Eskom Holdings Limited

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED PERSEUS-HYDRA 765kV TRANSMISSION POWER LINE

Geological and Engineering Geological Impact Assessment

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EXECUTIVE SUMMARY

The study area is underlain mainly by sedimentary rocks of the Karoo Supergroup, which has been intruded extensively by dolerite sills and dykes. Thick dolerite sill intrusions in the eastern portion of the study area have resulted in generally hilly to mountainous topography, in contrast to the remaining portion which is generally flat. The sedimentary rocks mainly comprise mudrock, with dark grey shale and mudstone the dominant rock types. The mudrocks in the study area are the disintegrating type, which will break down to angular gravel when exposed to atmospheric conditions.

Calcified soils have a widespread distribution in the study area. Widespread non-perennial pans occur over a large portion of the study area, but are mainly limited to the north of the Gariep River. Some of these are mined for salt and gypsum and are associated with poor drainage, corrosive and potentially erodible soils. The soil cover in the study area is mostly thin (<750mm), except along drainage channels where deposits with a thickness of up to 2m to 3m can be expected. These transported alluvial soils are often dispersive and therefore highly erodible.

Four alternative power line routes were identified by the specialists during the site visit. These routes occur to the west of the existing 765kV line with the far western route situated up to 10km from the existing line. The Centre and Western Route Alignments are the preferred options, from geological perspective, because these routes follow the higher ground in the interfluvial areas, formed mainly by dolerite.

Pylon founding will either be in dense calcified soil and/or mudrock. Suitable founding conditions are expected at an average depth of 1,0m, except in drainage areas where soil cover is thick and deeper excavations of more than 2m to 3m may be required. The mudrock will have to be protected from disintegration. Access roads over drainage areas will have to be protected from erosion by proper stormwater drainage and dolerite gravel surfacing.

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1 INTRODUCTION

1.1 Background

Knight Hall Hendry (KHH) was appointed by ARCUS GIBB (Pty) Ltd (ARCUS GIBB) to assess the engineering geological feasibility of the proposed Perseus-Hydra transmission power line, from Dealesville in the Free State to De Aar in the Northern Cape. The minimum total length of the line is in the region of 248km, but the study area includes a 10% increase of the length, which has resulted in an elliptical study area shape with a width of up to 70km. **Figure 1** provides an overview of the study area and also shows the positions of the existing transmission lines within the study area.

The purpose of the study is to provide input for the Environmental Impact Assessment (EIA), which comprises 3 phases, as follows:

- Initial Phase
- Scoping Phase
- EIA Process.

This work will form part of the scoping phase.

As shown in **Figure 1**, the existing transmission lines between the Perseus (Dealesville) and Hydra Sub-stations (De Aar) include one 765kV, 3 x 400kV and a 220kV line. Various other lines cross the study area almost perpendicular, which will have an affect on the design and construction of a new line.

Due to various physical constraints which are present to the east of the existing lines, this investigation mainly concentrated along the western portion of the study area. These constraints are briefly as follows:

- Kalkfontein Dam and Rolfontein Nature Reserves
- Main water bodies, *viz.* the Kalkfontein and Van der Kloof Dams
- Generally hilly to highly undulating topography.

Four alternative alignments were identified for the purpose of the scoping investigation. These are shown in **Figure 2** on the landcover background. As discussed above, these alignments are situated to the west of the existing lines as follows:

- *Existing 765kV Route Alignment (green)*
  This alignment follows the existing 765kV transmission line and will incorporate a minimum distance of about 50m between the two lines.

- *Eastern Route Alignment (yellow)*
  This alignment is situated approximately between 1km and 2km from the existing 765kV line.

- *Centre Route Alignment (blue)*
  This alignment is situated between 4km and 5km from the existing 765kV line.

- *Western Route Alignment (red)*

  This alignment is situated approximately 10km from the existing 765kV line and includes several cross-over sections with the Centre Route.

