The Proposed Construction of the Nchaupe and Ratsiepane Substations and 132kV Overhead Power Lines between SS-Nchaupe, SS-Ratsiepane, SS-Tswaing, and SS-Mathibestad

Moretele Local Municipality, Bojanala Platinum District Municipality, North West Province

Farms: Goedgewaagd 69, Bles 58, Kromkuil 99, Boschplaats 91, Be Wig 56, and Wynandskraal 64.

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Palaeontological Impact Assessment: Phase 1 Field Study

Commissioned by: Envirolution Consulting

Vista Place Suite 1a & 2, No 52 Cnr Vorster Avenue and Glen Avenue

Glenanda

0861 44 44 99

2017/03/20

Ref: DEA Pending

B. Executive summary

Outline of the development project: Envirolution Consulting has facilitated the appointed of Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA), Phase 1 Field study of the suitability of The Proposed Construction of the Nchaupe and Ratsiepane Substations and 132kV Overhead Power Lines between SS-Nchaupe, SS-Ratsiepane, SS-Tswaing, and SS-Mathibestad within the Moretele Local Municipality, Bojanala Platinum District Municipality in the North West Province.

The applicant, Eskom Holdings SOC Ltd proposes to construct a new 132kV powerline as well as two new proposed substations on the Farms Goedgewaagd 69, Bles 58, Kromkuil 99, Boschplaats 91, Be Wig 56, and Wynandskraal 64.

The Project includes Alternatives (Figure 2):
Alternative 1-6: T-R.
Alternative 1-2: New M (1 – Preferred).
Alternative 1-4: Subs 1 & 2.
The servitude width for a 132kV overhead distribution power line is 31m (15.5m on either side of the centre line of the power line). The area for a substation is 100m x 150m in size.

Legal requirements:-

The **National Heritage Resources Act (Act No. 25 of 1999) (NHRA)** requires that all heritage resources, that is, all places or objects of aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance are protected. The Republic of South Africa (RSA) has a remarkably rich fossil record that stretches back in time for some 3.5 billion years and must be protected for its scientific value. Fossil heritage of national and international significance is found within all provinces of the RSA. South Africa's unique and non-renewable palaeontological heritage is protected in terms of the National Heritage Resources Act. According to this act, palaeontological resources may not be excavated, damaged, destroyed or otherwise impacted by any development without prior assessment and without a permit from the relevant heritage resources authority.

The main aim of the assessment process is to document resources in the development area and identify both the negative and positive impacts that the development brings to the receiving environment. The PIA therefore identifies palaeontological resources in the area to be developed and makes recommendations for protection or mitigation of these resources.

For this study, resources such as geological maps, scientific literature, institutional fossil collections, satellite images, aerial maps and topographical maps were used. It provides an assessment of the observed or inferred palaeontological heritage within the study area, with recommendations (if any) for further specialist palaeontological input where this is considered necessary.

A Palaeontological Impact Assessment is generally warranted where rock units of LOW to VERY HIGH palaeontological sensitivity are concerned, levels of bedrock exposure within the study area are adequate; large scale projects with high potential heritage impact are planned; and where the distribution and nature of fossil remains in the proposed area is unknown. The specialist will inform whether further monitoring and mitigation are necessary.

Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):
(i) (i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens.

This report adheres to the guidelines of Section 38 (1) of the National Heritage Resources Act (Act No. 25 of 1999).
Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as (a) the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length; (b) the construction of a bridge or similar structure exceeding 50 m in length; (c) any development or other activity which will change the character of a site (see Section 38); (d) the re-zoning of a site exceeding 10 000 m² in extent; (e) or any other category of development provided for in regulations by SAHRA or a PHRA authority.

This report aims to provide comment and recommendations on the potential impacts that the proposed development could have on the fossil heritage of the area and to state if any mitigation or conservation measures are necessary.

Outline of the geology and the palaeontology:
The geology was obtained from map 1:100 000, Geology of the Republic of South Africa (Visser 1984) and 1:250 000 2528 Pretoria Geological Map (Walraven 1978).

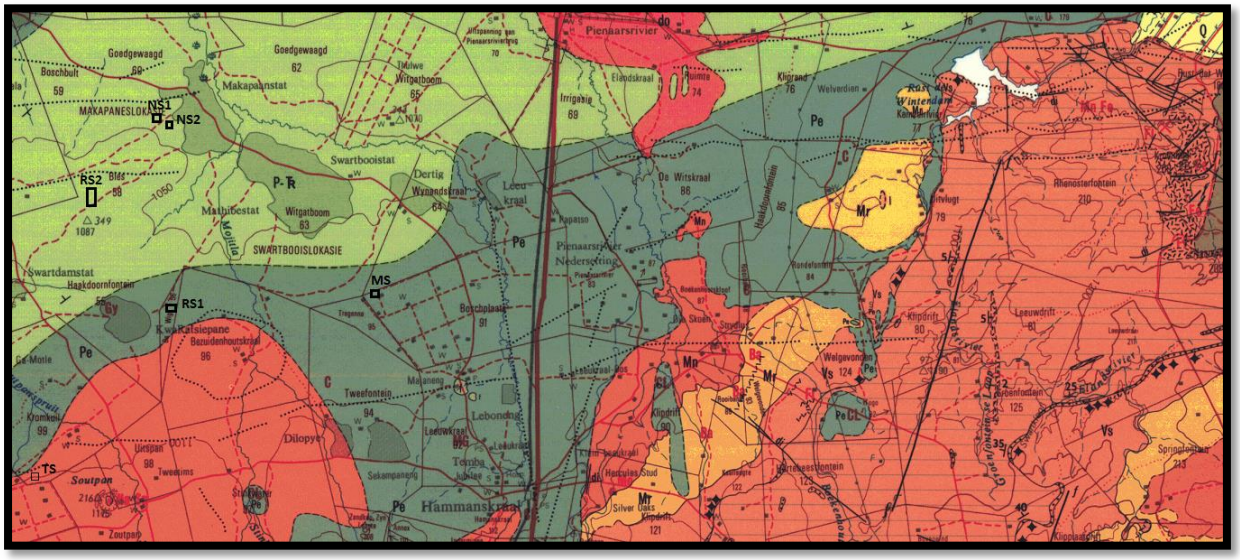

Figure 3: The geology of the development area.
Legend to map and short explanation.
P-Tri – (green) Multi-coloured siltstone, sandstone, marl, mudstone, shale. Irrigasie Formation, Ecca Group, Karoo Supergroup. Upper Permian.
Pe – (grey) Sandstone, shaly sandstone, grit, shale, conglomerate and coal near base and top. Vryheid Formation, Ecca Group, Karoo Supergroup. Permian.
Mn – (red) Grey to pink coarse-grained granite. Nebo Granite, Lebowa Granite Suite, Bushveld Complex. Mokolian.
…… – (black) Lineament (Landsat, aeromagnetic).
------ - Concealed geological boundary.
⊥35 – Strike and dip of bed.
□ – Approximate position of substations.

Mining Activities:
C – Coal. Gy – Gypsum.

Summary of findings: The Phase 1 PIA Field study was undertaken towards the middle of March 2017 in the summer in hot conditions and the following is reported:

The northern section will be situated on the Irrigasie Formation, the middle section will be situated on the Vryheid Formation, and the southern section will be developed on the Bushveld Complex strata. The site is covered in 'Bushveld' vegetation and housing.

The Karoo Supergroup is renowned for its fossil wealth. The Vryheid Formation (Pe,Pv), Ecca Group is rich in plant fossils such as the *Glossopteris* flora represented by stumps, leaves, pollen and fructifications. This formation is early to mid-Permian (Palaeozoic) in age and consists of sandstone, shaly sandstone, grit, conglomerate, coal and shale. Coal seams are present in the Vryheid Formation within the sandstone and shale layers. Fossils are mainly present in the grey shale which is interlayered between the coal seams (Kent 1980, Visser 1989). Borehole logs in the coalfields show the following layers; soil, shale and sandstone, shale and sandstone interbedded, sandstone, coal, conglomerate reworked diamictite, Dwyka Tillite, and the Pre-Karoo Basement (Appendix 1).

