Proposed Phase 2 Upgrade and Expansion of a Bulk Water Supply Pipeline in Nigel, Gauteng

Ekurhuleni Metropolitan Municipality, Gauteng Province

Farm: Portion 0 (RE), 1, 9 and 42 of Grootfontein 165-IR, Erf 2 of The Township Prosperita, Portion 28 of Draaikraal 166-IR, Portion 10, 18, 36, 61 and 75 of Varkensfontein 169-IR, and Erf 3, 4, 6, 83, 453, 1486 and 1531 of The Township Glenvarloch

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***Palaeontological Impact Assessment: Phase 1 Field Study***

Commissioned by: Exigo Sustainability (Pty) Ltd

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Ref: GAUT 0002/18-19/E0237

2019/09/19

**B. Executive summary**

Outline of the development project: Exigo Sustainability (Pty) Ltd has facilitated the appointment of Dr H. Fourie, a palaeontologist, to undertake a Palaeontological Impact Assessment (PIA), Phase 1 Field Study of the proposed Phase 2 Upgrade and Expansion of a Bulk Water Supply Pipeline in Nigel, Gauteng in the Ekurhuleni Metropolitan Municipality, Gauteng Province on Portion 0 (RE), 1, 9 and 42 of the Farm Grootfontein 165-IR, Erf 2 of The Township Prosperita, Portion 28 of the Farm Draaikraal 166-IR, Portion 10, 18, 36, 61 and 75 of the Farm Varkensfontein 169-IR, and Erf 3, 4, 6, 83, 453, 1486 and 1531 of The Township Glenvarloch

The applicant, Lamela Consulting (Pty) Ltd intends to upgrade and expand the existing bulk water pipeline providing water to the Nigel area from the Dunotter reservoir.

The Project includes one Alternative (Figure 2):
Alternative 1: The pipeline route is outlined in white, 4.2 km in a north-south direction from the existing reservoir at Dunotter, southwards and 1.2 km in an east-west direction along the R 42 Road. The approximate length of the pipeline is approximately 5.6 km.

**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.

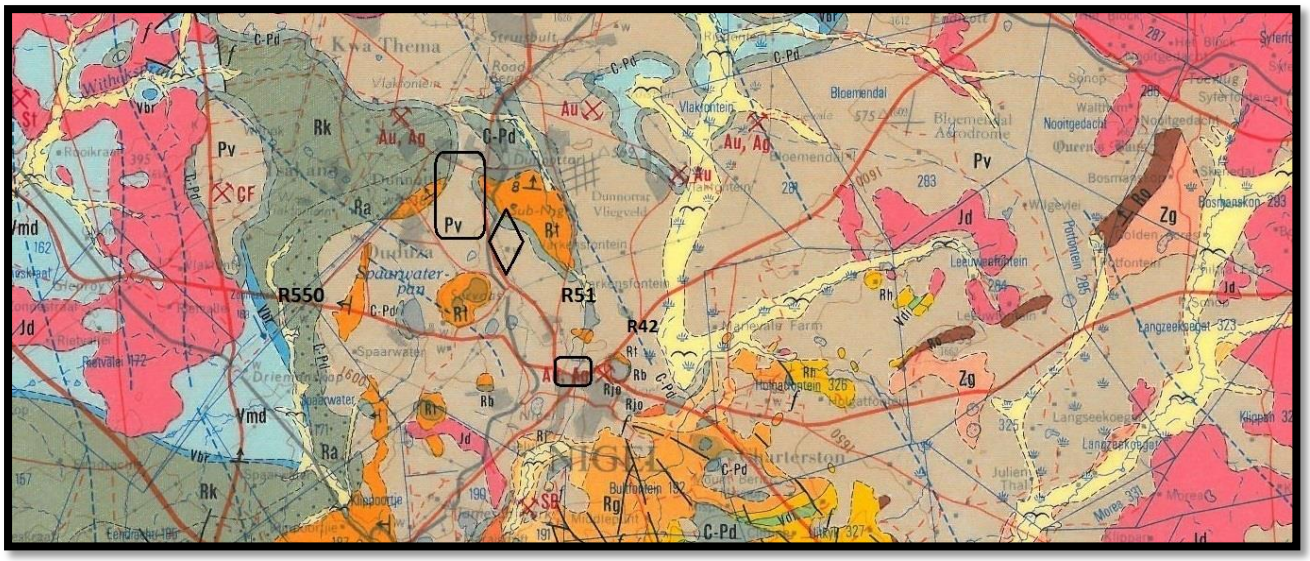
Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):
(i) (i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens.
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 project 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, 2628 East Rand (Keyser *et al.* 1986).

