GEOTECHNICAL DESK STUDY: PROPOSED CONSTRUCTION OF THE 132KV BOSCHMANSKOP - HENDRINA/ABERDEEN POWER LINE & SUBSTATION

For

ENVIROLUTION CONSULTING

VISTA PLACE

GLENANDA

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DECLARATION OF INDEPENDENCE

The undersigned declare that other than fair remuneration for the work performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity.

GEOTECHNICAL DESK STUDY: PROPOSED CONSTRUCTION OF THE 132kV BOSCHMANSKOP – HENDRINA/ABERDEEN POWER LINE & SUBSTATION

1. INTRODUCTION

At the request of ***ENVIROLUTION CONSULTING*** the undersigned conducted a geotechnical desk study for the proposed ***132kV BOSCHMANSKOP – HENDRINA/ABERDEEN POWER LINE & SUBSTATION*** in the Mpumulanga Province. The various alternative routes and substation position are as indicated on the attached map supplied by the client. The purpose of the desk study is to provide preliminary geotechnical information regarding the feasibility for the proposed project and to indicate potential geotechnical constraints that could be encountered during construction.

ESKOM Holdings SOC Ltd proposed to construct one new substation (Boschmanskop) that are required to support the existing network and also supply new developments in the area as well as the construction of a ***132kV*** distribution power line as follows.

- A ***132kV*** overhead power line from the proposed Boschmanskop substation to the existing Hendrina/Aberdeen 132kV power line.

1.1 BOSCHMANSKOP to HENDRINA/ABERDEEN ALTERNATIVE 1 (PREFERRED)

The proposed Boschmanskop substation to Hendrina/Aberdeen power line ***Alternative 1*** (preferred) has a route that runs north-north-west from the proposed Boshmanskop substation across the railway and over cultivated land. The route continues over cultivated land and cross over a low-lying vlei area with a perennial stream to the south-west of the route. A pan is present north-east of the route. The route then continues over a farm road and continue over another portion of cultivated land up to the existing 132kV Hendrina/Aberdeen power line.

1.2 BOSCHMANSKOP to HENDRINA/ABERDEEN ALTERNATIVE 2

The proposed Boschmanskop substation to Hendrina/Aberdeen power line ***Alternative 2*** has a route that runs west south-west from the proposed Boschmanskop substation site across the railway and over cultivated land. The route cross over a non-perennial stream, a tributary of the Woes-Alleenspruit, over a second portion of cultivated land before turning north-west and continues over cultivated land. The route continues and cross a farm road before crossing over the farm boundary between the farm Boschmanskop 154 IS and the farm Roodepoort 151 IS. The power line continues for a short distance over cultivated land before turning north and continues over cultivated land to join the existing Hendrina/Aberdeen 132kV power line.

1.3 BOSCHMANSKOP to HENDRINA/ABERDEEN ALTERNATIVE 3

The proposed Boschmanskop substation to Hendrina/Hendrina power line ***Alternative 3*** has a route that runs north-west from the proposed Boschmanskop substation site for a short distance after crossing the railway line over cultivated land, before turning north-north-east. The route continues over cultivated land then through a small farm settlement and over a small portion of cultivated land before turning north-west. The route continues over a portion of open land, a farm road an over another portion of cultivated land to joins the existing Hendrina/Aberdeen 132kV power line.

2. GEOLOGY

According to the available geological map sheet 2628 East Rand at a scale of 1:250 000 the power line route is underlain by sedimentary rocks of Permian age of the Ecca Group belonging to the Karoo Supergroup. These are described in detail in the following sections.

The various geological formations that would be encountered are described below.

- Fine-grained silty and sandy colluvium (transported soil), possibly with a pebble marker horizon at the bottom, both classed as Recent Deposits.
- Pedocretes, generally in the form of ferruginous concretions or a well-developed ferricrete layer at the base of the transported soils.
- Shale, shaly sandstone, gritstone, sandstone and conglomerate with coal beds of the Ecca Group belonging to the Karoo Supergroup.