The Irrigasie Formation (P-Tri) of the Karoo Supergroup is Trias in age (±209 million years). This basin is present in the Springbok Flats. The Irrigasie Formation is a succession of predominantly red mudstone lying between the Ecca Group and the Clarens Sandstone (Kent 1980). In this area, the Ecca Group forms the base. The red mudstone is interlayered with sandstone (Snyman 1996).

The Bushveld Complex (Mn) is Vaalian in age (2,100 – 1,920 Ma) and consists of an igneous intrusion with anorthosite, hybrid gabbro, gabbro, diabase, epidiorite, pyroxenite, and norite rocks. A small section is Mokolian in age. The Bushveld Complex is a massive body of igneous origin and it is intrusive in the Transvaal Supergroup. Both mafic and ultramafic rocks are present in the Rustenburg Layered Suite. The weathering product is known as 'black turf'(Kent 1980, Visser 1989).

Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, if there is the presence of Karoo Supergroup strata the palaeontological sensitivity can generally be LOW to VERY HIGH, and here locally **VERY HIGH** for the Vryheid and Irrigasie Formations (SG 2.2 SAHRA APMHOB, 2012) and **INSIGNIFICANT or ZERO** for the Bushveld Complex.

Recommendation:
The potential impact of the development on fossil heritage is **VERY HIGH** and therefore a field survey or further mitigation or conservation measures were necessary for this development (according to SAHRA protocol). A Phase 2 PIA and or mitigation are only recommended if the Phase 1: Field study finds fossils. The overburden and inter-burden consisting of Ecca rocks must always be surveyed for fossiliferous outcrops (shale). Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden as a site visit may miss a fossiliferous outcrop. An appropriate protocol and management plan are attached (Appendix 2).

The survey was done in summer towards the middle of March 2017, conditions were dry and hot and the area is covered by overburden, vegetation, natural grassland and other land uses include power lines and housing. The development will take place on Formations known for its fossils. The development will benefit the community. The development can go ahead, but there are several Alternatives with a very high impact.

The Project includes Alternatives (Figure 2):
Alternative 1-6: T-R.

Alternative 1-2: New M (1 – Preferred).
Alternative 1-4: Subs 1 & 2.
The servitude width for a 132kV overhead distribution power line is 31m (15.5m on either side of the centre line of the power line). The area for a substation is 100m x 150m in size.

Concerns/threats:

1. Threats are earth moving equipment/machinery (for example haul trucks, front end loaders, excavators, graders, dozers) during construction, digging of foundations (power line, substation) the sealing-in or destruction of the fossils by development, vehicle traffic, and human disturbance.
2. Mitigation may be needed (Appendix 2). Permission is needed from SAHRA.
3. No consultation with parties was necessary. Shale cannot be blasted without being checked for plant fossils. The Environmental Control Officer must familiarise him or herself with the Vryheid and Irrigasie Formations and check for fossils.
4. Due to thick vegetation it may have been possible to have missed a fossiliferous outcrop.

Stakeholders: Developer – Eskom Holdings SOC Ltd, Eskom Distribution, P.O. Box 1091, Johannesburg, 2001. Tel: 011 800 2706.
Environmental – Envirolution Consulting, Vista Place Suite 1a & 2, No 52 Cnr Vorster Avenue and Glen Avenue, Glenanda, 0861 44 44 99
Landowner – Eskom Holdings SOC Ltd, Eskom Distribution, P.O. Box 1091, Johannesburg, 2001. Tel: 011 800 2706.

C. Table of Contents

D. Background information on the project

Report

This report is part of the environmental impact assessment process under the National Environmental Management Act, as amended (Act No. 107 of 1998) (NEMA) and includes Appendix 6 (GN R38282 of 4 December 2014) of the Environmental Impact Assessment Regulations (see Appendix 3).

Outline of development

This report discusses and aims to provide the applicant with information regarding the location of palaeontological material that will be impacted by the development. In the pre-construction phase it is necessary for the applicant to apply for the relevant permit from the South African Heritage Resources Agency (SAHRA / PHRA) if recommended.

The applicant, Eskom Holdings SOC Ltd (Distribution) proposes to construct a new 132kV powerline (consists of three sections) as well as two new proposed substations, namely (1) the Ratsiepane SS to the east of the Ratsiepane township and (2) the Nchaupe SS to the west of the Makapanstad area.

Authorised Mathibestad SS-Proposed Nchaupe SS: This section includes the construction of the new Nchaupe Substation (two proposed site alternatives) from the new Nchaupe Substation to the authorised Mathibestad Substation.
Proposed Nchaupe SS – Proposed Ratsiepane SS: This section includes the construction of the new Ratsiepane Substation (two proposed site alternatives) as well as a power line (four proposed route alternatives) from the new Nchaupe Substation to the new Ratsiepane Substation.
Prposed Ratsiepane SS – Authorised Tswaing SS: This section includes the construction of a power line (six proposed route alternatives) from the new Ratsiepane Substation to the authorised Tswaing Substation.

The proposed power lines will connect to the Dinaledi-Dipompong substations and power lines will form part of the Geographic Network Upgrade.

Related infrastructure:

1. Power Lines,
2. Roads,
3. Substations.

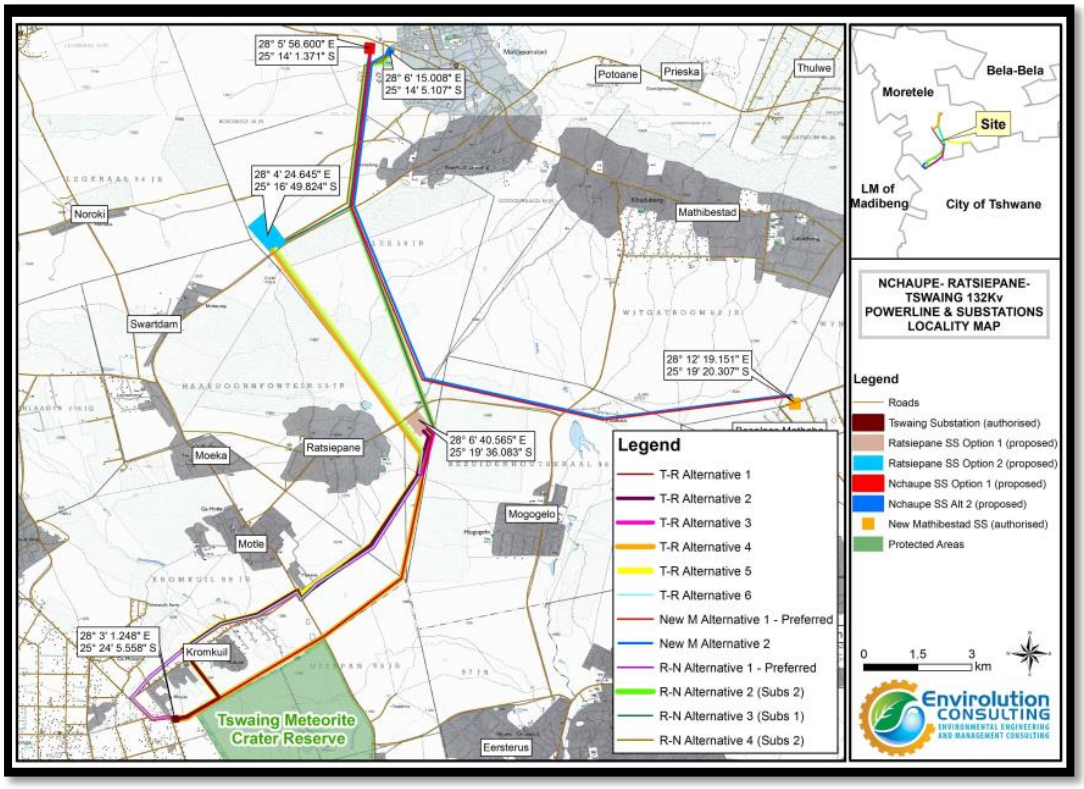

Figure 1: Proposed Layout plan (Envirolution).