**Figure 3:** The geology of the development area.




*Legend to map and short explanation.*
Jd – (pink) Dolerite (Jurassic).
Pv – Sandstone, shaly sandstone, grit, shale, conglomerate and coal near base and top (brown). Vryheid Formation, Ecca Group, Karoo Supergroup. Permian.
C-Pd – Diamictite, shale (grey). Dwyka Group, Karoo Supergroup. Carboniferous.
Rk – Basaltic lava, agglomerate, tuff (green). Klipriviersberg Group, Ventersdorp Supergroup. Randian.
Ra – Feldspar porphyry (green). Alberton Formation, Klipriviersberg Group, Ventersdorp Supergroup. Randian.
Rt – Quartzite, conglomerate, sandy shale (orange). Central Rand Group, Witwatersrand Supergroup. Randian.
------ – (blue) Lineament (Landsat, aeromagnetic).
------ - Concealed geological boundary.
⊥8 – Strike and dip of bed.
□ – Proposed development in middle of blocks (blocked in black).

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 (Appendix 1). 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 with the fossils 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.

*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**, and here locally **VERY HIGH** for the Vryheid Formation, **MODERATE** for the Dwyka Group, **LOW** for the Ventersdorp Supergroup and **VERY LOW** for the Witwatersrand Supergroup (SG 2.2 SAHRA APMHOB, 2012).

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).

Summary of findings (**1d**): The Phase 1 Palaeontological Impact Assessment: Field Study was undertaken in September 2019 in the summer in mild and dry conditions and the following is reported:

*Field observation* – The pipeline area is easily accessible, a gravel road is present in the south (middle block) next to the railway line. The northern part will run through vacant land towards the reservoir. During the survey, it was found that the pipeline will be installed mostly on the Vryheid Formation, but the Dwyka Group, Ventersdorp Supergroup and Witwatersrand Supergroup are also present on the northern perimeter of the project area. It is located on a fairly flat topography. The area is covered by overburden, vegetation, grass, wetland, and other land uses include roads. Fossils were not found during the walk through and drive through. Outcrops are present as isolated rocks and it is only representative of the Vryheid Formation.

The Project includes one Alternative (Figure 2):
Alternative 1: The pipeline route is outlined in white, 4.2 km in a north-south direction from the existing reservoir at Dunotter, southwards and 1.2 km in an east-west direction along the R 42 Road. The approximate length of the pipeline is approximately 5.6 km.

The pipe line will be situated on the Vryheid Formation. One Alternative is proposed.

Recommendation:
The potential impact of the development on fossil heritage is **VERY HIGH** for the Vryheid Formation and therefore a field survey was necessary for this development (according to SAHRA protocol). A Phase 2 PIA and or mitigation are generally only recommended if the Phase 1: Field Study finds fossils or fossils are found during construction excavations and blasting (plants).

Concerns/threats (**1g,1ni,1nii,1o,1p**) 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, 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:

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 blasting, drilling or excavating.
4. The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction 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 (pre-construction training of ECO) during the digging and excavation phase of the development.

Stakeholders: Developer – Lamela Consulting (Pty) Ltd.
Environmental – Exigo Sustainability (Pty) Ltd, Postnet Suite 74, Private Bag X04, Menlo Park, 0102, Tel. 012 751 2160.
Landowner – N/a.

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**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.

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, Lamela Consulting (Pty) Ltd intends to upgrade and expand the existing bulk water pipeline providing water to the Nigel area from the Dunotter reservoir. The existing pipeline will be upgraded to a 710 mm high-density polyethylene (HDPE) class 12.5 PE100 line and steel pipes with a diameter of 600 mm will also be installed. The peak output of the bulk water supply will increase to 500 litres per second at a velocity of 1.7 m/s. It is important to note that a section of the proposed pipeline has already been installed as part of Phase 1 of the pipeline development and therefore, the proposed project will entail Phase 2 which will complete the remainder of the pipeline.