No geological faults or dykes (intrusive bodies) are indicated on the geological map over the overhead power line routes or at the proposed substation position.

The climatic regime of the present and of the relatively recent plays a fundamental role in the development of the soil profile at any particular point below the earth's surface. As the site falls within the sub-humid part of South Africa where Weinerts climatic N-value is less than 5, residual soils are generally thick (deeply weathered), transported soils generally shallow, and pedocretes where present, are likely to be in the form of ferricrete and less often calcrete. Chemical disintegration is the dominant mode of weathering.

3. GEOTECHNICAL ASSESSMENT

3.1 RECENT DEPOSITS

By definition transported soils are the un-lithified sediments which have been derived from residual soils or through the slow disintegration of rocks and which have been removed from their original locations within the landscape and deposited elsewhere by various geomorphic agencies. The various transported soils (recent deposits) encountered in the study area are described in the following sections.

3.1.1 Colluvium

Colluvium is an all-embracing term that includes all soils on hill or mountain slopes that have moved down-slope under the influence of gravity and un-concentrated surface wash. Coarse colluvium includes talus, slide debris and colluvial gravel whilst fine grained hillwash consists of clayey or silty composition with variable amounts of sand.

Slope instability is the main concern on talus slopes whilst silty or clayey hillwash exhibit potential expansive characteristics with soil moisture fluctuations or might be potentially collapsible and compressible when subject to load.

3.1.2 Alluvium

Alluvial deposits result from the transportation and deposition of sediment by rivers. Within the channel sediment accumulations are of limited areal extent and include transitory bedload deposits and alluvial islands, formed initially of coarse sediment and subsequently overlain by finer material. Along the margins of channels there are lateral deposits in the form of discontinuous bars in straight channels, or point bars on the convex of meanders. Accumulations of sediment in aggrading or abandoned channels are termed channel fills.

Alluvial deposits vary in relation to the geology of the catchment area, the site of deposition and the competence of the river. Vertical and lateral gradation is frequently evident and layering of upward-fining sequences reflects episodic deposition.
Floodplain accumulations incorporate levee (sands and silts) and back-swamp (clayey) deposits and occupy significant land areas. Alluvial fans develop where streams emerge from mountainous terrain onto lowlands. Alluvial deposits vary in relation to the geology of the catchment area, the site of deposition and the competence of the river whilst vertical and lateral gradation is frequently evident.

Engineering problems related to alluvial deposits vary from being collapsible and compressible (sand and silt) and potentially expansive (clay). Ponding of surface water is a common problem on floodplains.

3.1.3 Pedocretes

Pedocretes are common superficial deposits in most parts of Southern Africa. These are materials that have formed in place either as weathering residues (laterites) or by cementation or replacement, sometimes both, of pre-existing soils by various authigenic minerals precipitated from the soil water or ground water.

Pedocretes are mixtures of the original host or parent material and the authigenic cement, which may either be introduced or relatively concentrated by leaching. As the pedocrete develop the authigenic mineral content increases until it may constitute almost the whole mass. The pedocretes likely to be encountered in the study area are mainly ferricrete with sub-ordinate calcrete. Both these are good sources of road building material and if well developed and sufficiently thick provide a good founding horizon for structures.

3.1.4 Pebble Marker

The base of the transported soil in a wide variety of environments in the subcontinent is characterised by the presence of a gravel horizon known as the pebble marker. This represents the most recent major geological unconformity in the soil profile and is generally less than two million years old, though in places it is still forming today. This is generally a zone of high permeability as it contains abundant gravel.

3.2 KAROO SUPERGROUP

The Karoo Super Group consists of a vast accumulation, nearly 8km thick, of shale, sandstone, and mudrock with diamictite and tillite at the bottom and coal about halfway up. These rocks have been extensively intruded by dolerite in the form of dykes and sills. The Karoo sediments are represented in the study area by the Vryheid Formation.