The Project includes Alternatives (Figure 2):
Alternative 1-6: Tswaing SS to Ratsiepane SS.
Alternative 1-2: Nchaupe SS to Mathibestad SS (1 – Preferred).
Alternative 1-4: Nchaupe SS to Ratsiepane SS
The servitude width for a 132kV overhead distribution power line is 31m (15.5m on either side of the centre line of the power line). The area for a substation is 100m x 150m in size.

Rezoning/ and or subdivision of land: N/a "agricultural" at present.
Name of developer and consultant: Eskom Holdings SOC Ltd and Envirolution Consulting.
Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a palaeontological impact assessment: field study to ascertain if any palaeontological sensitive material is present in the development area. This study will advise on the impact on fossil heritage mitigation or conservation necessary, if any.
Dr Fourie obtained a Ph.D from the Bernard Price Institute for Palaeontological Research (now ESI), University of the Witwatersrand. Her undergraduate degree is in Geology and Zoology. She specialises in vertebrate morphology and function concentrating on the Therapsid Therocephalia. For the past ten years she carried out field work in the Eastern Cape, Free State, Gauteng, Limpopo and Mpumalanga Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 22 years.
Legislative requirements: South African Heritage Resources Agency (SAHRA) for issue of permits if necessary. National Heritage Resources Act (Act No. 25 of 1999). An electronic copy of this report must be supplied to SAHRA.

E. Description of property or affected environment
Location and depth:
The Proposed Construction of the Nchaupe and Ratsiepane Substations and 132kV Overhead Power Lines between SS-Nchaupe, SS-Ratsiepane, SS-Tswaing, and SS-Mathibestad within the Moretele Local Municipality, Bojanala Platinum District Municipality in the North West Province.

Farms: Goedgewaagd 69, Bles 58, Kromkuil 99, Boschplaats 91, Be Wig 56, and Wynandskraal 64.

There are several mines past and present (gysum, coal) in the area. Depth is determined by the infrastructure to be developed. The thickness of the grey shale can vary and this is interlayered with the also variable yellow sandstone and coal seams.

The Project includes Alternatives (Figure 2):
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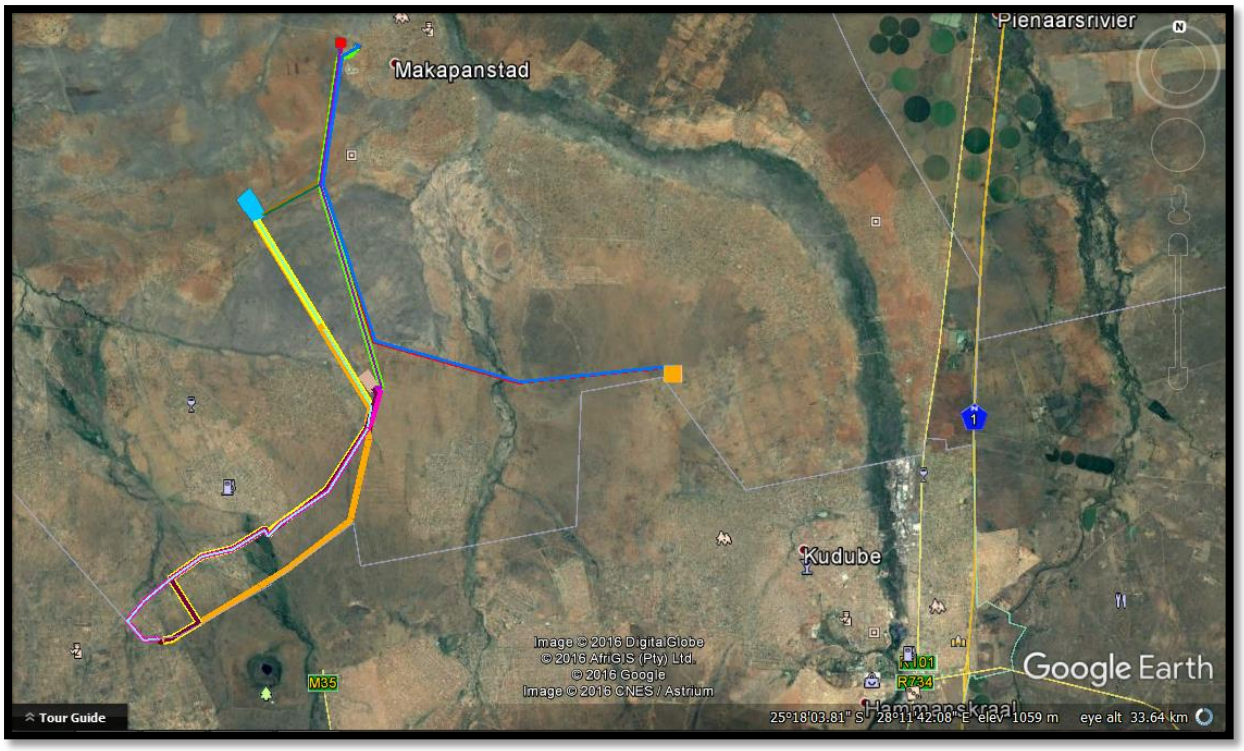

Figure 2: Google.earth image showing location (LEAP).

The northern half of the site is underlain by the flat-lying Vryheid and Irrigasie Formations of the Ecca Group, Karoo Supergroup sediments and the southern half is covered by Bushveld rocks, covered by grassland, vegetation, housing and trees.

F. Description of the Geological Setting

Description of the rock units:

Large areas of the southern African continent are covered by the Karoo Supergroup. The Ecca Group is early to mid-Permian (545-250 Ma) in age. Sediments of the Ecca group are lacustrine and marine to fluvio-deltaic (Snyman 1996). The Ecca group is known for its coal (mainly the Vryheid Formation) (five coal seams) and uranium. Coalfields formed due to the accumulation of plant material in shallow and large swampy deltas (see Appendix 1). The Ecca Group conformably overlies the Dwyka Group and is conformably overlain by the Beaufort Group, Karoo Supergroup. It consists essentially of mudrock (shale), but sandstone-rich units occur towards the margins of the present main Karoo basin in the south, west and north-east, with coal seams also being present in the north-east (Kent 1980, Johnson 2009).

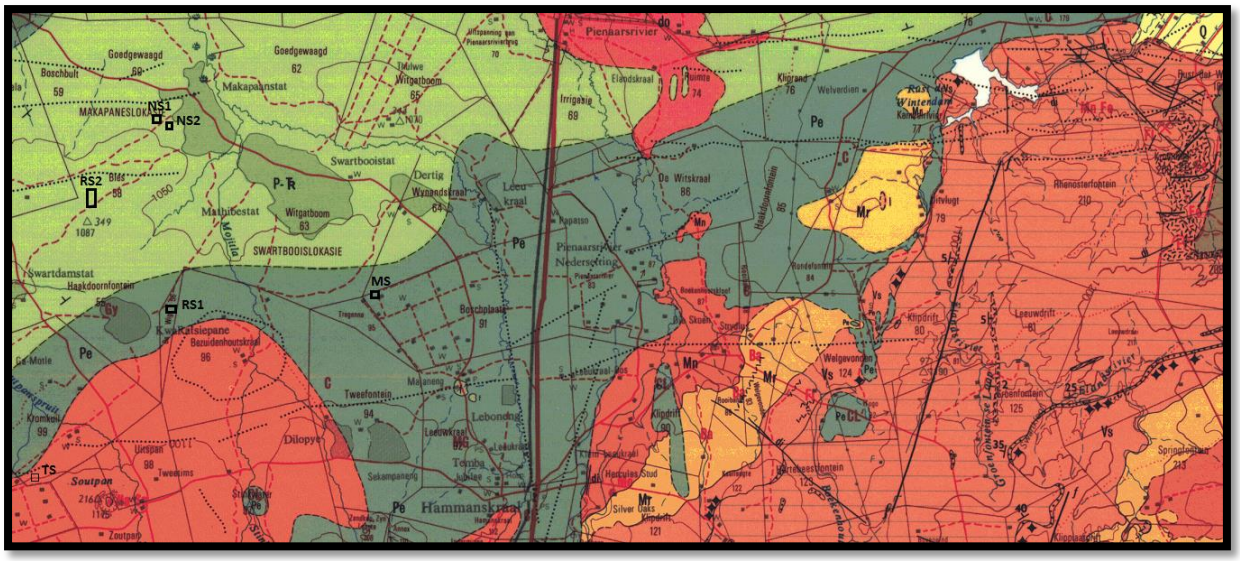

Figure 3: Excerpt of 1:250 000 Geological Map 2528 Pretoria (Walraven 1978).
Legend to map and short explanation.
P-TRi – (green) Multi-coloured siltstone, sandstone, marl, mudstone, shale. Irrigasie Formation, Ecca Group, Karoo Supergroup. Upper Permian.
Pe – (grey) Sandstone, shaly sandstone, grit, shale, conglomerate and coal near base and top. Vryheid Formation, Ecca Group, Karoo Supergroup. Permian.
Mn – (red) Grey to pink coarse-grained granite. Nebo Granite, Lebowa Granite Suite, Bushveld Complex. Mokolian.
…… – (black) Lineament (Landsat, aeromagnetic).
------ - Concealed geological boundary.
□ – Approximate position of substations.