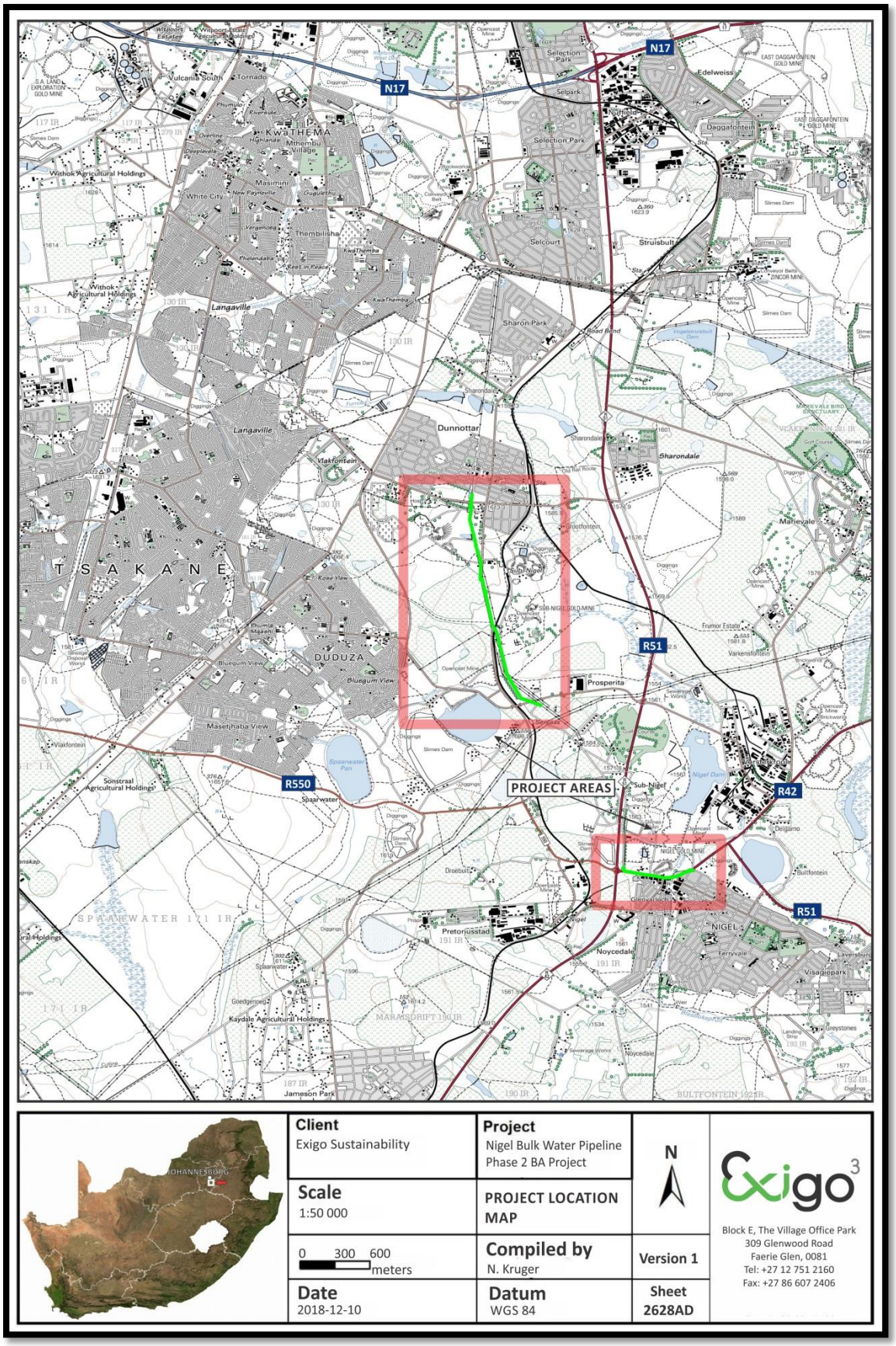
Furthermore, Phase 2 of the proposed project will commence in two segments namely, Phase 2 Part 1 spanning over 1296 m and Phase 2 Part 2 spanning over 4325 m. The proposed pipeline will be in a road reserve for part of the way, but will also cross vacant land in some areas.

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 (maintenance of pipeline).