  Two additional single power lines were added to the investigation at a later stage and are described and discussed in this report. They consist of a 33km transmission line from Perseus substation to a point south-west on the existing 400kV Beta-Hydra Power Line, and a 12km Transmission Power Line between the Perseus and Beta (south south-west of Dealesville) substations.

This report documents the results of the scoping phase investigation and deals with the geology and engineering geology of the study area, which include expected foundation conditions, soil erodibility and other geotechnical aspects, which may have an affect on the route or design of the line.

1.2 Study Approach

This investigation phase essentially consisted of an overview of available relevant information, such as published maps, text books, reports and remote sensing data. The study area was briefly visited by means of a helicopter flight from Perseus to Hydra Sub-stations. The site visit was undertaken between 25 and 26 August 2005. The site visit was attended by Mr Dawid Mouton, an engineering geologist. The flight path roughly corresponded to an area between the Eastern and Central Routes. Two pylons along the existing 765kV line were visited, where corrosional problems were previously experienced.

Some of the western portion of the study area were also visited by vehicle, during which several soil profiles exposed in borrow pits and cuttings, were briefly inspected.

It must be appreciated that the nature of this investigation only allows for a brief overview and all the comments made and conclusions drawn from this study, should be regarded as generalised. This initial investigation therefore consisted of visual observation of the area to determine aspects such as accessibility for construction and identification of potential problematic areas, such as wetlands, erodible soils and pans.

The following published 1:250 000 scale geological maps were consulted during this study:

- 2924 Koffiefontein
- 3024 Colesberg
- 3022 Britstown
- 2926 Bloemfontein

The 1:500 000 Hydrogeological Map Series of RSA, sheet 2924 Bloemfontein was used for the groundwater assessment.

It must be noted that access to the route was limited in the sense that only a single helicopter trip could be undertaken, while vehicle access is essentially limited to the positions where existing roads intersect the alignments.

2 DESCRIPTION OF AFFECTED ENVIRONMENT

2.1 Regional Geology and Soils

The regional geology of the study area is shown in **Figures 3** and **4**, which provide regional maps of the stratigraphy and lithology respectively. The stratigraphy refers to the names of a formation, group and supergroup, e.g. Ecca Group, while the lithology refers to the rock type, e.g. shale.

The entire study area is underlain by near-horizontally layered sedimentary rocks of the Karoo Supergroup. Two main groups are represented, *viz*. the older Ecca Group shale, which occur roughly along the western portion, while the younger Beaufort Group mudstone forms the higher-lying eastern portion. Sandstone and siltstone are subordinate in this area and usually occur as thin interlayered horizons. The predominant rock type along the proposed alignments is grey shale of the Tierberg Formation (part of the Ecca Group).

The continuous outpouring of magma during the terminal phase of the Karoo era covered a large area, which solidified into basalt, remnants of which today form the Drakensberg. The high strength and thickness of the basalt cover eventually restricted further outpouring, which resulted that the magma had to force its way along zones of weaknesses in the underlying rocks (Brink, 1983). Large dolerite sills and extensive dykes were formed this way. Large dolerite areas occur in the study area, mainly in the form of near-horizontal sills, which usually form the more resistant layers on the upper portions of the typical Karoo hills and koppies. Regional dykes were also observed, which are associated with linear hill ranges. The dolerite intrusions in this area are therefore generally associated with positive relief, while the prominent hills on the eastern portion of the study area, e.g. the Van der Kloof Dam, are associated with thick dolerite sill deposits.

The flat-lying portion of the study area is generally covered by a thin layer of transported soils. These soils are of mixed origin and varies between hillwash deposits in the northern portion and discontinuous aeolian sands towards the south (Brink, 1985). The mountainous zones to the east have virtually no transported soils. The soil cover, however, is generally relatively thin, except along drainage channels and around pans where soil thickness often exceeds 1m. **Figure 5** provides a generalised overview of soil thickness in the study area. It is evident that the thicker soils (450mm to 750mm) are concentrated north of the Modder River (mostly hillwash) and along the western portion to the west of Koffiefontein and Luckhoff. A broad zone of thick (>750mm) alluvial soils occur along the Gariep River.