The Vryheid Formation is named after the type area of Vryheid-Volksrust. In the north-eastern part of the basin the Vryheid Formation thins and eventually wedges out towards the south, southwest and west with increasing distance from its source area to the east and northeast (Johnson 2009). The Vryheid Formation consists essentially of sandstone, shale, and subordinate coal beds, and has a maximum total thickness of 500 m. It forms part of the Middle Ecca (Kent 1980). This formation has the largest coal reserves in South Africa. The pro-delta sediments are characterised by trace and plants fossils (Snyman 1996).

Coal has always been the main energy source in industrial South Africa. It is in Mpumalanga, south of the N4, that most of the coal-fired power stations are found. Eskom is by far the biggest electricity generator in Africa. Thick layers of coal just below the surface are suited to open-cast mining and where the overlying sediments are too thick, shallow underground mining. In 2003, coal was South Africa's third most valuable mineral commodity and is also used by Sasol for fuel- and chemicals-from-coal (Norman and Whitfield 2006). Grodner and Cairncross (2003) proposed a 3-D model of the Witbank Coalfield to allow easy evaluation of the sedimentary rocks, both through space and time. Through this, one can interpret the environmental conditions present at the time of deposition of the sediments. This can improve mine planning and mining techniques. The Vryheid Formation is underlain by the Dwyka Group and gradually overlain by mudstones (and shale) and sandstones of the Volksrust Formation.

The Irrigasie Formation of the Karoo Supergroup is Trias in age (±209 million years). This basin is present in the Springbok Flats. The Irrigasie Formation is a succession of predominantly red mudstone lying between the Ecca Group and the Clarens Sandstone (Kent 1980). In this area, the Ecca Group forms the base. The red mudstone

is interlayered with sandstone (Snyman 1996). The Irrigasie Formation is comparable to the Clarens Sandstone (±209 million years). The largest Karoo Supergroup basin is the area known as the Karoo, but smaller basins are located in the Lebombo area, Springbok Flats and Ellisras, and north of the Soutpansberg towards Tshipise-Pafuri and further westward into Namibia (Kent 1980). The presence of a number of outliers of Ecca strata between Witbank and Pienaarsrivier indicates that the Springbok Flats basin and the main Karoo basin were probably originally linked (Kent 1980). In this area, the Ecca Group forms the base. The red mudstone is interlayered with sandstone (Snyman 1996). The dumps an old smoke stacks near Hammanskraal are from the fire-clay workings. These are from weathered shale of the Ecca Group of the Karoo Supergroup (Norman and Whitfield 2006). Between Hammanskraal and Bela Bela the Karoo Supergroup sediments is believed to dip gently northwards.

The Bushveld Complex is a massive body of igneous origin and it is intrusive in the Transvaal Supergroup (Kent, 1980). It covers an area of 65 000 km² and is chrome and platinum rich (Visser, 1989). The age is Vaalian (2,100 – 1,920 Ma). The Rustenburg Layered Suite is so termed as it is intrusive in origin and the term is to be equivalent to a 'group'. It consists of mafic and ultramafic rocks and is rich in platinum, chrome and vanadium. The layered rocks of the Bushveld Complex are generally believed to be the result of crystals settling out of magma during slow cooling. The magmatic events petrogenetically related to and generally considered part of the whole magmatic evolution of the Complex are, the diabase sills and the Rooiberg Group. The Complex consists of three main units or suites of which the Rustenburg Layered Suite is one (Kent, 1980), the other two are the Rashoop and Lebowa Granite Suites (Visser, 1989). This region is covered by the 'Bushveld' vegetation.

The Bushveld Complex rocks (Figure 4) are classified mafic and ultramafic because of the iron and magnesium (and/or calcium) rich content, such as norite, gabbro and pyroxenite. The heaviest minerals, such as olivine and pyroxene, and any sulphide minerals (like magnetite and chromite) concentrate towards the base of each layer. Lighter minerals, such as feldspar and quartz, tend to form at the top (Norman and Whitfield, 2006).

It is believed that the Bushveld Complex looked like the Yellowstone National Park in the States of Wyoming, Idaho and Montana, United States of America, when it formed. The Rustenburg Layered Suite formed first. Erosion caused the Bushveld Complex to shrink in size. The Complex crops out at surface in three very long arcs, from Thabazimbi to Pretoria in the west, from Mokopane to Middelburg in the east, and north of Mokopane (McCarthy and Rubidge, 2005).

The Bushveld Complex is economically very important. By far the most important metal mined from the Rustenburg Layered Suite is platinum. Gold is also present, other minerals are nickel, copper, chrome, vanadium, tin, fluorspar and cobalt. Quarries provide dimension stone and granite (Visser, 1989).

The Project includes Alternatives (Figure 2):
Alternative 1-6: T-R.
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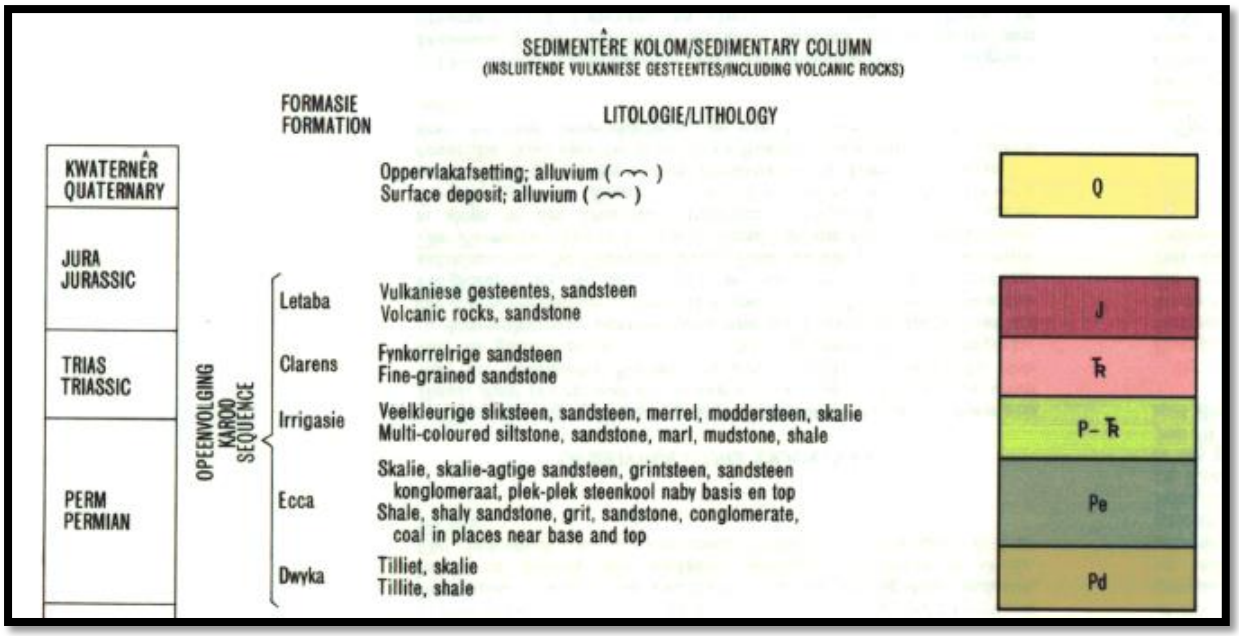


Figure 4: Lithostratigraphic column to show the Ecca Group (Walraven 1978).