Related infrastructure:

1. Pipes,
2. Culverts.

**Figure 1:** Lay-out plan (Exigo)




The Project includes one Alternative (Figure 2):

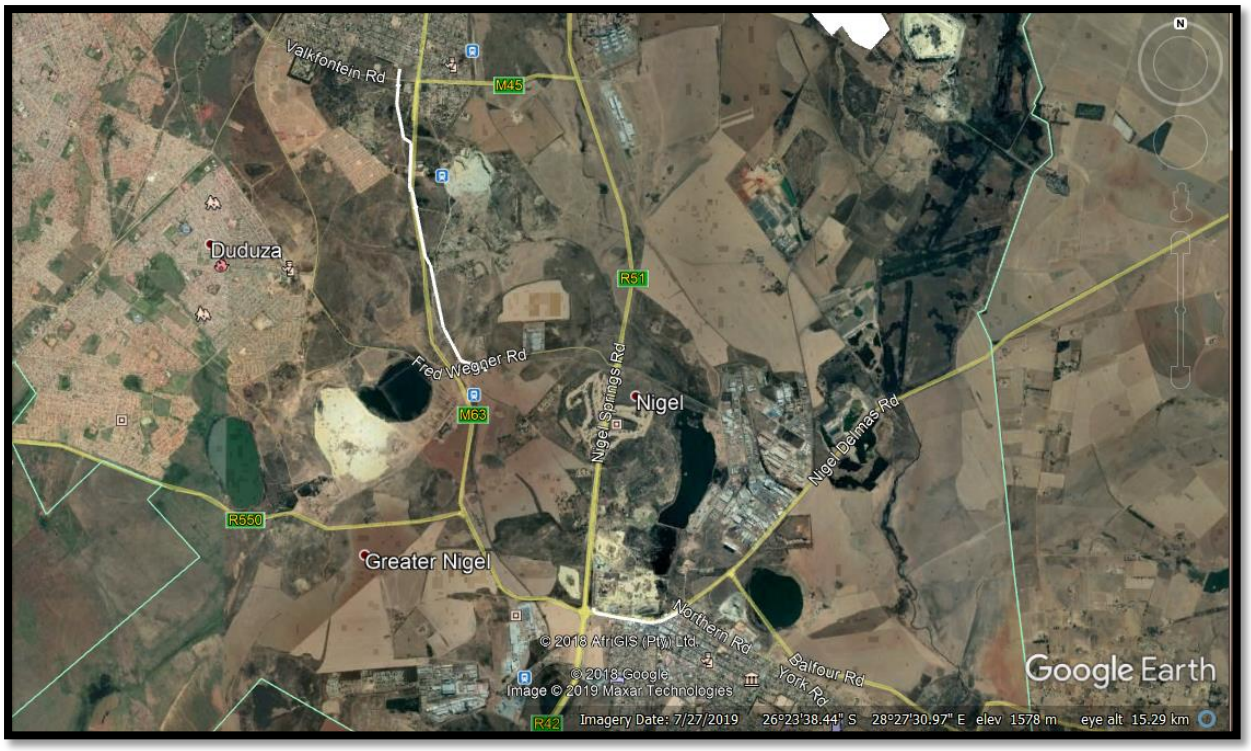
Alternative 1: The pipeline route is outlined in white, 4.2 km in a north-south direction from the existing reservoir at Dunotter, southwards and 1.2 km in an east-west direction along the R 42 Road. The approximate length of the pipeline is approximately 5.6 km.

Rezoning or subdivision of land: No.
Name of developer and consultant: Lamela Consulting (Pty) Ltd and Exigo Sustainability (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:* 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. She is currently employed by Ditsong: National Museum of Natural History as Curator of the fossil plant, invertebrate, amphibian, fish, reptile, dinosaur and Therapsid collections. For the past 13 years she carried out field work in the Eastern Cape, Western Cape, North West, Northern Cape, 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 25 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 Phase 2 Upgrade and Expansion of a Bulk Water Supply Pipeline in Nigel, Gauteng will be situated in Ekurhuleni Metropolitan Municipality, Gauteng Province on Portion 0 (RE), 1, 9 and 42 of the Farm Grootfontein 165-IR, Erf 2 of The Township Prosperita, Portion 28 of the Farm Draaikraal 166-IR, Portion 10, 18, 36, 61 and 75 of the Farm Varkensfontein 169-IR, and Erf 3, 4, 6, 83, 453, 1486 and 1531 of The Township Glenvarloch

Depth is determined by the related infrastructure to be developed and the thickness of the formation in the development area as well as depth of the foundations, footings and channels to be developed. 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. Depth of the overburden may vary a lot. Geological maps do not provide depth or superficial cover, it only provides mappable surface outcrops. The depth can be verified with test pit results or drill cores.