Calcrete, calcified pandune and surface limestone have a widespread distribution in the study area, particularly along the western, drier portion. These deposits have irregular shapes and distribution, but generally limited to the upper 1m to 2m of the soil profile. In some areas these deposits give rise to localised, elevated plateaus, due to the resistant nature of the calcified soils, particularly the hardpan variety.

2.2 Hydrogeology

The majority of the study area has a moderate to low groundwater potential. Typical borehole yields are between 0,5ℓ/s to 2,0ℓ/s and the aquifer is mostly the fractured type. Higher yields of up to 5ℓ/s are associated with the large calcrete deposits, e.g. in the Petrusburg region. Groundwater quality is, however, generally poor with high electrical conductivity of more than 70mS/m. Excessively high electrical conductivities of up to 12 000 were recorded, which are believed to occur within the spheres of influence of salt pans (Meyer, 2003). Nitrate concentrations exceeding the maximum allowable limit for drinking water of 10mg/ℓ occur at various localities, which are ascribed to agricultural practices. Groundwater from the Ecca group rocks generally has a sodium-chloride character (Meyer, 2003).

2.3 Mineral Occurrences and Mining Potential

As shown in **Figure 4**, known mineral occurrences include sodium and gypsum associated with the pans, while diamonds occur as alluvial deposits as well as pipe intrusions in the study area.

Currently, active mining of salts is taking place in some of the pans to the south of Perseus. Koffiefontein is essentially a mining village where diamonds were mined from Kimberlite pipes, since 1870. Although of a low grade, mining has commenced again in 1987 and is still mined by De Beers (Council for Geoscience, 1998).

During finalisation of the route, it is recommended that the relevant role players in the mining industry be approached to ensure that the line will not affect possible future mining activities in the area.

3 IDENTIFICATION OF RISK SOURCES

3.1 Soil Corrosivity

Soil corrosivity is closely related to soil type and particle size, pH and the chemical condition of soils, particularly sulphide, chloride and other salts, while micro-organisms, organic matter and temperature are also contributing factors (Janse van Rensburg, 2005).

Corrosivity problems were responsible for premature failures along the existing 765kV Beta Hydra 2 line, which affected anchor u-bolts. It was established that the problem areas are closely related to the presence of the non-perennial pans. These pans are associated with poor subsurface drainage, which lead to the accumulation of water in the upper, weathered horizons and enrichment of salts due to seasonal evapotranspiration. Many salt pans occur in the study area, which are mined commercially.

Although soil corrosivity is probably not only limited to the pans, it was established that the soil chemistry of the pan environments is generally conducive to high corrosivity with respect to mild steel and galvanised mild steel.

3.2 Erodibility

Although the thickness of soils is generally thin in the study area, it was observed during the site visit that highly erodible (dispersive) soils are present near drainage channels and areas of poor drainage also associated with pans. Thick transported soils often result in donga formation when vegetation is disturbed due to overgrazing, cattle paths, etc. It will therefore be required to identify erodible soils to ensure that access roads along the transmitting line do not cause excessive erosion.

3.3 Disintegrating Mudrock

The grey to black shale and mudstone of the Ecca Group (collectively referred to as mudrock) is known for its tendency to break down rapidly after exposure, for example in foundation excavations. Three types of responses can occur, but only the disintegrating type was identified in the study area (Brink, 1983). This involves the breaking down into hard fragments of various shapes and sizes, generally angular gravel size. The breakdown process happens almost instantaneous after exposure and is adversely affected by wet-dry cycles.

4 ENVIRONMENTAL ASSESSMENT

4.1 Existing 765kV Route Alignment

4.1.1 Site Description

This alternative follows the existing 765kV power line, which has incurred the corrosivity damage associated with the areas of poor drainage/pans. The route is generally flat-lying with very gentle slopes, if any. The route is covered by sparse grass and short bush, while irrigated cultivated lands are present along major rivers, *viz*. Modder, Riet and Gariep Rivers, while large-scale irrigation occurs along the Jacobsdal canal, to the west of Luckhoff.

