Bismarck Dam, Pipeline and Orchards

Makhado Local Municipality, Vhembe District Municipality, Limpopo Province.

Farm: Bismarck 116-MS, Koningsmark 117-MS, Skutwater 115-MS, Portion 2 of Weipe 47-MS

Fourie, H. Dr heidicindy@yahoo.com

012 322 7632/079 940 6048

Palaeontological Impact Assessment: Phase 1 Field Study

Commissioned by: AGES Limpopo (Pty) Ltd

120 Marshall Street,

Polokwane,

0699

015 291 1577

Ref: Pending

2020/08/28

Fossil plant – Irrigasie Formasie

B. Executive summary

Outline of the development project: AGES Limpopo (Pty) Ltd has facilitated the appointment of Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA), Phase 1: Field Study of the suitability of the Bismarck Dam, Pipeline and Orchards project at Bismarck 116-MS, Koningsmark 117-MS, Skutwater 115-MS, Portion 2 of Weipe 47-MS in the Makhado Local Municipality, Vhembe District Municipality, within the Limpopo Province.

The applicant, Bismarck Irrigation & Development (Pty) Ltd intends to build a dam to provide water storage and irrigation water. Water will be used for orchard irrigation.

The Project includes two Alternatives for the pipeline (Figure 1):
The site is located on either side of the R572 Road with the Limpopo River and border with Zimbabwe to the north. Total size is approximately 700 hectares for the orchards and 250 hectares for the dam.
Alternative 1 Preferred (purple): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.
Alternative 2 (blue): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.

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.

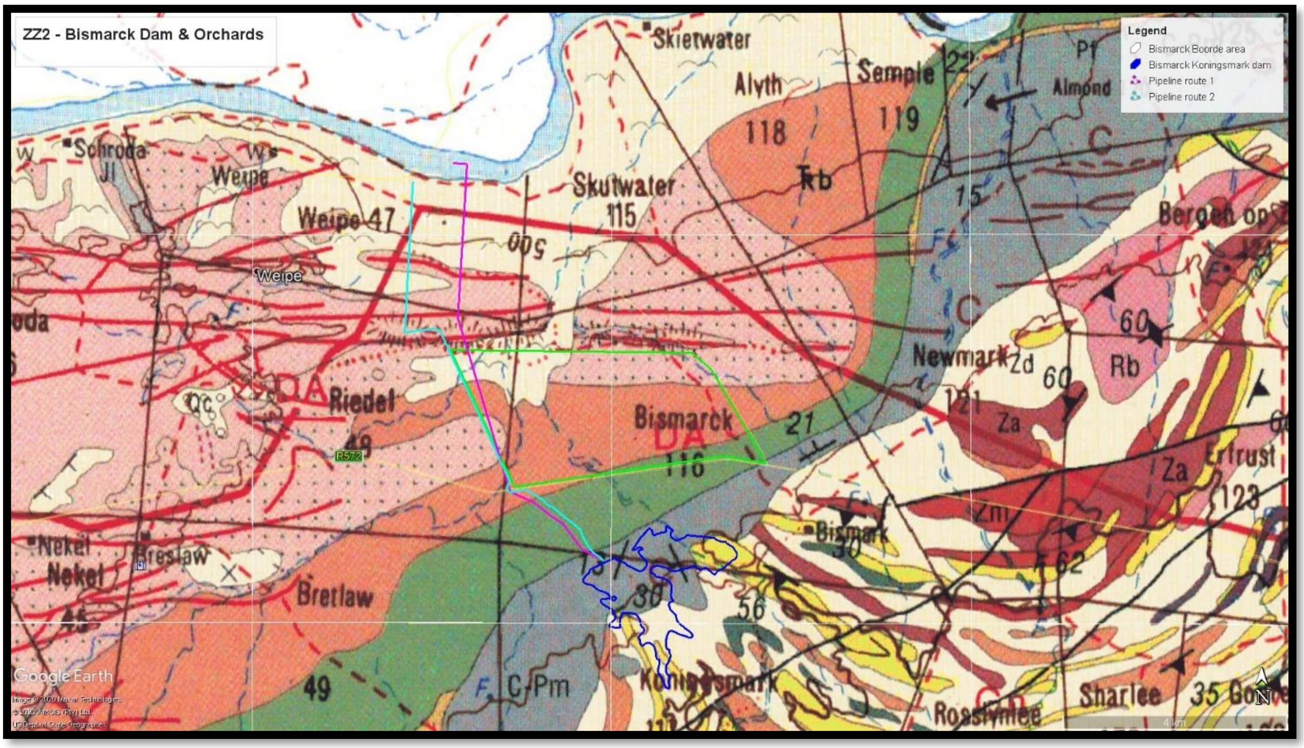
Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):

(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 (**1c)** aims to provide comment and recommendations on the potential impacts that the proposed development project / mining 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); 1:250 000, 1:100 000 Provincial Geological Map of The Limpopo Belt and Environs (Watkyes 1981); 1:250 000 Map of Alldays, 2228 (Brandl and Pretorius 2000).

Figure 3: The geology of the development area, 2228 Alldays (Brandl and Pretorius 2000) (AGES Limpopo).



Legend to map and short explanation.
Qs – Qs – Sandy soil (beige); sand (::); alluvium (m); calcrete (xx); scree (ΔΔ); high level gravel (○○).
TRct – Fine-grained, whitish to pinkish sandstone (pink). Tshipise Formation, Clarens, Karoo Supergroup.
TRcr – Fine-grained, white and red mottled argillaceous sandstone (pink ::). Red Rocks Member, Clarens Formation, Karoo Supergroup.
TRb – Brick-red to purplish mudstone and siltstone (amber). Bosbokpoort Formation, Beaufort Group, Karoo Supergroup.

TRs – Multi-coloured siltstone, sandstone and mudstone (green). Solitude Formation, Beaufort Group, Karoo Supergroup.
C-Pm – Mudstone, shale, carbonaceous shale, sandstone, conglomerate, coal seams; locally diamictite or conglomerate at the base (grey). Tshidzi Formation, Dwyka Group, Karoo Supergroup.
Zm – Amphibolite, minor mafic granulite (darker green); pink granitoid hornblende gneiss (orange). Malala Drift Group, Beit Bridge Complex.
Zd – (beige). Mount Dowe Group, Beit Bridge Complex.
-♦- - Vertical foliation.
…… – (black) Lineament (Landsat, aeromagnetic).
------ - Concealed geological boundary.
┴21 – Strike and dip of bed.
□ – Proposed development (overlay).

Summary of findings (**1d**): The Phase 1 PIA: Field Study was undertaken in the middle of July 2020 in the winter in mild and dry conditions during the official Level 3 of the covid-19 lockdown period and the following is reported:

Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary (Qs), are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Some of these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996) **[dam].**

The Clarens Formation has a maximum thickness of 250 m in the south. Pink and yellow sandstone is fine and never coarse. Cave and cliff formations are common (Visser 1989). In the Kruger National Park and northern Limpopo the Clarens Formation is represented by the lowermost Red Rocks Member that shows diagnostic calcareous concretions ranging in diameter from around 1-10 cm. They're unusual in sometimes having fine crystals of calcite in the centre. The grey to mauve sandstone is very fine-grained and devoid of any visible bedding (Norman 2013). The Tshipise Formation is also present here consisting of white and cream coloured sandstone with calcrete nodules, it reaches a thickness of 300 m in the west (Visser 1989) **[Pipelines, orchard].**

The Beaufort Group is represented by the Solitude Formation with a maximum thickness of 170 m. Occasional coal is present (Hancox and Gőtz 2014). Dominant red mudstone and siltstone characterise the Bosbokpoort Formation. Numerous calcareous concretions may occur (Kent 1980) **[orchard, pipeline]**.

