is increased. Moderate erosion sensitivity is anticipated in areas underlain by Tertiary-Quaternary soils. The implementation of effective mitigating measures can reduce the overall impact level to an acceptable level.

A visual assessment of the study area should be undertaken in the EIA phase to provide more accurate sensitivity mapping. Simultaneously, a basic geotechnical engineering assessment of the site should also be undertaken in the EIA phase to determine the constraints on the development which may affect the positioning of the infrastructure.

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