From Dealesville to the Gariep River numerous salt pans occur, while very few pans occur to the south of the Gariep River.

4.1.2 Geotechnical Evaluation

The salt pans are associated with poor drainage, corrosive soils, subjected to shallow groundwater, albeit seasonal fluctuation is expected. The transported soils along the flat-lying portion are also highly erodible and prone to donga formation.

Loose, potentially collapsible soils are associated with drainage features, which will have to be removed below footings and concrete blocks for anchor cables. Such excavations may have to extend to more than 2m in places. The interfluvial areas are, however, associated with shallow soils and either calcrete horizons or weathered mudrock occurs at a relatively shallow depth. All freshly exposed mudrock must, however, be protected from disintegration by sealing the exposed surface with shotcrete directly after excavations have been completed.

The doleritic soils are generally expected to provide stable, suitable foundations for the pylons and should be preferred for other infrastructure development, such as the construction camps, substations, etc.

Detailed geotechnical investigations will be required to determine the extent of the erodible, collapsible and corrosive soils, while founding characteristics of the calcrete and mudrock must also be determined.

4.2 Eastern Route Alignment

4.2.1 Site Description

This route is very similar to the existing 765kV alignment, except that the intensity of the pans seems to decrease somewhat towards the west. Pans seem to be concentrated in poorly defined clusters, with virtually no pans present to the south of the Gariep River.

4.2.2 Geotechnical Evaluation

From a geotechnical point of view, this alignment is very similar to the existing 765kV power line.

4.3 Centre Route Alignment

4.3.1 Route Description

This alignment seems to avoid most of the pans along the northern portion and makes use of the scattered dolerite sills in places to follow a slightly elevated route compared to the previous two alignments. The route is therefore somewhat undulating in places, but still relatively flat. Some route adjustment is necessary in the Oppermans area to avoid a couple of large pans that seem to be situated in a loosely defined cluster.

4.3.2 Geotechnical Evaluation

This route is considered more favourable from a geotechnical point of view, due to the better drainage associated with the somewhat higher and gentle sloping ground. The doleritic soils are also considered to be relatively resistant to erosion, even along moderate slopes.

The main advantage of this route is the marked decrease in the number of pans along the route. Other aspects such as disintegrating mudrock and transported, erodible soils along drainage channels will be similar to the other routes.

4.4 Western Route Alignment

4.4.1 Route Description

This alignment follows a route that is situated up to 10km form the existing 765kV power line. It often crosses the top of high ground formed by regional dolerite sills, but is otherwise very similar to the Centre Route.

4.4.2 Geotechnical Evaluation

From a geotechnical point of view this route is generally very similar to the Centre Route and various cross-over options between them, can be considered.

4.5 Additional 33km Transmission Power Line

4.5.1 Route Description

This alignment follows a route between Perseus to a point on the existing 400 kV Beta-Hydra Power Line and is approximately parallel to the existing 765kV power line. The topography is quite flat along its path and intersects three non perennial pans.

4.5.2 Geotechnical Evaluation

The northern section of the route is on dolerite for a stretch of 5km, which is relatively resistant to erosion. The remainder of the route, i.e. most of the south-western section is underlain by horizontally layered Volksrust Formation shale, siltstone and subordinate sandstone. The area is extensively covered by clayey soils, but the total soil thickness is limited to less than 1m. The dolerite residual soils retain sandy grasslands with little or no agricultural activity. The non-perennial pans to the south-west are associated with poor drainage and potentially erodible soils.

Overall the slope is quite flat and has the same general conditions as the Alternative 1 765kV Power Line Corridor to the west, although the latter line doesn't intersect the non-perennial pans.

From a geotechnical point of view, the only red flag areas in this study area are the non-perennial pans due to poor drainage, aggressive soil conditions and presence of gypsum and salt at some of the pans. Two potential routes exist, viz. a western route along the existing 765kV Power Line Corridor, and an eastern route along one of the existing 400kV transmission lines. The latter may have to cross a number of existing lines.