Ecca rocks are stable and lend themselves well to developments. It is only unstable in or directly above mining activities (Snyman 1996). The site itself is situated on the flat-lying Vryheid Formation, Ecca Group, Karoo Supergroup. Dolerite dykes do occur throughout the Karoo Supergroup. Structural geological features such as dykes and faults can have a measurable influence on ground water flow and mass transport.

The typical colours for the Vryheid Formation are grey and yellow for the sediments and black for the coal seam. The thickness of the grey shale can vary and this is interlayered with the also variable yellow sandstone and coal seams.

The walk through was done towards the middle of March 2017, conditions were hot and dry. Photographs below show the gentle sloping topography. A variety of soil types (overburden and topsoil) will be present. The Vryheid Formation sediments may attain a thickness of 120 – 140 m. A typical profile includes soil and clay, sandstone and siltstone, shale, 2 upper seam, shale, 2 seam, sandstone, no 1 seam, shale and dolomite at the bottom. The vegetation is very thick.

Field Observations

Figure 5: Site where the new Tswaing Substation will be situated (authorised). Underlain by Bushveld strata.

Figure 6: Location of Ratsiepane Substation Option 1 (proposed). Underlain by Vryheid Formation rocks.

Figure 7: Location of Ratsiepane SS Option 2 (proposed). Underlain by Irrigasie Formation sediments.

Figure 8: Site for new Nchaupe SS Option 1 (proposed). Underlain by Irrigasie Formation sediments.

Figure 9: Site for new Nchaupe SS Alt 2 (proposed). Underlain by Irrigasie Formation rocks.

Figure 10: Site for new Mathibestad SS (authorised). Underlain by Vryheid Formation rocks.

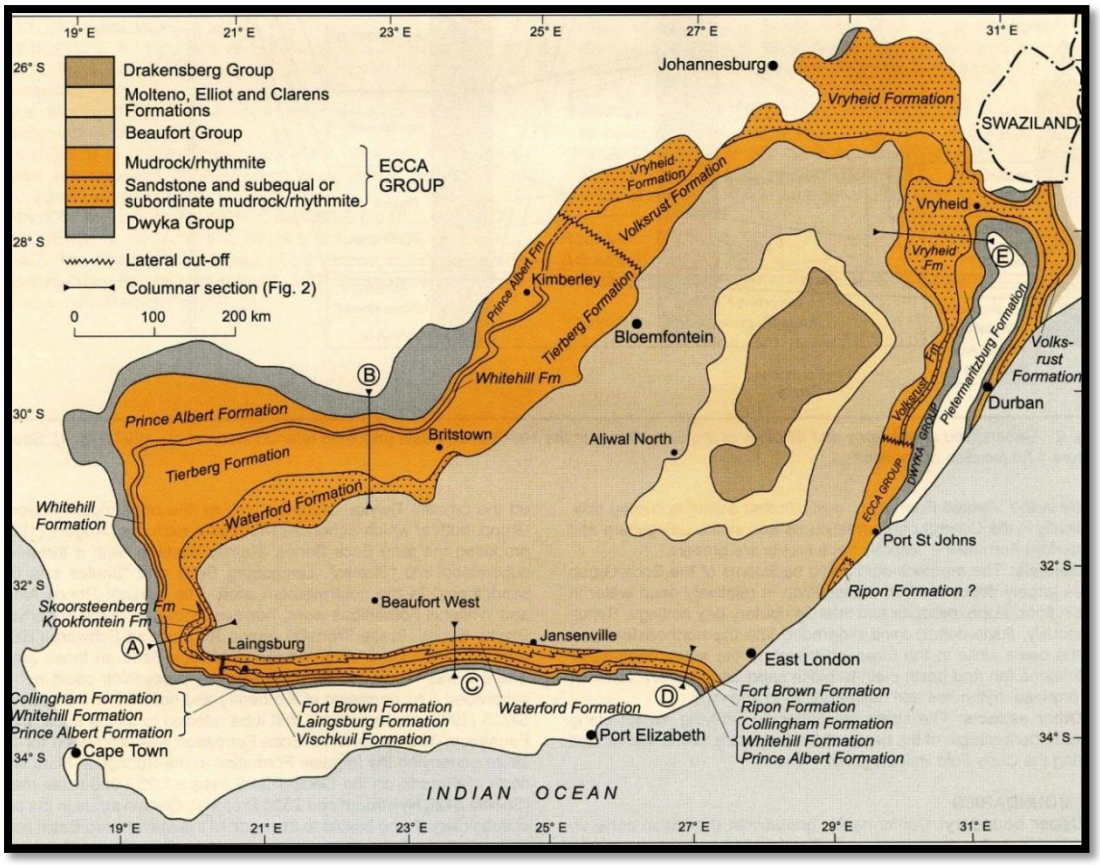
Figure 11: Ferricrete and grit confirms the presence of Vryheid Formation.

There is some concern with the project due to the presence of the Vryheid and Irrigasie Formations. The depth of the Formation can be verified with geological cores. The topsoil, subsoil and overburden must be surveyed for fossils and Mitigation is needed for the shale layer. Care must be taken during the digging of foundations for the planting of poles for power lines.

It is recommended to wait for the response from SAHRA on the Phase 1 Field study (this report), and if mitigation is recommended then the SAHRA protocol must be followed. Alternatives will not be feasible as all proposed development portions and surrounding areas are on the Vryheid and Irrigasie Formations.

G. Background to Palaeontology of the area

Summary: When rock units of moderate to very high palaeontological sensitivity are present within the development footprint, a desk top and or field scoping (survey) study by a professional palaeontologist is usually warranted. The main purpose of a field scoping (survey) study would be to identify any areas within the development footprint where specialist palaeontological mitigation during the construction phase may be required (SG 2.2 SAHRA AMPHOB, 2012).



Map 1: Extent of the Ecca Group, more specifically the Vryheid Formation (Johnson 2009).

The Ecca Group may contain fossils of diverse non-marine trace, *Glossopteris* flora, mesosaurid reptiles, palaeoniscid fish, marine invertebrates, insects, and crustaceans (Johnson 2009). *Glossopteris* trees rapidly colonised the large deltas along the northern margin of the Karoo Sea. Dead vegetation accumulated faster than it could decay, and thick accumulations of peat formed, which were ultimately converted to coal. It is only in the northern part of the Karoo Basin that the glossopterids and cordaitales, ferns, clubmosses and horsetails thrived (McCarthy and Rubidge 2005).

The Glossopteris flora is thought to have been the major contributor to the coal beds of the Ecca. These are found in Karoo-age rocks across Africa, South America, Antarctica, Australia and India. This was one of the early clues to the theory of a former unified Gondwana landmass (Norman and Whitfield 2006).

A big section of the development will be situated on the Irrigasie Formation of the Karoo Supergroup which is usually fossiliferous. Conifers are present often associated with ferns, cycads and cycadioides (Anderson 1999). It shows extensive bioturbation by trace fossils. Dinosaur fossils include the possible remains of 'Euskelosaurus' and *Gigantoscelis* (Groenewald & Groenewald 2014).

Figure 12: Photograph of fossil horsetail fern stem, courtesy of Prof. Bamford, The Evolutionary Studies Institute (Photograph: H. Fourie).

Subgroup / Supergroup	Group	Formation	Fossil Heritage	Comment
Karoo Supergroup	Ecca	Vryheid	Rich fossil plant assemblages of the Permian Glossopteris flora, rare fossil wood, diverse palynomorphs. Abundant low diversity trace fossils, rare insects, possible conchostracans, non-marine bivalves, fish scales	Globally important and under collected
Karoo Supergroup	Ecca	Irrigasie	Bioturbation by trace fossils. Dinosaur remains include *Euskelosaurus* and *Gigantoscelis.*	Outcrops scarce

Table 1: Taken form palaeotechnical report (Groenewald and Groenewald 2014).

Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, if there is the presence of Karoo Supergroup strata the palaeontological sensitivity is generally LOW to VERY HIGH, but here locally **VERY HIGH** for the Vryheid and Irrigasie Formations.

Rock Unit	Significance/vulnerability	Recommended Action
Vryheid Formation (Pv) (Pe)	Very High	Field assessment and protocol for finds is required
Irrigasie Formation (P-TRi)	Very High	Field assessment and protocol for finds is required
Bushveld Complex	Insignificant or zero	No studies required

Table 2: Criteria used (Fossil Heritage Layer Browser/SAHRA).

Databases and collections: Ditsong: National Museum of Natural History. Evolutionary Studies Institute, University of the Witwatersrand (ESI).
Impact: **VERY HIGH** for the Vryheid and Irrigasie Formations. There are significant fossil resources that may be impacted by the development (shale) and **INSIGNIFICANT or ZERO** for the Bushveld Complex .

H. Description of the Methodology

The palaeontological impact assessment field study was undertaken towards the middle of March 2017. The walk through of the affected portion was done and photographs (in 7.1 mega pixels) were taken of the site with a digital Canon camera (PowerShot SX620HS). It was not necessary to use a Global Positioning System (GPS)

(Garmin eTrex 10) to record outcrops where not covered with topsoil, subsoil, overburden, and vegetation. The walk through did identify the Vryheid and Irrigasie Formations. A literature survey is included.

Assumptions and Limitations:-
The accuracy and reliability of the report may be limited by the following constraints:

1. Most development areas have never been surveyed by a palaeontologist or geophysicist.
2. Variable accuracy of geological maps and associated information.
3. Poor locality information on sheet explanations for geological maps.
4. Lack of published data.
5. Lack of rocky outcrops.
6. Insufficient data from developer and exact lay-out plan for all structures.

A Phase 1 Palaeontological Impact Assessment: Field Study will include:

1. Recommendations for the future of the site.
2. Background information on the project.
3. Description of the property of affected environment with details of the study area.
4. Description of the geological setting and field observations.
5. Background to palaeontology of the area.
6. Heritage rating.
7. Stating of significance (Heritage Value).

A Phase 2 Palaeontological Impact Assessment: Mitigation will include:

1. Recommendations for the future of the site.
2. Description of work done (including number of people and their responsibilities).
3. A written assessment of the work done, fossils excavated, not removed or collected and observed.
4. Conclusion reached regarding the fossil material.
5. A detailed site plan.
6. Possible declaration as a heritage site or Site Management Plan.

The National Heritage Resources Act No. 25 of 1999 further prescribes -

> Act No. 25 of 1999. National Heritage Resources Act, 1999.
> The National Estate as: 3 (2) (f) archaeological and palaeontological sites, (i)(1) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens,
> Heritage assessment criteria and grading used: (a) Grade 1: Heritage resources with qualities so exceptional that they are of special national significance;
> (b) Grade 11: Heritage resources which, although forming part of the national estate, can be considered to have special qualities which make them significant within the context of a province or a region; and (c) Grade 111: Other heritage resources worthy of conservation.
> SAHRA is responsible for the identification and management of Grade 1 heritage resources.
> Provincial Heritage Resources Authority (PHRA) identifies and manages Grade 11 heritage resources.
> Local authorities identify and manage Grade 111 heritage resources.
>
> No person may damage, deface, excavate, alter, remove from its original position, subdivide or change the planning status of a provincially protected place or object without a permit issued by a heritage resources authority or local authority responsible for the provincial protection.

Archaeology, palaeontology and meteorites: Section 35.
(2) Subject to the provisions of subsection (8) (a), all archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

Mitigation involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or excavation, recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before a Phase 2 may be implemented.

The Mitigation is done in order to rescue representative fossil material from the study area to allow and record the nature of each locality and establish its age before it is destroyed and to make samples accessible for future research. It also interprets the evidence recovered to allow for education of the public and promotion of palaeontological heritage.

Should further fossil material be discovered during the course of the development (*e. g.* during bedrock excavations), this must be safeguarded, where feasible *in situ,* and reported to a palaeontologist or to the Heritage Resources authority. In situations where the area is considered palaeontologically sensitive (*e. g.* Karoo Supergroup Formations, ancient marine deposits in the interior or along the coast) the palaeontologist might need to monitor all newly excavated bedrock. The developer needs to give the palaeontologist sufficient time to assess and document the finds and, if necessary, to rescue a representative sample.

When a Phase 2 palaeontological impact study is recommended, permission for the development to proceed can be given only once the heritage resources authority has received and approved a Phase 2 report and is satisfied that (a) the palaeontological resources under threat have been adequately recorded and sampled, and (b) adequate development on fossil heritage, including, where necessary, *in situ* conservation of heritage of high significance. Careful planning, including early consultation with a palaeontologist and heritage management authorities, can minimise the impact of palaeontological surveys on development projects by selecting options that cause the least amount of inconvenience and delay.

Three types of permits are available; Mitigation, Destruction and Interpretation. The specialist will apply for the permit at the beginning of the process (SAHRA 2012).

I. Description of significant fossil occurrences

All Karoo Supergroup geological formations are ranked as LOW to VERY HIGH, and here the impact is potentially **VERY HIGH** for the Vryheid Formation, Ecca Group. Rocks of Permian age in South Africa are particularly rich in fossil plants (Rayner and Coventry 1985). The fossils are present in the grey shale interlayered with the coal seams. The fossils are not very rare and also occur in other parts of the Karoo stratigraphy. The pollen of the Greenside Colliery also on the Vryheid formation was the focus of a Ph.D study. It is often difficult to spot the greyish fossils as they are the same colour as the grey shale in which they are present as these coalified compressions have been weathered to leave surface replicas on the enclosing shale matrix. A locality close to Ermelo, also Vryheid Formation, has yielded *Scutum, Glossopteris* leaves, *Neoggerathiopsis* leaves, the lycopod *Cyclodendron leslii,* and various seeds and scale leaves (Prevec 2011).

Fossils likely to be found are mostly plants (Appendix 1) such as '*Glossopteris* flora' of the Vryheid Formation. The aquatic reptile *Mesosaurus* and fossil fish may also occur with marine invertebrates, arthropods and insects. Trace fossils can also be present. The marine bivalve *Megadesmus* is found in the upper part of the Volksrust Formation near Newcastle (Johnson 2009).

During storms a great variety of leaves, fructifications and twigs accumulated and because they were sandwiched between thin films of mud, they were preserved to bear record of the wealth and the density of the vegetation around the pools. They make it possible to reconstruct the plant life in these areas and wherever they are found, they constitute most valuable palaeobotanical records (Plumstead 1963) and can be used in palaeoenvironmental reconstructions.

Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to be determined due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot. The vast coal mining industry provides palaeontologists with fantastic access to coal-associated plant fossils, while simultaneously resulting in the destruction of important National palaeontological heritage.

Fossils likely to be found are mostly plants such as ferns, cycads, cycadioides and conifers. Macro-and microfossils were reported from Hammanskraal to the south. The Hammanskraal locality is present in the Vryheid Formation and the pollen was studied in depth by MacRae (1987).

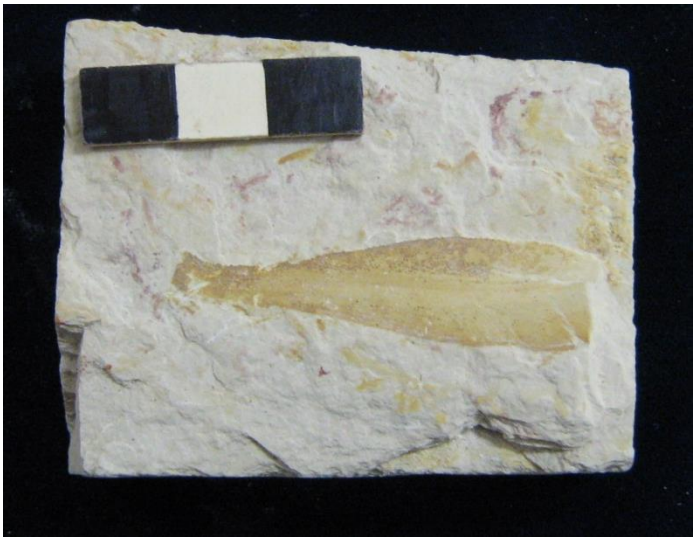


Figure 13: Photograph (H. Fourie) of a fossil leave from Hammanskraal (DNMNH).