The Ecca Group in the north is represented by the Mikambeni and Madzaringwe Formations which are grouped with the Tshidzi Formation. It is these two formations that are mined. In the Soutpansberg Coalfield the basal part of the Karoo succession is formed by the Dwyka Group referred to as the Tshidzi Formation. This unit is 5-20 m thick and is composed of diamictite and coarse-grained sandstone (Hancox and Gőtz 2014). The Madzaringwe Formation overlies the Tshidzi Formation of the Dwyka Group consisting of shale, sandstone, siltstone, and coal. It reaches a maximum thickness of 190 m. Overlying the Madzaringwe Formation is the Mikambeni Formation with a maximum thickness of 140 m. consisting of mudstone, shale and sandstone (Kent 1980, Visser 1989). The Madzaringwe Formation comprises up to 200 m of alternating feldspathic, often cross-bedded sandstone, siltstone and shale containing coal seams. It is overlain by the 20-150 m thick Mikambeni Formation which is comprised predominantly of medium to dark grey siltstone, minor carbonaceous mudstone and khaki-red to grey sandstone. Scattered thin coal seams occur throughout [**dam, pipeline]**.

Palaeontology - 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** (SG 2.2 SAHRA APMHOB, 2012).

Table 2: Criteria used (Fossil Heritage Layer Browser/SAHRA) (**1cB)**.

Rock Unit	Significance/vulnerability	Recommended Action
Quaternary (Qs)	**Moderate**	Desktop study
Clarens	**Very High**	Field assessment and protocol for finds is required
Beaufort Group	**Very High**	Field assessment and protocol for finds is required
Ecca Group	**Very High**	Field assessment and protocol for finds is required
Dwyka Group (C-Pm)	**Moderate**	Desktop survey
Limpopo Belt	**Very Low**	No action required

Fossils may be present in the Quaternary, Clarens, Beaufort and Ecca Formations, fossils have not been recorded from the Dwyka Group in this region. Inland quaternary deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous.

The Quaternary Formation may contain fossils. A very wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms, and other micro fossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens, within calc tufa. Stromatolite structures range from a centimetre to several tens of metres in size. The famous archaeological site of Mapungubwe is close by.

The Karoo Supergroup is renowned for its fossil wealth. Fossils are scarce in the Clarence Formation, but dinosaurs are found with the fish *Semionotus capensis* (Norman and Whitfield 2006, Snyman 1996, Visser 1998). The Beaufort Group is characterised by the presence of *Dicroidium* flora and isolated dinosaur remains. 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 (MaCarthy and Rubidge 2005).

Trace fossils are relatively abundant in the shales occurring near the top of the Dwyka Group in the southern part of the basin. Lycopods (*Leptophloem australe*) have been described from the northern Free State (Mac Rae 1999). Spores and acritarchs have been reported from the interglacial mudrocks of the Dwyka Group, also spores, pollen, wood, and plant remains in the interbedded mudrocks as well as the diamictite itself, while anthropod trackways and fish trails are present in places on bedding planes (Visser *et al.* 1990). So far fossils have not been recorded form this northern area of the Karoo Supergroup.

Field Observation – The Bismarck Project falls within the Karoo Supergroup. The site visit was done in July 2020, conditions were mild and dry. It was possible to access most of the entire property, it is extremely large. The photographs show the flat topography with some mountainous areas. A variety of soil types (overburden and topsoil) will be present. No fossils were found during the walk-through.

Recommendation:

The potential impact of the development on fossil heritage is **VERY HIGH** for the Clarens, Beaufort and Ecca Groups and **MODERATE** for the Quaternary soils and Dwyka Group, 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 (macro) or fossils are exposed during excavating or blasting (mining). The Limpopo Belt rocks have a **VERY LOW** palaeontological sensitivity.

The Project includes two Alternatives for the pipeline (Figure 1) with the above sensitivities:
The site is located on either side of the R572 Road with the Limpopo River and border with Zimbabwe to the north. Total size is approximately 700 hectares for the orchards and 250 hectares for the dam.
Alternative 1 Preferred (purple): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.
Alternative 2 (blue): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.
The shorter preferred Alternative 1 is also preferred in this report as it is shorter and therefore the impact should be less.

Concerns/threats (**1g**) to be added to the EMPr:

1. Threats are earth moving equipment/machinery (for example haul trucks, front end loaders, excavators, graders, dozers) during construction, the sealing-in or destruction of the fossils by development, vehicle traffic, planting, and human disturbance.
2. 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 have missed a fossiliferous outcrop. An appropriate Protocol and Management plan is attached for the Environmental Control Officer (Appendix 2).

The recommendations are (**1ni,1niA,1nii)**:

1. Mitigation may be needed (Appendix 2) if fossils are found.
2. No consultation with parties was necessary. The Environmental Control Officer must familiarise him- or herself with the formation present and its fossils.
3. The development may go ahead with caution, but the ECO must survey for fossils before and or after clearing, drilling, flooding, blasting, planting, or excavating.
4. The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during mining activities. For a chance find, the protocol is to immediately cease all construction activities, construct a 30 m no-go barrier, and contact SAHRA for further investigation. It is recommended that the EMPr be updated to include the involvement of a palaeontologist (1-day pre-construction training of ECO).

Stakeholders: Developer – Bismarck Irrigation & Development (Pty) Ltd, Skutwater, Musina.
Environmental – AGES (Pty) Ltd, P.O. Box 2526, Polokwane, 0700. Tel: 051 291 1577.
Landowner – Mr Piet Esterhuyse, Skutwater, Musina.

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 R326 of 7 April 2017) of the Environmental Impact Assessment Regulations (see Appendix 3). It is also in compliance with The Minimum Standards for Palaeontological Components of Heritage Impact Assessment Reports, SAHRA, APMHOB, Guidelines 2012, pp 1-15 (**2**).