3.2.1 Vryheid Formation

This group consists primarily of shale (mudrock) and sandstone and contains coal beds all deposited under shallow water conditions. The term mudrock is used to include all sedimentary rocks which are composed predominantly of silt-sized or smaller particles. It is not unusual for a lenticular body of coarse sandstone to occur within a predominantly argillaceous horizon, while a weak lens of mudrock occurring within a competent layer of sandstone is equally common. From semi-quantitative work it was estimated that illite is the most abundant mineral, followed by quartz, feldspar and mixed-layer montmorillonite-illite and chlorite.

3.2.2 Engineering Characteristics

One of the most troublesome properties of the shale and mudrock is their tendency to break down rapidly after exposure, for example in cuttings and tunnels. It seems that micro-cracks develop as a result of moisture loss or stress relief. Residual soils formed by the advanced *in-situ* weathering of certain Karoo mudrocks exhibit expansive characteristics and even fresh mudrock undergo dimensional changes on changes in moisture content.

This material is generally considered suitable for use as selected layers in road construction, but seldom as base course. Mudrock is widely used in compacted fill in embankments. Mudrocks are used fairly generally in wearing courses of gravel roads but not all types are suitable and the breakdown and plasticity properties should be ascertained beforehand. During construction Karoo mudrocks can usually be excavated by ripping, but blasting might occasionally be required. The grid roller is considered very suitable for breaking up mudrocks during compaction.

Slope instability may occur when slip occurs on bedding planes. In general sliding instability occurs if cuttings are made in a direction roughly parallel to the strike of dipping layers. Ingress of water into layers and the resulting high pore-water pressure play a major role in sliding failures.

The most economically exploitable coal seams in South Africa are encountered within the Vryheid Formation. In general the coals seams are thickest, up to 18m, around the northern edge of the northern part of the Karoo basin. They thin progressively towards the basin centre where they are only a few centimetres thick. Coal is a stratified rock composed largely of altered plant remains. The change from vegetable manner to coal during metamorphism is termed coalification.

The old mines were worked with the board-and-pillar method and surface subsidence in these areas is common. Due to increased demand for coal, either for generation of electricity or for export purposes, more sophisticated mining methods, such as pillar extraction, longwall mining or open cast and strip mining, was introduced. Several disused coal mines exist within the study area and the main problem are the unrehabilitated coal dumps and possible decanting of acid mine water. Spontaneous combustion in the old discard dumps and underground workings is extremely hazardous.

3.3 TRANSVAAL SUPERGROUP

3.3.1 Rooiberg Group

The Rooiberg Group consists essentially of red porphyritic rhyolite, a very fine-grained or cryptocrystalline volcanic rock of granitic composition containing phenocrysts of alkali-feldspar. In some exposures the rhyolites are clearly flow-banded while in others they are massive. Pyroclastic materials, often in the form of soft tuffs, and minor layers of sandstone and shale are commonly intercalated with the rhyolite.

3.3.2 Engineering Characteristics

Owing to the presence of a large amount of free silica in the rock, coupled with its very fine-grained texture, rhyolite is extremely resistant to chemical decomposition in the zone of weathering thus residual soils, where present, are very thin. Even below the African erosion surface, where the rocks have been exposed to weathering processes for some twenty million years, the thickness of residual rhyolite seldom exceeds 1,5 to 2m.

Apart from its extreme hardness and resistance to decomposition, perhaps the most characteristic feature of the rhyolite from an engineering point of view is its high degree of jointing. Exposures of the rock commonly show up to as many as eight major joint sets, mainly vertical or steeply inclined. Joint planes are for the most part very smooth, planar and continuous. This feature presents a hazard in the stability of deep cuts with steep batters, particularly where a thin coating of clay has been washed into the joint planes.

In addition to jointing, the rock often displays very marked flow-banding, giving the appearance of bedding planes. Associated with the flow-banding in the hard rock are thin layers of clayey silt which probably represent tuffaceous material or volcanic ash. Although such soft layers are usually few and far between, and seldom more than about 100m thick, they may present problems in the founding of very heavy structures.

In spite of the presence of flow-banding and the high degree of jointing, rhyolite almost invariably require blasting for excavation, even at shallow depths. Within a short period of time after blasting has exposed a fresh face of rhyolite, there is a tendency for the rock to spall into slabby fragments along the direction of the flow-banding. This effect is certainly not associated with chemical action, it would seem to result from release of stress in the rock.