The threats are:- earth moving equipment/machinery (for example haul trucks, front end loaders, excavators, graders, dozers) during construction, the sealing-in or destruction of fossils by development, vehicle traffic, and human disturbance. See Description of the Geological Setting (F) above.

Impacts assessment

Nature of impacts : Destruction, Damage & Loss of fossil material
ACTIVITY: The sources of these impacts include the, the removal of vegetation, sealing-in or destruction of fossils, and digging of foundations. This activity is particularly significant where pylons are planted and the substations are constructed.

	Without mitigation	With mitigation
CONSTRUCTION PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Long term (4)	Medium term (3)
Extent	Limited to the Region (3)	Limited to Local Area (2)
Magnitude	High (8)	Moderate (6)
Significance	**60 (high)**	**33 (moderate)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Improbable (2)
Duration	Long term (4)	Long term (4)
Extent	Limited to the Region (3)	Limited to the Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**39 (moderate)**	**20 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Footprint of Pylon foundation should be as small as possible
- A temporary fence or demarcation must be erected around the works area to prevent access to sensitive environs. The works areas generally include the servitude, construction camps, areas where material is stored and the actual footprint of the tower/pylon
- Consider the various methods of stringing and select whichever method(s) that will have the least impact e.g. shooting a pilot cable and pull cables with a winch, or flying cables over
- Stringing should preferably not make use of vehicles If unavoidable, plan stringing activities and use equipment with the smallest possible footprint e.g. quad bikes
- Access roads and bridges should have a small footprint
- Formalise access roads and make use of existing roads and tracks where feasible, rather than creating new routes through naturally vegetated areas.
- Maintenance activities should not impact on fossiliferous outcrops
- Maintenance vehicles must stay on dedicated roads/ servitudes

Cumulative impacts: Construction activities may result in cumulative impact to the fossiliferous layers It is very important that protective measures should be put into place and monitored.

Residual Risks: Impacts to fossiliferous outcrops (mudstone) are likely to be permanent unless rehabilitated.

J. Recommendation

a. There is no objection (see Recommendation B) to the development, but it was necessary to request a Phase 1 Palaeontological Impact Assessment: Field study to determine whether the development will affect fossiliferous outcrops as the palaeontological sensitivity is **VERY HIGH**. A Phase 2 Palaeontological Mitigation is only required if the Phase 1 Palaeontological Assessment identified a fossiliferous formation or surface fossils. Protocol is attached (Appendix 2).

b. This project will benefit the economy and social development of the community.

c. Preferred choice: None. The impact on the palaeontological heritage is **VERY HIGH for the Vryheid and Irrigasie Formations.** The presence of shale is problematic. Care must be taken during the digging of foundations and removing topsoil, subsoil and overburden (see Executive Summary).
d. The following should be conserved: if any palaeontological material is exposed during digging, excavating, drilling or blasting SAHRA must be notified. All construction activities must be stopped and a palaeontologist should be called in to determine proper mitigation measures.

Sampling and collecting:
Wherefore a permit is needed from the South African Heritage Resources Agency (SAHRA / PHRA).

a. Objections: Cautious. See heritage value and recommendation.
b. Conditions of development: See Recommendation.
c. Areas that may need a permit: **Yes if a fossil is uncovered**.
d. Permits for mitigation: **Needed from SAHRA/PHRA prior to Mitigation**.

K. Conclusions

a. All the land involved in the development was assessed and none of the property is unsuitable for development (see Recommendation B).
b. All information needed for the Phase 1 Palaeontological Impact Assessment and Field scope was provided by the Consultant. All technical information was provided by Envirolution Consulting.
c. As such this study has not identified any palaeontological reason to prejudice the progression of the proposed development subject to adequate mitigation programs suggested, herein, being put in place.
d. Areas that would involve mitigation and may need a permit from the South African Heritage Resources Agency are discussed (Sections E, G).
e. The following should be conserved: if any palaeontological material is exposed during digging, excavating, drilling or blasting, SAHRA must be notified. All development activities must be stopped and a palaeontologist should be called in to determine proper mitigation measures, especially for shallow caves.
f. Condition in which development may proceed: It is further suggested that a Section 37(2) agreement of the Occupational, Health and Safety Act 85 of 1993 is signed with the relevant contractors to protect the environment and adjacent areas as well as for safety and security reasons.

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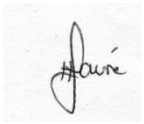
Declaration (disclaimer) 1(b)

I, Heidi Fourie, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project for which I was appointed to do a palaeontological assessment. There are no circumstances that compromise the objectivity of me performing such work.

I accept no liability, and the client, by receiving this document, indemnifies me against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by the use of the information contained in this document.

It may be possible that the Phase 1 PIA study may have missed palaeontological resources in the project area as outcrops are not always present or visible due to vegetation while others may lie below the overburden of earth and may only be present once development commences.

This report may not be altered in any way and any parts drawn from this report must make reference to this report.



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Heidi Fourie
2017/03/20

Appendix 1:

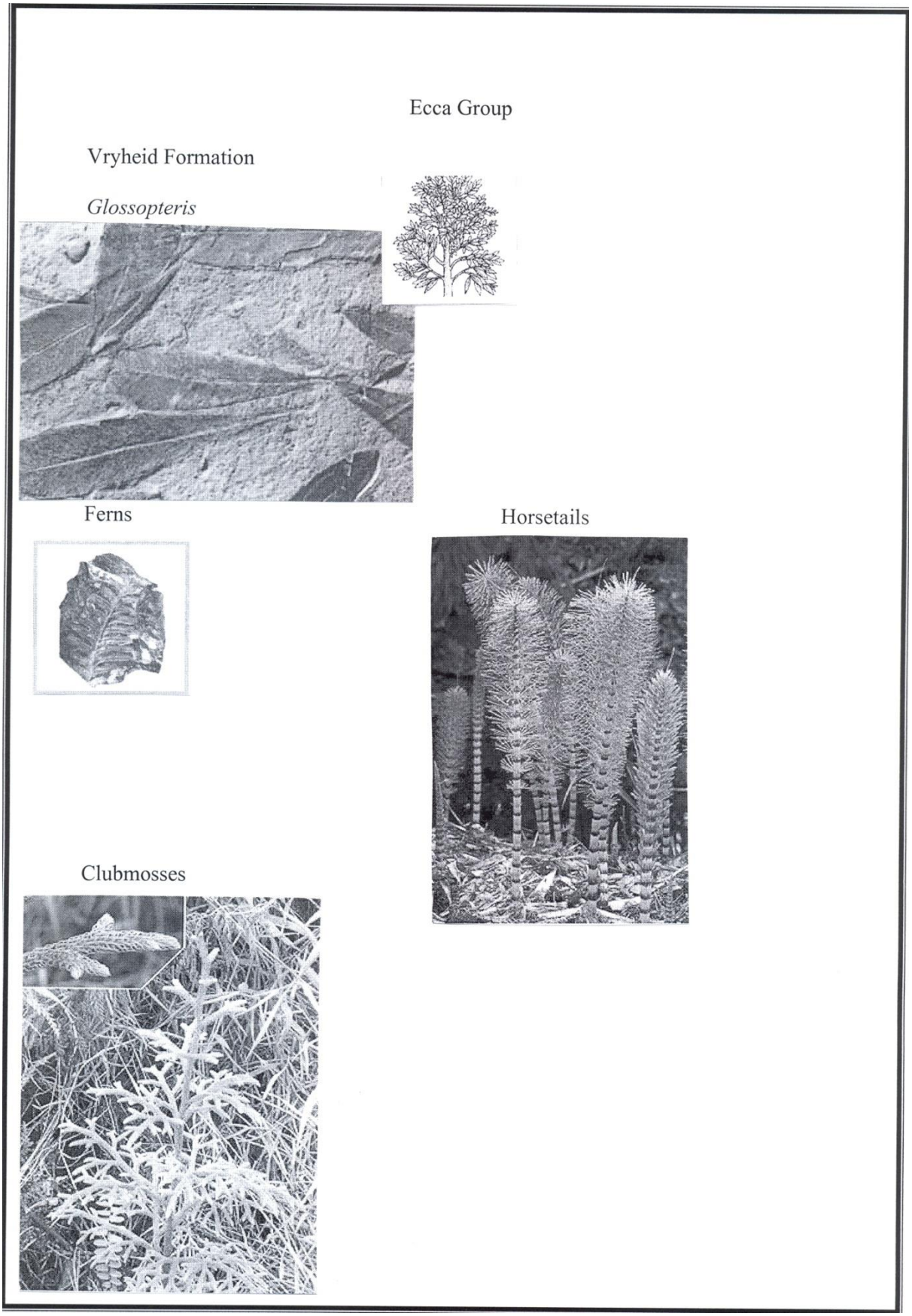

Figure 14: Examples of Vryheid Formation fossils.