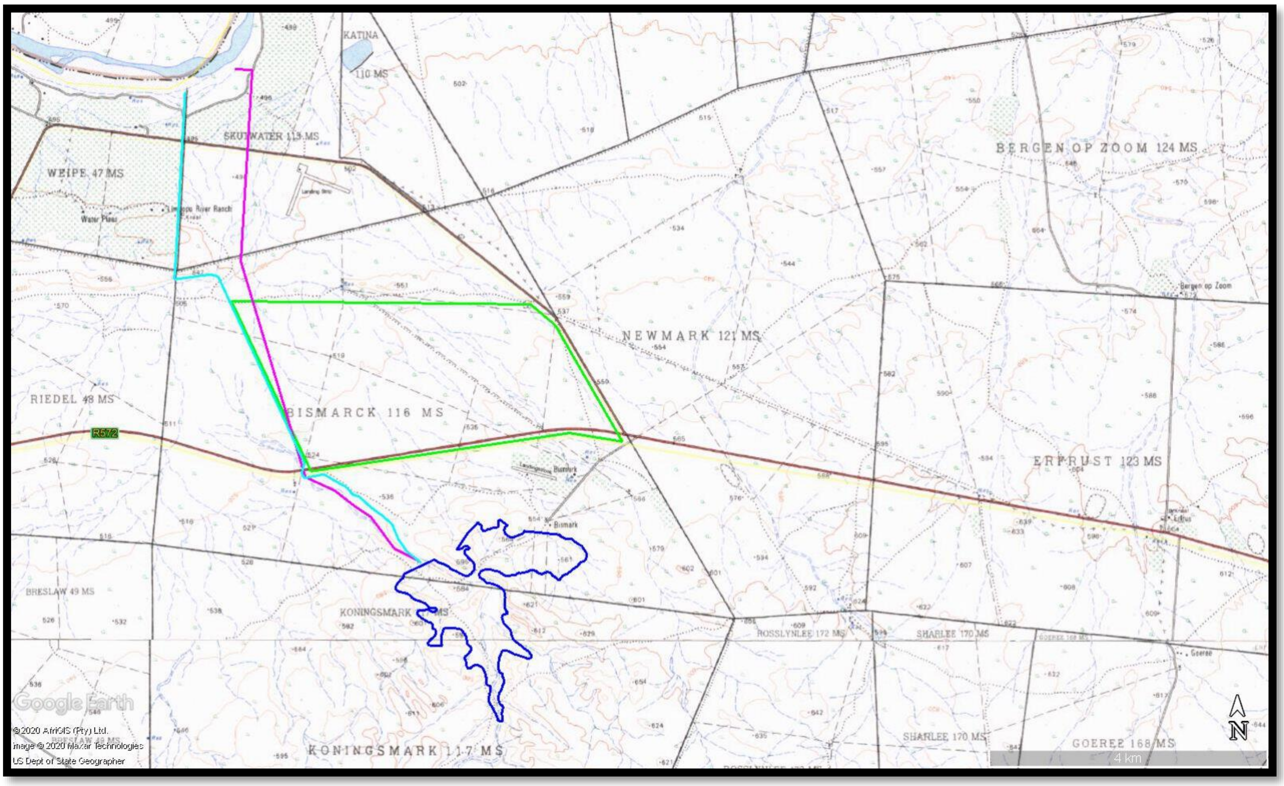
Outline of development

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 construction phase, it may be necessary for the applicant to apply for the relevant permit from the South African Heritage Resources Agency (SAHRA / PHRA) if a fossil is unearthed.

The applicant, Bismarck Irrigation & Development (Pty) Ltd intends to construct a dam for water storage and irrigation. Water will be pumped from the Limpopo River during surface flow to the dam in order to reduce groundwater abstraction during dry periods. Development of orchards in an area that is climate wise improves food security.

Local benefits of the proposed development include benefits to the local economy through possible job creation and local supplier procurement during the construction phase as well as during the operational phase of the development.

Figure 1: Topographic section showing location of pipeline, orchard and dam (AGES (Pty) Ltd).



Related infrastructure (**1f)**:

1. Dam (blue outline),
2. Pipeline (blue, purple outline),
3. Dam wall,
4. Orchard (green outline).

The Project includes two Alternatives for the pipeline (Figure 1):
The site is located on either side of the R572 Road with the Limpopo River and border with Zimbabwe to the north. Total size is approximately 700 hectares for the orchards and 250 hectares for the dam.
Alternative 1 Preferred (purple): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.
Alternative 2 (blue): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.

Rezoning/ and or subdivision of land: No.
Name of developer and consultant: Bismarck Irrigation & Development (Pty) Ltd and AGES Limpopo (Pty) Ltd.
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.
Short *Curriculum vitae* ***(1ai,1aii)***: 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. At present she is employed by Ditsong: National Museum of Natural History as curator of the large fossil invertebrate, Therapsid, dinosaur, amphibia, fish, reptile and plant collections. For the past 14 years she carried out field work in the Eastern

Cape, Western Cape, Northern Cape, North West, Free State, Gauteng, Limpopo, Kwazulu Natal, and Mpumalanga Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 26 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.

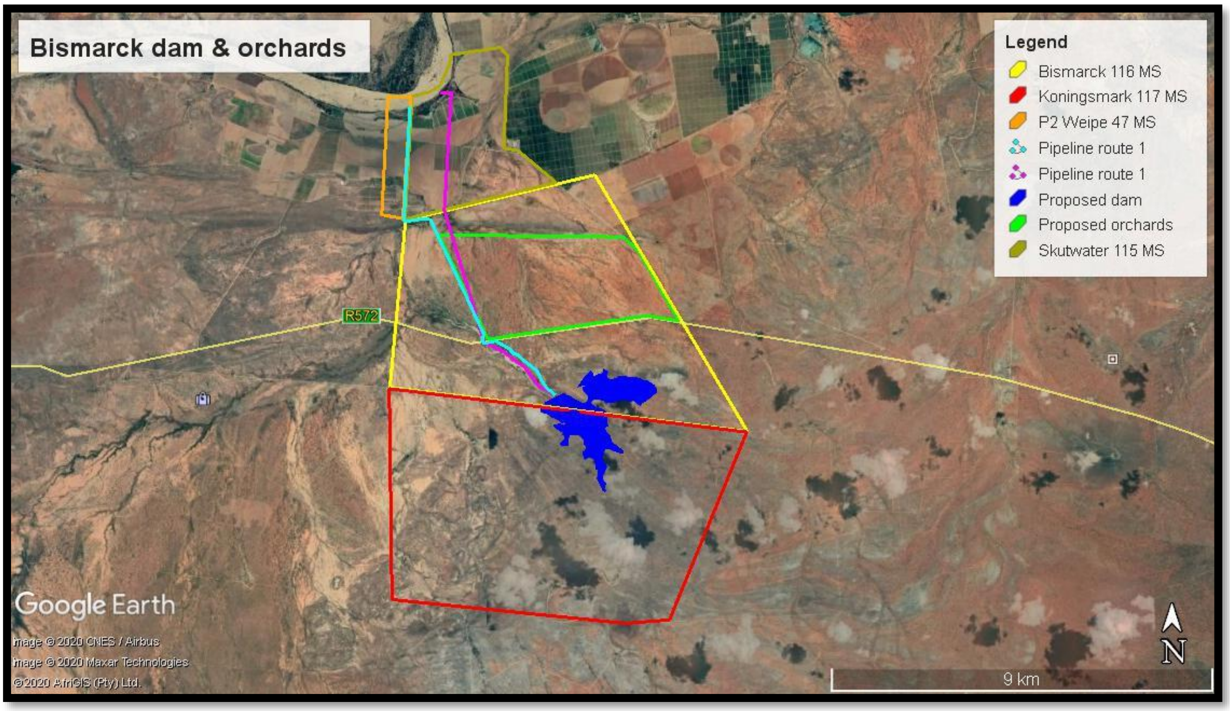
E. Description of property or affected environment

Location and depth:

The proposed Bismarck dam, pipeline and orchards project will be located at Bismarck 116-MS, Koningsmark 117-MS, Skutwater 115-MS, Portion 2 of Weipe 47-MS in the Makhado Local Municipality, Vhembe District Municipality, within the Limpopo Province.

Depth is determined by the related infrastructure to be developed, and the thickness of the formation in the development area, such as foundations, footings and channels. Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to determine due to thick topsoil, subsoil, overburden and alluvium. Geological maps do not provide depth or superficial cover, it only provides mappable surface outcrops.

Figure 2: Location map (AGES (Pty) Ltd).



The Project includes two Alternatives for the pipeline (Figure 1):

The site is located on either side of the R572 Road with the Limpopo River and border with Zimbabwe to the north. Total size is approximately 700 hectares for the orchards and 250 hectares for the dam.

Alternative 1 Preferred (purple): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.

Alternative 2 (blue): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.

The site is underlain by the Quaternary sediments, Karoo Supergroup and the Beit Bridge Complex.

F. Description of the Geological Setting

Description of the rock units:

Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary (Qs), are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Inland deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous. Some of these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996) **[Pipelines].**

The Karoo Supergroup is renowned for its fossil wealth (Kent 1980, Visser 1989). Large areas of the southern African continent are covered by the Karoo Supergroup. An estimated age is 150 – 180 Ma. and a maximum thickness of 7000 m is reached in the south. Three formations overlie the Beaufort Group, they are the Molteno, Elliot and Clarens Formations. At the top is the Drakensberg Basalt Formation with its pillow lavas, pyroclasts, and basalts (Kent 1980, Snyman 1996). The Beaufort Group is underlain by the Ecca Group which is underlain by the Dwyka Group. In the Soutpansberg are, the Karoo rocks are faulted against and overlie the Soutpansberg rocks (Norman and Whitfield 2006).