**Figure 2:** Location map (Exigo).

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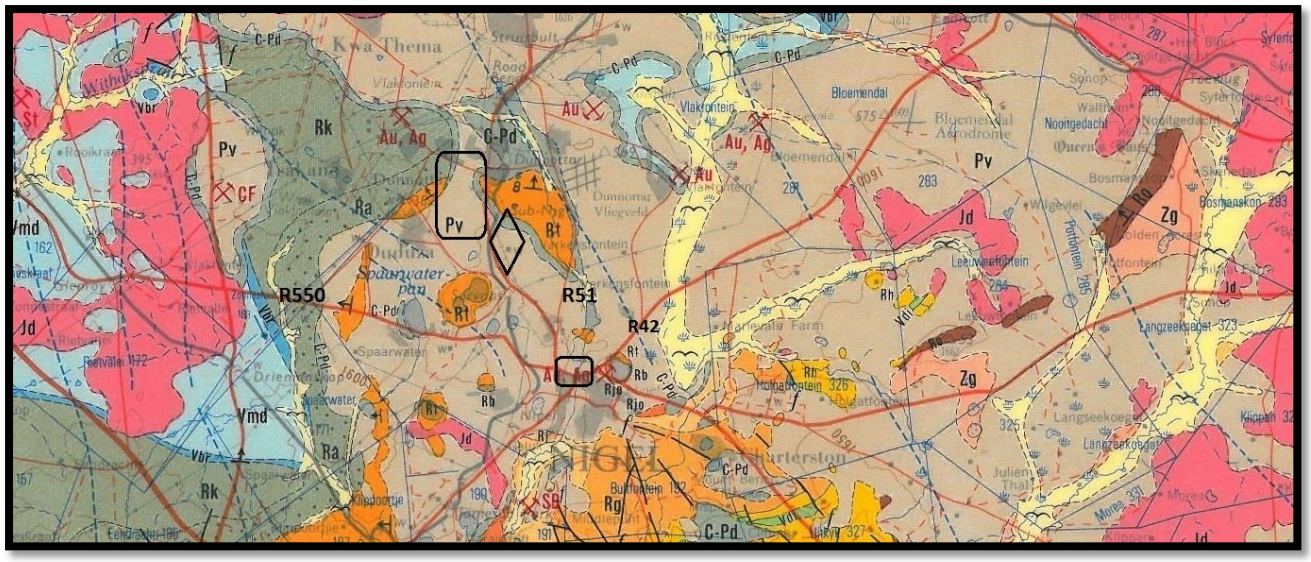
**F. Description of the Geological Setting**

Description of the rock units:

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.

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 2628 East Rand (Keyser *et al.*1986).




*Legend to map and short explanation.*

Jd – (pink) Dolerite. Jurassic.

Pv – (brown) Sandstone, shaly sandstone, grit, shale, conglomerate and coal near base and top. Vryheid Formation, Ecca Group, Karoo Supergroup. Permian.

C-Pd – Diamictite, shale (grey). Dwyka Group, Karoo Supergroup. Carboniferous.

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Rt – Quartzite, conglomerate, sandy shale (orange). Central Rand Group, Witwatersrand Supergroup. Randian.

------ – (blue) Lineament (Landsat, aeromagnetic).

------ - Concealed geological boundary.

⊥8 – Strike and dip of bed.

□ – Proposed development in middle of blocks (blocked in black).