Figure 15: Example of a plant fossil (courtesy of the ESI). *Glossopteris* leave.

Appendix 2: **Protocol for finds and Management plan**

This section covers the recommended protocol for a Phase 2 Mitigation process as well as for reports where the Palaeontological Sensitivity is LOW; this process guides the palaeontologist / palaeobotanist on site and should not be attempted by the layman / developer. The developer needs to employ an Environmental Control Officer (ECO) to oversee the construction activities so that when a fossil is unearthed they can notify the relevant department and specialist to further investigate. This ECO should familiarise him- or herself with the Ecca Group formations and its fossils. The Evolutionary Studies Institute, University of the Witwatersrand has good examples of Ecca Group Fossils.

The developer must survey the areas affected by the development and indicate on plan where the construction / development / mining will take place. Trenches have to be dug to ascertain how deep the sediments are above the bedrock (can be a few hundred metres). This will give an indication of the depth of the topsoil, subsoil, and overburden, if need be trenches should be dug deeper to expose the interburden.

Mitigation will involve recording, rescue and judicious sampling of the fossil material present in the layers sandwiched between the geological / coal layers. It must include information on number of taxa, fossil abundance, preservational style, and taphonomy. This can only be done during mining or excavations. In order for this to happen, in case of coal mining operations, the process will have to be closely scrutinised by a professional palaeontologist / palaeobotanist to ensure that only the coal layers are mined and the interlayers (siltstone and mudstone) are surveyed for fossils or representative sampling of fossils are taking place.

The palaeontological impact assessment process presents an opportunity for identification, access and possibly salvage of fossils and add to the few good plant localities. Mitigation can provide valuable onsite research that can benefit both the community and the palaeontological fraternity.

A Phase 2 study is very often the last opportunity we will ever have to record the fossil heritage within the development area. Fossils excavated will be stored at a National Repository.

A Phase 2 Palaeontological Impact Assessment: Mitigation will include (SAHRA) -

1. Recommendations for the future of the site.
2. Description and purpose of work done (including number of people and their responsibilities).
3. A written assessment of the work done, fossils excavated, not removed or collected and observed.
4. Conclusion reached regarding the fossil material.
5. A detailed site plan and map.
6. Possible declaration as a heritage site or Site Management Plan.
7. Stakeholders.
8. Detailed report including the Desktop and Phase 1 study information.
9. Annual interim or progress Phase 2 permit reports as well as the final report.
10. Methodology used.

Mitigation involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or excavation, recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before a Phase 2 may be implemented.

The Mitigation is done in order to rescue representative fossil material from the study area to allow and record the nature of each locality and establish its age before it is destroyed and to make samples accessible for future research. It also interprets the evidence recovered to allow for education of the public and promotion of palaeontological heritage.

Should further fossil material be discovered during the course of the development (*e. g.* during bedrock excavations), this must be safeguarded, where feasible *in situ,* and reported to a palaeontologist or to the Heritage Resources authority. In situations where the area is considered palaeontologically sensitive (*e. g.* Karoo Supergroup Formations, ancient marine deposits in the interior or along the coast) the palaeontologist might need to monitor all newly excavated bedrock. The developer needs to give the palaeontologist sufficient time to assess and document the finds and, if necessary, to rescue a representative sample.

When a Phase 2 palaeontological impact study is recommended, permission for the development to proceed can be given only once the heritage resources authority has received and approved a Phase 2 report and is satisfied that (a) the palaeontological resources under threat have been adequately recorded and sampled, and (b) adequate development on fossil heritage, including, where necessary, *in situ* conservation of heritage of high significance. Careful planning, including early consultation with a palaeontologist and heritage management authorities, can minimise the impact of palaeontological surveys on development projects by selecting options that cause the least amount of inconvenience and delay.

Three types of permits are available; Mitigation, Destruction and Interpretation. The specialist will apply for the permit at the beginning of the process (SAHRA 2012).

The Palaeontological Society of South Africa (PSSA) does not have guidelines on excavating or collecting, but the following is suggested:

1. The developer needs to clearly stake or peg-out (survey) the areas affected by the mining/ construction/ development operations and dig representative trenches and if possible supply geological borehole data.
2. Fossils likely to occur are for example the fossil plants from the Vryheid Formation, these are present in the grey shale (or any other fossiliferous layer ranked as VERY HIGH or HIGH) or invertebrates from the Volksrust Formation (or any other fossiliferous layer).
3. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work.
4. A Palaeobotanist / palaeontologist (contact SAHRIS for list) must then inspect the affected areas and trenches for fossiliferous outcrops / layers. The contractor / developer may be asked to move structures, and put the development on hold.
5. If the palaeontologist / palaeobotanist is satisfied that no fossils will be destroyed or have removed the fossils, development and removing of the topsoil can continue.
6. After this process the same palaeontologist / palaeobotanist will have to inspect and offer advice through the Phase 2 Mitigation Process. Bedrock excavations for footings may expose, damage or destroy previously buried fossil material and must be inspected.
7. When permission for the development is granted, the next layer can be removed, if this is part of a fossiliferous layer, then with the removal of each layer of sediment, the palaeontologist / palaeobotanist must do an investigation (a minimum of once a week).
8. At this stage the palaeontologist / palaeobotanist in consultation with the developer / mining company must ensure that a further working protocol and schedule is in place. Onsite training should take place, followed by an annual visit by the palaeontologist / palaeobotanist.

Fossil excavation if necessary during Phase 2:

1. Photography of fossil / fossil layer and surrounding strata.
2. Once a fossil has been identified as such, the task of extraction begins.
3. It usually entails the taking of a GPS reading and recording lithostratigraphic, biostratigraphic, date, collector and locality information.
4. Using Paraloid (B-72) as an adhesive and protective glue, parts of the fossil can be kept together (not necessarily applicable to plant fossils).
5. Slowly chipping away of matrix surrounding the fossil using a geological pick, brushes and chisels.
6. Once the full extent of the fossil / fossils are visible, it can be covered with a plaster jacket (not necessarily applicable to plant fossils).
7. Chipping away sides to loosen underside.
8. Splitting of the rock containing palaeobotanical material should reveal any fossils sandwiched between the layers.

SAHRA has the following documents in place:
Guidelines to Palaeontological Permitting policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.
Palaeotechnical Reports for all the Provinces.

Appendix 3:

Section	Point in Act	Heading
B	1(c)	Outline of development project
	1(d)	Summary of findings
	1(g)	Concerns/threats:

	1(n)i	“
	1(n)ii	“
	1(o)	“
	1(p)	“
D	1(h)	Figures
	1(a)i	Terms of reference
H	1(e)	Description of Methodology
	1(i)	Assumptions and Limitations
I	1(f)	Heritage value
J	1(j)	Recommendation
	1(l)	“
	1(m)	Sampling and collecting
	1(k)	“
Declaration	1(b)	Declaration
Appendix 2	1(k)	Protocol for finds
	1(m)	“
	1(q)	“

Table 4: Listing points in Appendix 6 of the Act and position in Report.