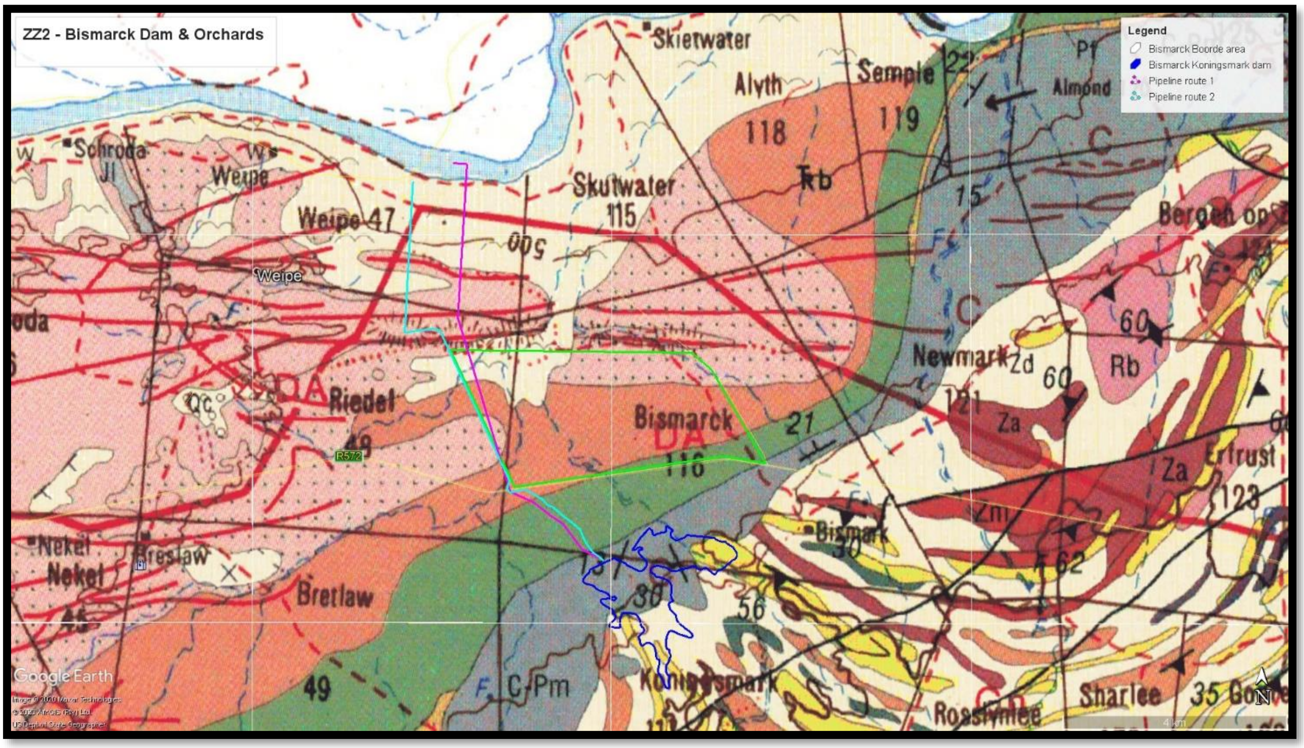
The Clarens Formation is the lowermost formation of the Stormberg Group and has a maximum thickness of 250 m in the south. Pink and yellow sandstone is fine and never coarse. Cave and cliff formations are common. Fossils are scarce, but dinosaurs are found with the fish *Semionotus capensis* (MCCarthy and Rubidge 2005, Norman and Whitfield 2006, Snyman 1996, Visser 1998). Here in the Kruger National Park and northern Limpopo the Clarens Formation is represented by the lowermost Red Rocks Member that shows diagnostic calcareous concretions ranging in diameter from around 1-10 cm. They're unusual in sometimes having fine crystals of calcite in the centre. The grey to mauve sandstone is very fine-grained and devoid of any visible bedding (Norman 2013). The Tshipise Formation is also present here consisting of white and cream coloured sandstone with calcrete nodules, it reaches a thickness of 300 m in the west (Visser 1989). **[Pipelines, orchard].**

The southern part of the Karoo basin is 3000 m thick, but the northern part of the basin is much thinner. Here the Karoo Supergroup overlies the Soutpansberg Group and rocks of the Beit Bridge Complex. A new set of nomenclature is used. (Kent 1980). The Klopperfontein Formation consists of greyish-white medium- to coarse-grained feldspathic sandstone up to 20 m thick. Dominant red mudstone and siltstone characterise the Bosbokpoort Formation (TRb). Numerous calcareous concretions may occur (Kent 1980). **[Pipelines, orchard].**

The Beaufort Group is represented by the Solitude Formation (TRs). It has a maximum thickness of 170 m. This formation can also contain coal (Hancox and Gőtz 2014). The animals present during Beaufort times flourished on the floodplanes, lakes and marshes. Sandstone is deposited in times of flooding in the river channels and the mudstones were deposited on the floodplains in the shallow lakes (Snyman 1996). The Fripp Formation (Pf) overlies the Mikambeni Formation and is up to 110 m thick and its correlation is uncertain, it may be lowermost Beaufort. Occassional coal is present (Hancox and Gőtz 2014). Consisting mainly of sandstone and reaches a maximum thickness of 110 m (Visser 1989). It is absent in certain areas (Kent 1980). [**Pipelines].**

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 geology of the area (**1h**).



Legend to map and short explanation.

Qs – Sandy soil (beige); sand (::); alluvium (m); calcrete (xx); scree (ΔΔ); high level gravel (○○).

TRct – Fine-grained whitish to pinkish sandstone (pink). Tshipise Formation, Clarens, Karoo Supergroup.

TRcr – Fine-grained, white and red mottled argillaceous sandstone (pink ::). Red Rocks Member, Clarens Formation, Karoo Supergroup.

TRb – Brick-red to purplish mudstone and siltstone (amber). Bosbokpoort Formation, Karoo Supergroup.

TRs – Multi-coloured siltstone, sandstone and mudstone (green). Solitude Formation, Beaufort Group, Karoo Supergroup.

C-Pm – Mudstone, shale, carbonaceous shale, sandstone, conglomerate, coal seams; locally diamictite or conglomerate at the base (grey). Tshidzi Formation, Dwyka Group, Karoo Supergroup.

Zd – (Beige). Mount Dowe Group, Beit Bridge Complex.


Zd
Metaquartzite, minor magnetite quartzite and massive magnetite; leucocratic quartzo-feldspathic gneiss ( ); metapelite ( ); amphibolite, mafic granulite ( ); marble, calc-silicate rocks ( )
Metakwartsiet, ondergeskikte magnetietkwartsiet en massiewe magnetiet; leukokratiese kwarts-veldspaat gneis ( ); metapeliet ( ); amfiboliet, mafiese granuliet ( ); marmer, kalksilikaatgesteentes ( )

Zm – (Orange). Malala Drift Group, Beit Bridge Complex.