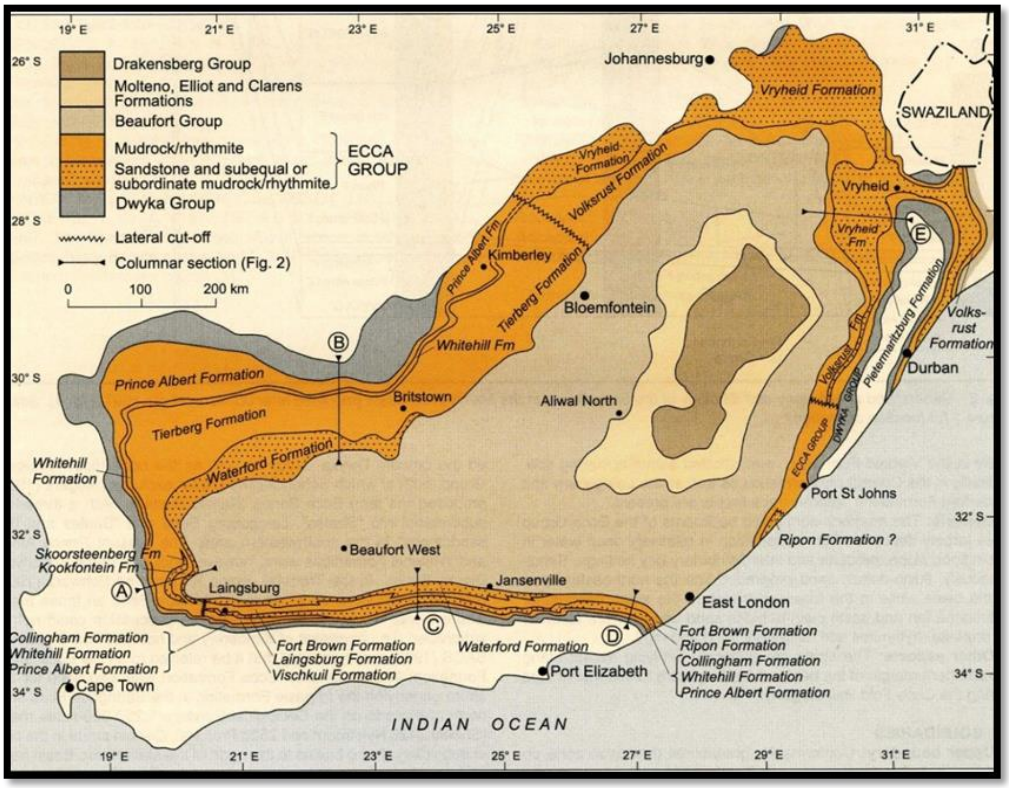
Mining Activities on Figure:

Ag – Silver Au – Gold.

The mining past and present has no influence on the development.

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).

**Figure 4:** Karoo Supergroup distribution and lithostratigraphy (Johnson 2009).




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.

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 partly situated on the flat-lying Vryheid Formation, Ecca Group, Karoo Supergroup. 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 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 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 Dwyka Group is the lowermost unit of the Karoo Supergroup overlain by the Ecca Group and underlain by the Witteberg Group, Bokkeveld or Table Mountain Groups and various other groups. It ranges in age from Late Carboniferous to early Permian. Clastic rocks containing diamictite, varved shale, conglomerate, pebbly sandstone and mudrock are present. The rocks display features reflecting a glacial and glacially-related origin.

Fossils are present (Kent 1980, Visser *et al.* 1990). Thickness varies between 100-800 m (Visser *et al.* 1990). As Gondwana drifted northward the first sediments to be deposited would have been the Dwyka. As the glaciers melted they left striations on the surface also vast quantities of mud and large fragments of rock which formed the characteristic, poorly sorted Dwyka tillite (McCarthy and Rubidge 2005). Visser *et al.* (1990) proposed two subdivisions for the Dwyka Group in the main Karoo basin, the Elandsvlei and Mbizane Formations. In the far north, the Tshidzi and Wellington Formations also form part of the Dwyka Group.

A volcanic event that started 2,714 million years ago is responsible for the Klipriviersberg Group of the Ventersdorp Supergroup, further eruptions of basalt and rhyolite formed the Platberg Group (McCarthy and Rubidge 2005). The Ventersdorp Supergroup consists mainly of andesitic lava, tuff and agglomerate. The Klipriviersberg Group and the Platberg Group are Randian in age, where the Rietgat Formation is Vaalian in age (Sheet information 2626 Wes Rand). The Ventersdorp Supergroup sits disconformably on the Witwatersrand Supergroup and is made up of the lower Klipriviersberg Group, the middle Platberg Group, and two formations (Bothaville and Allanridge). Together it can reach a maximum thickness of 4,260 m in some areas. The Klipriviersberg Group comprises the Edenville, Westonarea, Alberton and Orkney Formations. Several formations make up the Platberg Group, the Kameeldoorns, Makwassie, Rietgat, Bothaville and Allanridge (Kent 1980). It is described as an elliptical basin named after the town of Ventersdorp. Sediments accumulated in fault-bounded troughs or grabens and gold can be present (Norman and Whitfield 2006).