3.3 MINING INDUCED SEISMICITY

Mining induced seismicity is the failure of the earth's crust or rock mass as a result of mining induced changes in rock stress levels. Seismic events range in size from barely discernible ground motions to very large tremors. There are three types of mining induced seismicity namely:

1. Failure at pre-existing geological weaknesses such as faults, dykes and joints which result in medium to large events often far away from workings.
2. Failure of the intact rock mass in the form of shear fractures that result in larger events close to workings.
3. Localised bursting or failure of brittle rock types often referred to as strain bursting or face bursting (small events at the working face).

The most economically exploitable coal seams in South Africa are encountered within the Vryheid Formation and there are several open-cast coal mines in this area. Thus, the power line route and substation could be influenced by mining induced seismic events due to the presence of the coal mines but these would however be of the types described in numbers 2 & 3 above.

In addition to the direct damage that may be caused by a seismic event, indirect effects such as the liquefaction of saturated soils and slope failure may also pose a hazard to structures. It is also possible that the area has been undermined, but his could not be established with certainty.

4. LAND CAPABILITY

4.1 GENERAL

Land capability is defined as the ability of land to accept a type and intensity of use permanently, or for specified periods under specific management, without permanent damage. The need for land use planning is frequently brought about by changing needs and pressures involving the competing uses for the same area of land. There has been strong pressure on arable agricultural land from competing urban uses such as housing and commercial over the past decades. The important factors influencing land capability include the soils, the relief or topography, climate, past cropping history etc.

4.1.1 Soil

The soil is the most important feature and a basic unit in agriculture, its quality profoundly affecting the ability of the land to produce. The following soil factors should be evaluated:

- Soil depth (this is the depth of soil from the top to the parent material or bedrock and has a profound effect on the range of crops that can be grown). Soil depth in areas underlain by Karoo sediments are generally deep with a thick cover of transported soil that would support root growth and penetration. Soil depth over rhyolite is generally very shallow.
- Soil texture (this refers to the proportion of particles of different sizes. The presence of gravel will affect the suitability for various crops. Soil texture and structure will influence the root penetration and the movement of air and water). Transported and residual soils over Karoo sediments are generally fine with a low percentage of gravel whilst over rhyolite it contains a high percentage of gravel.
- Soil reaction (this will influence the ability of certain crops to grow and produce at the optimum level and relates to the alkalinity or acidity of soil. Both influence the fertility status in terms of both major and minor element availability and toxicity).
- Soil drainage (this is influenced by the structure and texture of the soil which will either promote internal drainage or cause the soil to be waterlogged). Transported and residual soils over Karoo sediments bedrock are generally fine and have poor to moderate internal drainage. Soils over rhyolite have good internal drainage. Waterlogged soils are expected on the floodplains along the streams and where deeply weathered shale/mudrock is present.
- Water availability (this is directly related to soil texture and structure, the presence or absence of a ground water table, the rainfall and evapo-transpiration rate). Soils that have limited moisture have limitations in the kind of crop that can be grown without irrigation. Transported and residual soils over Karoo sediments are generally fine and would retain moisture. In areas of shallow rock a perched water table might be present during the wet season. On the vlei areas and floodplains the soils would retain more moisture, but would be water logged during the wet season.

4.1.2 Topography & Erosion

Topography and erosion are interrelated. The slope of the land as well as the soils structure will influence the amount of past and potential erosion. Previous erosion cycles reduce crop yields by removing the more fertile soil. Land on steeper slopes will be more prone to erosion. The transported soil is generally cohesion-less and are prone to erosion even on fairly flat slopes. These soils can be classified as moderately erodible.

4.1.3 Climate

Local climate factors interact to influence land capability to varying degrees. The main climatic factors to be considered include rainfall, temperature, wind and evapo-transpiration. The summer temperatures are high with fairly windy conditions which would promote evapo-transpiration.