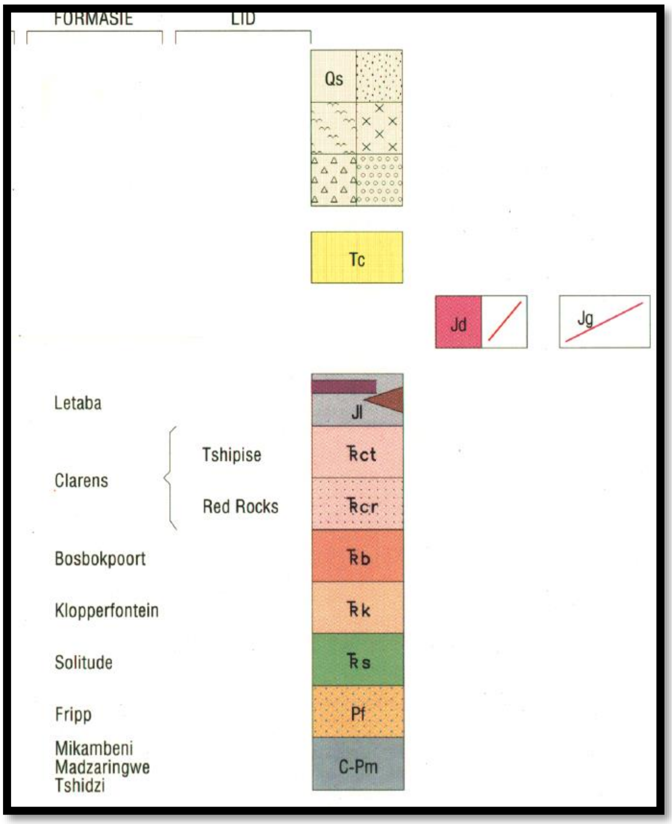
Zm Leucocratic quartzo-feldspathic gneiss, in places garnetiferous; metaquartzite ( ); pink granitoid hornblende gneiss ( ); felsic granulite ( ); metapelite ( ); amphibolite, minor mafic granulite ( ); marble, calc-silicate rocks ( )
Leukokratiese kwarts-veldspaatgneis, plek-plek granaatdraend; metakwartsiet ( ); rooskleurige granietagtige horingblendegneis ( ); felsiese granuliet ( ); metapeliet ( ); amfiboliet, ondergeskikte mafiese granuliet ( ); marmer kalksilikaatgesteentes ( )

-♦- - Vertical foliation.
…… – (black) Lineament (Landsat, aeromagnetic).
------ - Concealed geological boundary.
┴15 – Strike and dip of bed.
□ – Proposed development (overlay).

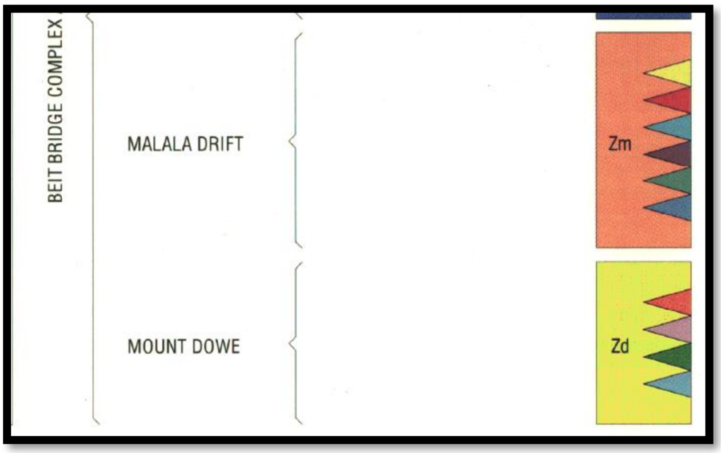
Mining Acticities on Figure above:
DA – Diamond C – Coal.

In the Soutpansberg Coalfield the basal part of the Karoo succession is formed by the Dwyka Group referred to as the Tshidzi Formation (C-Pm). This unit is 5-20 m thick and is composed of blue-grey diamictite and coarse-grained sandstone. This formation is overlain by the Madzaringwe Formation (Hancox and Gőtz 2014). The 1:250 000 geological map of Alldays does not distinguish between the Mikambeni, Madzaringwe and Tshidzi Formation and they are lumped together as C-Pm also including the Fripp Formation. Conglomerates are also present (Kent 1980). It is these two formations (Mikambeni, Madzaringwe) that are mined. The Madzaringwe Formation overlies the Tshidzi Formation of the Dwyka Group consisting of shale, sandstone, siltstone, and coal. It reaches a maximum thickness of 190 m (Kent 1980). Hancox and Gőtz (2014) described the Madzaringwe Formation as comprising of up to 200 m of alternating feldspathic, often cross-bedded sandstone, siltstone and shale containing coal seams. Overlying the Madzaringwe Formation is the Mikambeni Formation with a maximum thickness of 150 m. (20 – 150m) consisting of dark mudstone, shale and subordinate laminated sandstone (Kent 1980, Visser 1989), also predominantly of medium to dark grey siltstone, minor carbonaceous mudstone and khaki-red to grey sandstone. Scattered thin coal seams occur throughout (Hancox and Gőtz 2014). **[Dam, pipelines].**

Figure 4: Northern Karoo Supergroup distribution and lithostratigraphy (Brandl and Pretorius 2000).



Beit Bridge Complex: Malala Drift and Mount Dowe.



Nineteen coalfields are generally recognised in South Africa with four coalfields occurring partly or wholly within the Limpopo Province containing as much as 70% of the remaining coal reserves (Hancox and Gőtz 2014). 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 is gradually overlain by mudstones (and shale) and sandstones of the Volksrust Formation. 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.

Coal in the Soutpansberg Coalfield has coal seams high in vitrinite content and the coal rank steadily increases towards the east as well as to a more limited extent with depth. Ecca rocks are stable and lend themselves well to developments. It is only unstable in or directly above mining activities (Snyman 1996). Dolerite dykes 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 Limpopo Belt consists of granulite, charnocite, orthogneiss, and other volcanic rocks. It is Zwazium in age (>3860 - 2900 Ma) and situated at the bottom of the Geological Time Scale above the Baberton Supergroup. The Limpopo Metamorphic Province is also known as the Limpopo Mobile Belt. It consists of the Sand River Gneiss, Beit Bridge Complex, the Messina Suite and the Bandelierkop Complex. Radiometric age determinations and detailed structural investigations established that the Sand River Gneiss acted as a 'basement' to the overlying Beit Bridge Complex. Dyke-like bodies of tholeiitic composition occurs. The Beit Bridge Complex is subdivided into the Mount Dowe, Malala Drift and Gumbu Groups. The Messina Suite, Singelele Gneiss and Bulai Gneiss lies above the Gumbu Group (Kent 1980). **[Dam, pipelines].**

Field Observations

The Bismarck Project falls within the Karoo Supergroup. The site visit was done in July 2020, conditions were mild and dry. It was possible to access most of the entire property, it is extremely large. The photographs show the flat topography with some mountainous areas. A variety of soil types (overburden and topsoil) will be present. No fossils were found during the walk-through.

Figure 5: View of dam area north. It is covered in thick sands.

Figure 6: View of dam area to the south.

Figure 7: Pipeline route **Preferred**.

Figure 8: View of pipeline route Alternative 2.

Figure 9: View dam at Hunting Lodge.


24/07/2020

Figure 10: View of corner of property in south-west corner where both pipeline routes intersect with the R 572 Road. Also, corner of orchard.

Figure 11: View of orchard, eastern area.

Figure 12: view of orchard. North-western corner. Pipeline route is also present here.

Figure 13: Solitude Formation rocks.

Figure 14: Dwyka Formation rocks.

Figure 14: Bosbokpoort Formation rocks. This photograph was taken on the Weipe Road as example.

There is some concern with the project due to the presence of the Karoo Supergroup rocks and its fossil wealth. 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 if fossils are present.

The project includes two Alternative for the pipeline (Figure 1) and all Alternatives, dam and orchards fall on the Karoo Supergroup rocks and Quaternary sands.
The site is located on either side of the R572 Road with the Limpopo River and border with Zimbabwe to the north. Total size is approximately 700 hectares for the orchards and 250 hectares for the dam.
Alternative 1 Preferred (purple): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.
Alternative 2 (blue): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.

G. Background to Palaeontology of the area (1j).
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).

Fossils may be present in the Quaternary, Beaufort and Ecca Formations, fossils have not been recorded from the Dwyka Group in this region. The Quaternary Formation may contain fossils. A very wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms, and other micro fossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens, within calc tufa. Stromatolite structures range from a centimetre to several tens of metres in size. Mapungubwe is to the north, close to the South African – Zimbabwe border. Mapungubwe has produced the most prolific archaeological gold collection in sub-Saharan Africa. The archaeological site of K2 is also close by. Both these sites are located on the Clarens sandstone (Norman 2013).