4.6 Additional Single 765kV 12km Transmission Power Line

4.6.1 Route Description

This alignment runs from Perseus Substation to Beta Substation. Approximately half of the route is on dolerite with the other half on Karoo mudstone (Volksrust Formation).

4.6.2 Geotechnical Evaluation

From a geotechnical point of view, this study area is largely underlain by dolerite soils, which are resistant to erosion, characterised by shallow soil conditions and limited clay content (<15%). No large pans occur in the study area and the topography is generally flat to slightly undulating.

From a geotechnical point of view it will be advantageous to select an eastern alignment that will maximise the length of line on dolerite as much as possible.

5 RECOMMENDED MITIGATION MEASURES

The most effective mitigation measure from a geotechnical point of view will be to avoid the pan areas, if possible. These areas are associated with both highly corrosive soils, potentially erodible soils and possible soft compressible or unconsolidated soils.

It is appreciated that all the alternative routes do cross or flank clusters of pans, particularly the northern and central portion (north of Gariep River), where the pans have a generalised and widespread distribution. Where pylons are situated within the influenced area of the pan in corrosive soils, special measures will have to be used to protect all buried metallic components against corrosion by either concrete encapsulation or the other insulation methods as suggested in a report by Burger, Combrinck and Van Rensburg, 2004.

Disintegrating mudrock exposed in foundations must be covered immediately by shotcrete or similar sealer to prevent the disintegration process to weaken foundations, particularly the shear strength along the concrete/rock interface.

Natural slopes along the proposed route alignments are generally flat and no unstable ground is expected. Erosion could, however, be expected where access roads have to cross drainage features, where thick deposits of potentially erodible soils occur. Proper stormwater drainage along access roads in these areas will prevent erosion and the road surface will have to be covered by doleritic gravel to protect the exposed areas against erosion.

6 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made from the scoping level engineering geological assessment of the Perseus-Hydra 765kV transmission power line.

- The study area is underlain mainly by sedimentary rocks of the Karoo Supergroup, which has been intruded extensively by dolerite sills and dykes. Thick dolerite sill intrusions in the eastern portion of the study area have resulted in generally hilly to mountainous topography, in contrast to the remaining portion which is generally flat. The sedimentary rocks mainly comprise mudrock, with dark grey shale and mudstone the dominant rock types. The mudrocks in the study area are the disintegrating type, which will break down to angular gravel when exposed to atmospheric conditions. Calcified soils have a widespread distribution in the study area, particularly towards the south-western portions where hardpan varieties are common.

- Widespread non-perennial pans occur over a large portion of the study area, but are mainly limited to the north of the Gariep River. Some of these are mined for salt and gypsum and are associated with poor drainage, corrosive and potentially erodible soils.

- The soil cover in the study area is mostly thin (<750mm), except along drainage channels where deposits with a thickness of up to 2m to 3m can be expected. These transported alluvial soils are often dispersive and therefore highly erodible.

- Four alternative routes were identified. These routes occur to the west of the existing 765kV line with the far western route situated up to 10km from the existing line.

- From a geotechnical point of view, the main objective in route selection will be to avoid the pans and associated areas of poor drainage. The pan areas are highly corrosive to mild steel and special precautionary measures will have to be taken, should pylons be situated within the affected areas of these pans.

- The Centre and Western Route Alignments are the preferred alternative because these routes follow the higher ground in the interfluvial areas, formed mainly by dolerite. Although pans do occur along these routes in places, particularly in the Oppermans area, they seem to avoid most of the prominent pan clusters.

- Pylon founding will either be in dense calcified soil and/or mudrock. Suitable founding conditions are expected at an average depth of 1,0m, except in drainage areas where soil cover is thick and deeper excavations of more than 2m to 3m may be required. The mudrock will have to be protected from disintegration by shotcrete or similar sealing methods.

- Access roads over drainage areas will have to be protected from erosion by proper stormwater drainage and dolerite gravel surfacing. This problem is common to all the alternatives since the routes intersect the major drainage features more or less perpendicular.

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