4.1.4 Flooding Hazard

Flooding is an important phenomenon that influences the utilization of land in susceptible areas. Naturally land subjected to varying degrees of flooding will restrict the choice of crops that can be grown. The streams and drainage gullies would generally transport a large amount of water at a high flow rate during and after thunder storms, which is typical of this environment. Thus damage to crops and infrastructure adjacent to these would be the norm with potential water logged conditions.

4.1.5 Past Cropping History

This will affect the present and future use of land. This is affected by the farmer's attitude from the point of view of the decisions he makes in what to plant, how to plant and where to plant. The cultivation practices will affect the extent of erosion and gullying. Continuous cropping of arid areas with unsuitable irrigation water may result in the development of saline and sodic soils. These soils are innately unstable, exhibiting poor physical and chemical properties, which impede water infiltration, water availability and ultimately plant growth.

The power line route traverses mainly over land zoned as agricultural and this area is a major crop producer with large areas being cultivated.

5. POTENTIAL DEVELOPMENT CONSTRAINTS

The following development constraints might be encountered along the powerline routes and at the substation sites. These are directly related to the underlying geology.

- Potentially collapsible and/or compressible transported soil (colluvium) overlying residual soil or bedrock, **NHBRC class C1/S1** or **C2/S2** depending on the thickness thereof.
- The possible presence of shallow rock (rhyolite) or hardpan ferricrete (within 1,5m of surface) could result in areas of difficult excavation, **NHBRC class R**. In these areas a shallow perched water table could also be present during the wet season and sub-surface drainage might be required.
- Potentially expansive clayey alluvium or residual mudrock, **NHBRC Class H to H3** depending on the degree of expansiveness (medium to high) as well as the topographic situation. To be catered for in the design of the substations, if present.
- The wind factor (direction and strength) should be determined and incorporated in the design of pylon foundations.
- Surface water (ponding) could be expected along the streams and adjacent vlei areas which will result in access problems for personnel and vehicles. This problem would be more severe during the wet season.
- Floodplains and areas in close proximity to streams need to be avoided.
- No pylons should be placed in or close to pans, vleis and wetlands.
- Steep slopes (>45°) and areas immediately below them should be avoided for the siting of pylons and maintenance roads wherever possible. These areas are subject to slope failure and are vulnerable to erosion.
- A shallow perched water table could saturate foundation soils and have a detrimental effect on bearing capacity at the substation site. A shallow perched water table might be present due to the impermeable clayey residual mudrock or alluvium.

- Groundwater pollution is a huge threat to the groundwater (a scarce resource) and adequate measures need to be implemented for the disposal of sewage and waste water etc. During the construction process.
- All waste water from offices, workshops etc. should be adequately controlled and disposed of.

6. SUMMARY

The project is moderately complex due to three alternatives and all have ***the same geotechnical constraints*** (listed in section 5) as there are no changes in the geology. The geotechnical constraints can only be verified and described in detail after the fieldwork phase, i.e. excavation of test pits etc.

The summary provided in the table below is based on the route description and physical characteristics that might be encountered.

Component (Lines)	**Ranking (1 - 3)**	**Comments**
Boschmanskop – Hendrina/Aberdeen ***Alternative 1*** (preferred)	2	Shortest route with railway line crossing and mostly over cultivated land, cross over potential vlei area.
Boschmanskop - Hendrina/Aberdeen ***Alternative 2***	1	Only slightly longer than preferred and also cross over railway line. Mostly over cultivated land but avoid potential vlei area.
Boschmanskop - Hendrina/Aberdeen ***Alternative 3***	3	Longest route with railway line crossing. Mostly over cultivated land and cross non-perennial stream and potential adjacent vlei area.

It is recommended that a detail geotechnical investigation be conducted along the power line routes as well as substation site in order to verify this desk study and to provide site specific appropriate founding solutions. The recurrence interval of mining induced seismic events and potential undermining should be determined and taken into consideration for the design of pylons and the substation.

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BOSCHMANSKOP 132 KV CHIKADEE POWERLINE ROUTES & SUBSTATION