Amphibians, non-dinosaurian archosaurs, theropod dinosaurs, dinosaur eggs, therapsids, mammaliaformes, crocodilomorphs, and chelonia make up the fauna of the Elliot and Clarens Formations (Chinsamy-Turan 2012, Groenewald 1986). Most recently, the fossil bones of a plant-eating dinosaur (Highland Giant) have been discovered near the Lesotho border in Clarens and a new species of *Eucnemesaurus* in Aliwal North from the lower Elliot Formation. Aeolonites, belonging to the Jurassic aged Clarens and Tshipise Formations contain petrified logs, trace fossils of insects and dinosaur trackways (possibly *Massospondylus, Syntarsus / Coelophysis*) (Groenewald and Groenewald 2014).

The Beaufort group is characterised by the presence of *Dicroidium* flora and isolated dinosaur remains (Table below).

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).

Trace fossils are relatively abundant in the shales occurring near the top of the Dwyka Group in the southern part of the basin. Lycopods (*Leptophloem australe*) have been described from the northern Free State (Mac Rae 1999). Spores and acritarchs have been reported from the interglacial mudrocks of the Dwyka Group, also spores, pollen, wood, and plant remains in the interbedded mudrocks as well as the diamictite itself, while anthropod trackways and fish trails are present in places on bedding planes (Visser *et al.* 1990). So far fossils have not been recorded form this northern area of the Karoo Supergroup.

Table 1: Taken form The Palaeotechnical Report (Groenewald and Groenewald 2014) (**1cA**).

Aeolian sand, alluvium, colluvium, spring tufa (calcareous) and sinter (siliceous), lake deposits, peats, pedocretes or duricrusts (calcrete, ferricrete), soils, river terrace gravel	Very wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms and other microfossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens Fossil leaves and palynomorphs within calc tufa	Lake Fundudzi is one of few inland lakes in southern Africa- still to be palaeontologically investigated Key palynological studies on peats from Wonderkrater Spring Mound – important information on palaeoclimate and vegetation change over past 20 000 years

TSHIPISE TULI	Bosbokpoort (P-TRkb; bo) Probably Elliot		Red mudrocks and sst with calcareous concretions, minro conglomerates in arid meandering fluvial setting (rarely exposed).	Dinosaur remains – including juveniles - in red siltstones (e.g. Nyalaland, Kruger Park) attributed to several genera including "Euskelesaurus" and Massospondylus (but straitigraphy uncertain). In Tuli Basin small bone fragments in upper red mudrocks that are probably equivalent to the "Euskelesaurus" Range Zone of the L. Elliot Fm	Stratigraphic context of dinosaur fossils often unclear in the literature. Upper Unit P-Trkb in part Red Rocks Member (Elliot Fm).

Solitude (P-TRs; P- s)		Reddish and grey mudrocks, sandstones and minor coals, meandering fluvial setting	Coal floras including *Dicroidium* in basal Solitude succession. Dinosaur remains supposedly recorded from this unit may rather be from the younger Bosbokport Fm (qv)	Upper part possibly Elliot Lower part probably Molteno
Fripp (Pm; Pfr) Prob. Molteno		Braided fluvial sandstones, grits, conglomerates, mudrocks	*Dicroidium* flora in upper part of succession (i.e. Triassic)	

TSHIPISE TULI (Unfidiferentiated Mikambeni and Madzaringwe (C-Jk7))	Mikambeni (Pm; Pmi)		Fluvial / lacustrin mudstones, carbonaceous shales, sandstones, coals.	Diverse Glossopterid coal flora preserved in buff siltstones. Siderite nodules might also be fossiliferous (cf Euamerican Carboniferous Coal Measures)	Historical records of fossil plants along the Sabie River (Kruger Park) in the late 19th Century Probably Ecca Group. Basal Unit Pm (Dwyka Ecca of Main Karoo Basin). Coal Zone of Pm correlated with Vryheid Fm (Middle Ecca) of Main Karoo Basin
	Madzaringwe (Pm; Pma)		Fluvial sandstones with conglomerates, siltstones, shales plus coals	Glossopterid coal flora, including root casts (*Vertebraria*) and root impressions	Ecca equivalent plant fossils include leaves, *Vertebraria* root systems and petrified wood. Probably Ecca Group

TSHIPISE TULI	Tschidzi (Pm; Pts)		Glacial and fluvioglacial diamictite, sandstone.	No fossils recorded to date. Glossopterid coal flora can be expected

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 **MEDIUM** for the Alluvium and Tschidzi Formations; to **VERY HIGH** for the Madzaringwe, Mkambeni, Solitude, Fripp and Bosbokpoort Formations.

Table 2: Criteria used (Fossil Heritage Layer Browser/SAHRA) (**1cB**).

Rock Unit	Significance/vulnerability	Recommended Action
Quaternary (Qs)	**Moderate**	Desktop study
Beaufort Group (TRs)	**Very High**	Field assessment and protocol for finds is required
Ecca Group (Pf)	**Very High**	Field assessment and protocol for finds is required
Dwyka Group (C-Pm)	**Moderate**	Desktop survey
Limpopo Belt	**Very Low**	No action required

Databases and collections: Ditsong: National Museum of Natural History. Evolutionary Studies Institute, University of the Witwatersrand (ESI).

Impact: **VERY HIGH** and **MODERATE**. There are significant fossil resources that may be impacted by the development (shale).

The project includes two Alternatives for the pipeline (Figure 2):

The site is located on either side of the R572 Road with the Limpopo River and border with Zimbabwe to the north. Total size is approximately 700 hectares for the orchards (**VERY HIGH**) and 250 hectares for the dam (**MODERATE**).

Alternative 1 Preferred (purple): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.

Alternative 2 (blue): Runs from the Limpopo River in the north in a southernly direction through a crop field, over the Weipe road, cotton fields, the proposed orchards site, over the R 572 Road, through natural vegetation and ends in the proposed dam site.

The shorter preferred Alternative 1 is also preferred in this report as it is shorter and therefore the impact should be less.

H. Description of the Methodology (1e)

The palaeontological impact assessment field study was undertaken in the July 2020. The walk through of the surrounding portions were done and photographs (in 20 mega pixels) were taken of the site with a digital camera (Canon PowerShot SX620HS). It was not necessary to use a Global Positioning System (GPS) (Garmin eTrex 10) to record outcrops if not covered with topsoil, subsoil, overburden, and vegetation. A literature survey is included and the study relied on literature, geological maps, google.maps, and google.earth images.

SAHRA Document 7/6/9/2/1 requires track records/logs from archaeologists not palaeontologists as palaeontologists concentrate on outcrops which may be recorded on a GPS. Isolated occurrences of rocks usually do not constitute an outcrop. Fossils can occur in dongas, as nodules, in fresh rock exposures, and in riverbeds. Finding fossils require the experience and technical knowledge of the professional palaeontologist, but that does not mean that an amateur can't find fossils. The geology of the region is used to predict what type of fossil and zone will be found in any particular region. Archaeozoologists can be called upon to survey for more recent fossils in the Quaternary and Tertiary deposits.

Assumptions and Limitations (**1e**):-
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. Inaccessibility of site.
7. Insufficient data from developer and exact lay-out plan for all structures (for this report all required data/information was provided).

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 2: 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 3: 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 2 heritage resources. Local authorities identify and manage Grade 3 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 (1f)

The Cenozoic Era, in which we are presently living, is popularly known as the 'Age of the Mammals'. These fossils are preserved on the river gravel terraces (Cornelia), cave systems (Makapan), coastal plains (Langebaanweg), and basins. The Cenozoic Era of South Africa has been subdivided into six African Land Mammal Ages, namely, Recent, Florisian, Cornelian, Makapanian, Langebaanian, and Namibian (MacRae 1999). Magungubwe is located to the north near the South African border with Zimbabwe. A very wide range of possible fossil remains may occur, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms, and other micro fossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens, within calc tufa. Stromatolite structures range from a centimetre to several tens of metres in size. They are the result of algal growth in shallow water, indicating a very rich growth that would have caused an enrichment in the amount of oxygen in the atmosphere (Groenewald and Groenewald 2014).

All Karoo Supergroup geological formations are ranked as **LOW** to **VERY HIGH**, and here the impact is potentially **VERY HIGH** for several Groups. During the Triassic the mammals had advanced and the archosaurs now came into their own. These were crocodile-like, *Coelophysis* was one of the first dinosaurs. Other creatures present were nothosaurs, the first plesiosaurs and ichthyosaurs, and pterosaurs. Amphibians, non-dinosaurian archosaurs, theropod dinosaurs, dinosaur eggs, therapsids, mammaliaformes, crocodilomorphs, and chelonia make up the fauna of the Elliot and Clarens Formations (Chinsamy-Turan 2012, Groenewald 1986). Aeolonites, belonging to the Jurassic aged Clarens and Tshipise Formations contain petrified logs, trace fossils of insects and dinosaur trackways (possibly *Massospondylus, Syntarsus / Coelophysis*) (Groenewald and Groenewald 2014).

The Beaufort group is characterised by the presence of *Dicroidium* flora and isolated dinosaur remains. 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).

Trace fossils are relatively abundant in the shales occurring near the top of the Dwyka Group in the southern part of the basin. Lycopods (*Leptophloem australe*) have been described from the northern Free State (Mac Rae 1999). Spores and acritarchs have been reported from the interglacial mudrocks of the Dwyka Group, also spores, pollen, wood, and plant remains in the interbedded mudrocks as well as the diamictite itself, while anthropod trackways and fish trails are present in places on bedding planes (Visser *et al.* 1990). So far fossils have not been recorded form this northern area of the Karoo Supergroup.

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

J. Recommendation (1o,1p,1q)

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 or if fossils are found during excavating or blasting. The Protocol for Chance Find and Management Plan is attached (Appendix 2) for the ECO.

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

c. Preferred choice: Alternative 1 is preferred, two are proposed with the same impact (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, a 30 m no-go barrier constructed and a palaeontologist should be called in to determine proper mitigation measures.

Sampling and collecting (**1m,1k**):
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: Only if a fossil is unearthed.
d. Permits for mitigation: **SAHRA/PHRA**.

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 AGES Limpopo (Pty) Ltd.
c. Areas that would involve mitigation and may need a permit from the South African Heritage Resources Agency are discussed.
d. 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.
e. 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 (fossils) and adjacent areas as well as for safety and security reasons.

L. Bibliography

ALMOND, J., PETHER, J, and GROENEWALD, G. 2013. South African National Fossil Sensitivity Map. SAHRA and Council for Geosciences.

BRANDL, G. and PRETORIUS, S.J. 2000. Geological Map of Alldays, 2228, 1:250 000. South African Committee for Stratigraphy. Council for Geoscience, Pretoria.

CHINSAMY-TURAN, A. (Ed.) 2012. *Forerunners of Mammals.* Indiana University Press Bloomington and Indiapolis. Pp1330.

DE ZANCHE, V. and MIETTO, P. 1977. *The World of Fossils.* Sampson Low Guides, Berkshire, Printed in Italy, Pp 256.

GRODNER, M. and CAIRNCROSS, B. 2003. A regional scale 3-D model of the Witbank Coalfield, Northern Karoo Basin, South Africa. *South African Journal of Geology,* **106(4):** 249-264.

GROENEWALD, G and GROENEWALD, D. 2014. SAHRA Palaeotechnical Report. Palaeontological Heritage of the Limpopo Province, Pp 24.

HANCOX, P.J. and GőTZ, A.E. 2014. South Africa's coalfields – a 2014 perspective. International Journal of Coal Geology, **132:** 170-254.

JOHNSON, M.R. 2009. Ecca Group. Karoo Supergroup. Catalogue of South African Lithostratigraphic Units. SACS, **10:** 5-7.

KENT, L. E., 1980. Part 1: Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda. SACS, Council for Geosciences, *Stratigraphy of South Africa. 1980. South African Committee for Stratigraphy.* Handbook 8, Part 1, pp 690.

MACRAE, C. 1999.*Life Etched in Stone: Fossils of South Africa.* Geological Society of south Africa, Johannesburg. Pp 305.
MCCARTHY, T and RUBIDGE, B. 2005. *The Story of Earth Life: A southern African perspective on a 4.6-billion-year journey.* Struik. Pp 333.
NORMAN, N. and WHITFIELD, G., 2006. *Geological Journeys.* De Beers, Struik, P 1-320.
PLUMSTEAD, E.P. 1963. The influence of plants and environment on the developing animal life of Karoo times. *South African Journal of Science,* **59(5):** 147-152.
RUBIDGE, B. S. (ed.), 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Biostratigraphy, Biostratigraphic Series No. 1, 46pp. Council for Geoscience, Pretoria.
SG 2.2 SAHRA APMHOB Guidelines, 2012. Minimum standards for palaeontological components of Heritage Impact Assessment Reports, Pp 1-15.
SNYMAN, C. P., 1996. *Geologie vir Suid-Afrika*. Departement Geologie, Universiteit van Pretoria, Pretoria, Volume 1, Pp. 513.
VAN DER WALT, M., DAY, M., RUBIDGE, B. S., COOPER, A. K. & NETTERBERG, I., 2010. Utilising GIS technology to create a biozone map for the Beaufort Group (Karoo Supergroup) of South Africa. *Palaeontologia Africana,* **45:** 1-5.
VISSER, D.J.L. 1984 (ed). Geological Map of South Africa 1:100 000. South African Committee for Stratigraphy. Council for Geoscience, Pretoria.
VISSER, D.J.L. 1989 (ed). *Toeligting: Geologiese kaart (1:100 000). Die Geologie van die Republieke van Suid Afrika, Transkei, Bophuthatswana, Venda, Ciskei en die Koningkryke van Lesotho en Swaziland*. South African Committee for Stratigraphy. Council for Geoscience, Pretoria.
WATKEYS, M.K.1981. Provincial Geological Map of The Limpopo Belt and Environs, 1: 100 000. Geological Surveys of Botswana, South Africa and Zimbabwe; Universities of Leeds, the Witwatersrand, and Zimbabwe; Rand Afrikaans University.

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.

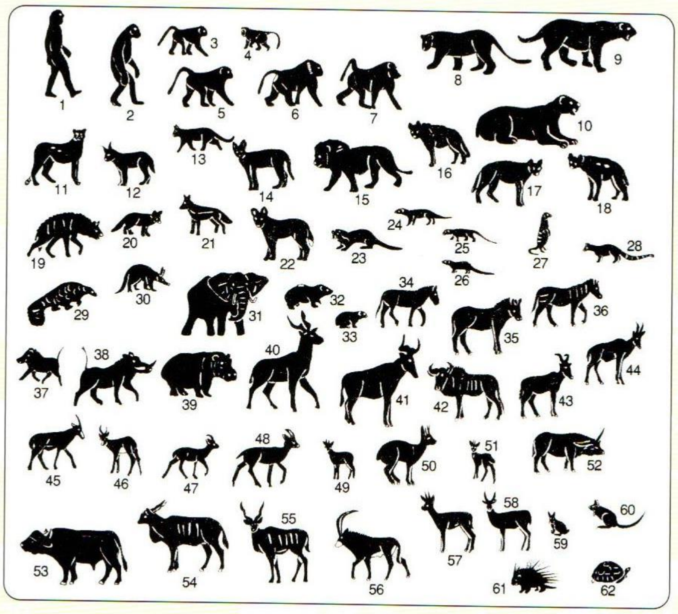
I accept no liability, and the client, by receiving this document, indemnifies me against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by the use of the information contained in this document.

It may be possible that the Phase 1 PIA: Field 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.

Heidi Fourie
2020/08/28

Appendix 1: Examples of quaternary fossils (MacRae 1999).



Silhouette representation of the larger vertebrates whose remains are represented in Members 1-3 of the Swartkrans site on the outskirts of the town of Krugersdorp. Numbers after each taxon comprise minimum numbers of individuals represented in the remains of the lower bank (Member 1), hanging remnant (Member 1), Member 2 and Member 3 respectively.
Courtesy of Dr C.K. Brain.
Museum of Natural History, Pretoria

FAUNA FROM MEMBERS 1 - 3, SWARTKRANS (Makapanian Mammal Age)
Courtesy Dr B. Brain, - Museum of Natural History, Pretoria

1: *Homo erectus* (man) 1,3,2,0. **2**: *Australopithecus robustus* (robust apeman) 13,87,17,9. **3**: *Parapapio jonesi* 0,8,0,0. **4**: *Cercopithecoides* sp. 1,0,0,0. **5**: *Papio hamadyryas robinsoni* 6,38,8,11. **6**: *Theropithecus oswaldi danieli* 1,17,1,14. **7**: *Dinopithecus ingens* 1,26,0,0. **8**: *Panthera pardus* (leopard) 4,12,2,5. **9**: *Dinofelis* sp. (false sabre-toothed cat) 0,1,0,0. **10**: *Megantthereon* sp. (dirk-toothed cat) 0,1,0,1. **11**: *Acinonyx jubatus* (cheetah) 0,1,0,1. **12**: *Felis caracal* (caracal) 1,0,0,0. **13**: *Felis lybica* (African wild cat) 0,0,0,1. **14**: *Felis serval* (serval) 1,0,0,0. **15**: *Panthera leo* (lion) 1,1,0,0. **16**: *Hyaena brunnea* (brown hyaena) 1,4,2,3. **17**: *Chasmaporthetes nitidula* (hunting hyaena) 2,8,1,2. **18**:*Crocuta crocuta* (spotted hyaena) 0,2,1,1. **19**: *Proteles* sp. (large fossil aardwolf) 1,1,0,1. **20**: *Vulpes* sp. (fox) 0,2,0,3. **21**: *Canis mesomelas* (black-backed jackal) 3,4,4,5. **22**: Large canid gen. and sp. indet. 0,0,1,1. **23**: *Aonyx capensis* (Cape clawless otter) 2,0,1,2. **24**: *Atilax* sp. (water mongoose) 0,0,1,1. **25**: *Cynictis penicillata* (yellow mongoose) 0,0,1,1. **26**: *Herpestes ichneumon* (large grey mongoose) 1,0,0,0. **27**: *Suricata suricatta* (suricate) 0,0,2,1. **28**: *Genetta tigrina* (large-spotted genet) 0,0,0,1. **29**: *Manis* sp. (pangolin) 0,0,0,1. **30**: *Orycteropus afer* (antbear) 1,0,1,1. **31**: cf. *Elphas* sp. 2,0,0,1. **32**: *Procavia transvaalensis* (large fossil dassie) 3,8,3,5. **33**: *Procavia antiqua* (fossil dassie) 17,16,10,11. **34**: *Hipparion lybicum steytleri* (three-toed horse) 1,1,1,1. **35**: *Equus capensis* (giant Cape horse) 2,6,3,5. **36**: *Equus burchelli* (Burchell's zebra) 0,0,0,1. **37**: *Phacochoerus* sp. (warthog) 1,0,3,1. **38**: cf. *Tapinochoerus meadowsi* (large fossil pig) 1,7,1,1. **39**: *Hippopotamus* sp. (hippopotamus) 1,0,0,1. **40**: Giraffid 0,1,1,1. **41**: *Megalotragus* sp. (giant hartebeest) 0,3,1,3. **42**: *Connochaetes* sp. (wildebeest) 7,19,7,7. **43**: Medium alcelaphine: *Alcelaphus* sp. or *Beatragus* sp. (hartebeest) 3,22,3,6. **44**: *Rabaticerus porrocornutus* 0,2,0,0. **45**: *Damaliscus* sp. (blesbok) 2,4,6,6. **46**: *Antidorcas marsupialis australis* (springbok) 11,0,10,18. **47**: *Antidorcas recki* 0,6,2,1. **48**: cf. *Gazella* sp. (gazelle) 5,6,5,14. **49**: *Oreotragus oreotragus* (klipspringer) 1,0,0,1. **50**: *Oreotragus major* (fossil klipspringer) 0,1,0,0. **51**: *Raphicerus campestris* (steenbok) 1,0,1,3. **52**: *Makapania* sp. (musk ox) 0,3,0,0. **53**: *Syncerus* sp. (buffalo) 2,3,2,3. **54**: *Taurotragus oryx* (eland) 0,0,1,1. **55**: *Tragelaphus strepsiceros* (kudu) 0,4,0,1. **56**: *Hippotragus* cf. *niger* (sable) 0,0,1,3. **57**: *Pelea* sp. (rhebck) 0,2,0,2. **58**: *Redunca arundinum* (reedbuck) 0,1,0,0. **59**: Lagomorph gen. and sp. indet. (hare) 9,0,4,7. **60**: *Pedetes* sp. (springhare) 1,0,1,1. **61**: *Hystrix africaeaustralis* (porcupine) 2,2,1,2. **62**: *Chelonia* indet. (tortoise) 1,0,2,2.

Left: Teeth of the white rhino *Ceratotherium simum* from Makapansgat. **Right**: View from above shows the sharp cutting edges of the tooth row of this predominant grazer. Specimen 170 mm long.
In the collection of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg.
Photograph C.S. MacRae

Appendix 2 (**1k,1l,1m**): **Protocol for Chance 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. As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to oversee the construction activities in line with the legally binding Environmental Management Programme (EMPr) so that when a fossil is unearthed they can notify the relevant department and specialist to further investigate. Therefore, the EMPr must be updated to include the involvement of a palaeontologist during the digging and excavation (ground breaking) phase of the development or pre-construction training of ECO.

The EMPr already covers the conservation of heritage and palaeontological artefacts that may be exposed during construction activities:

- The protocol is to immediately cease all construction activities if a fossil is unearthed and contact SAHRA for further investigation.
- The area must be fenced-off with a 30 m barrier and the construction workers must be informed that this is a no-go area.
- If fossils were found, they must be placed in a safe area for further investigation.
- The ECO should familiarise him- or herself with the fossiliferous formations and its fossils.
- A site visit is recommended after digging, blasting, drilling or excavating and the keeping of a photographic record.
- Most Museums and some Universities have good examples of Fossils.
- The developer may be asked to survey the areas affected by the development and indicate on plan where the construction / development / planting will take place. Trenches may 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.

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. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work.
3. 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.
4. 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.
5. 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.
6. 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).
7. 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. Use 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 is 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 Documents:
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: Table of Appendix 6 requirements.

Section in Report	Point in Act	Requirement

B	1(c)	Scope and purpose of report
B	1(d)	Duration, date and season
B	1(g)	Areas to be avoided
D	1(ai)	Specialist who prepared report
D	1(aii)	Expertise of the specialist
F Figure 3	1(h)	Map
B	1(ni)(niA)	Authorisation
B	1(nii)	Avoidance, management, mitigation and closure plan
G Table 1	1(cA)	Quality and age of base data
G Table 2	1(cB)	Existing and cumulative impacts
D	1(f)	Details or activities of assessment
G	1(j)	Description of findings
H	1(e)	Description of methodology
H	1(i)	Assumptions
J	1(o)	Consultation
J	1(p)	Copies of comments during consultation
J	1(q)	Information requested by authority
Declaration	1(b)	Independent declaration
Appendix 2	1(k)	Mitigation included in EMPr
Appendix 2	1(l)	Conditions included in EMPr
Appendix 2	1(m)	Monitoring included in EMPr
D	2	Protocol or minimum standard