The Witwatersrand Supergroup is famous for its gold-bearing conglomerates and is divided into the Central Rand Group and the West Rand Group (Kent 1980). This 7500 m thick lithostratigraphic unit consists of quartzite, shale and conglomerate (Snyman 1996). The Witwatersrand Supergroup is divided into two groups based on differing types and proportions of sedimentary strata. The basin is oval-shaped running from northeast to southwest. The lower West Rand Group containing shale, sandstone and minor conglomerate layers, the upper CentralRand Group containing quartzite and minor shale, as well as most of the gold-rich 'reefs' (Norman and Whitfield 2006).

The upper Central Rand Group is further subdivided into the Turffontein and Johannesburg Subgroups (Johnson 2006). The Turffontein Subgroup (Rt) comprises the Kimberley (quartzites, conglomerates), Elsburg (quartzite) and Mondeor (conglomerate) Formations. The Maraisburg Quartzite Formation, Main Conglomerate Formation, Langlaagte Quartzite Formation, Johnstone Conglomerate Formation, Livingstone Conglomerate Formation, Randfontein Quartzite Formation, Luipaardsvlei Quartzite Formation, Bird Conglomerate Formation, Krugersdorp Quartzite Formation, and Booysens Shale Formation are all present in the Johannesburg Subgroup (Rjo). At the top lies the Ventersdorp Supergroup (Johnson 2006, Kent 1980, Visser 1989).

Johnson (2006) revised the subdivision of the Johannesburg Subgroup and only recognised the Blyvooruitzicht Formation at the base; the Main Formation with the Main Reef, Carbon Leader, and Main Reef Leader; Randfontein Formation; Luipaardsvlei Formation; Krugersdorp Formation and the Booysens Formation at the top. The Turffontein Subgroup is Randian in age (2,300-2,800 Ma) and consists of quartzite, conglomerate and sandy shale (Kent, 1980; Visser, 1989). There is a presence of mining past and present in the area.

The West Rand Group is subdivided into the Hospital Hill, Government and Jeppestown Subgroups. The Government Subgroup (Rg) differs from the Hospital Hill Subgroup in that the quartzites are subgraywackes rather than orthoquartzites and in that the ferruginous shales are rather more magnetic. This Subgroup comprises the Promise Diamictite, the Coronation Shale, Tusschenin Quartzite, Palmiet shale and quartzite, Elandslaagte Quartzite, and Afrikander shale and quartzite Formations (Johnson 2006, Kent 1980, Visser 1989).

**Field Observations**

The pipeline area is easily accessible, a gravel road is present in the south (middle block) next to the railway line. The northern part will run through vacant land towards the reservoir. During the survey, it was found that the pipeline will be installed mostly on the Vryheid Formation, but the Dwyka Group, Ventersdorp Supergroup and Witwatersrand Supergroup are also present at the northern perimeter of the project. It is located on a fairly flat topography. The area is covered by overburden, vegetation, grass, watercourse, and other land uses include roads. Fossils were not found during the walk through and drive through. Outcrops are present as isolated rocks and only represented the Vryheid Formation.

**Figure 5:** Water pipeline in the south, this section runs in the Central Business District area along the R42 Road.


**Figure 6:** The pipeline will be installed on the road reserve.


**Figure 7:** View of area in the south at Prosperita.


**Figure 8:** Isolated rocks present in the south next to the gravel road. Only the Vryheid Formation was found as outcrops.


**Figure 9:** View of area where the pipeline will cross the M63 Motorway.


**Figure 10:** View of area where pipeline will be following the Nigel-Dunotter Road on the road reserve.


**Figure 11:** Area with watercourse, last section before pipeline crosses the Dunotter Aerodrome (M45) Motorway to the reservoir.


**Figure 12:** Dunotter reservoir in the north.

There is some concern with the project due to the presence of the Vryheid Formation. 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 one Alternative (Figure 2)
Alternative 1: The pipeline route is outlined in white, 4.2 km in a north-south direction from the existing reservoir at Dunotter, southwards and 1.2 km in an east-west direction along the R 42 Road. The approximate length of the pipeline is approximately 5.6 km.
Alternative 1: Will avoid sensitivities on site.
Alternative 2: Incorporate conservation measures for graves.

**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).

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. 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).
Cyanobacteria have been described from the gold bearing conglomerates of the Witwatersrand Supergroup (MacRae 1999). These are significant recordings as it gives a possible indication of very early life forms, possibly

ancient lichens that existed up to 2900 million years ago. These structures are for example associated with the Carbon Leader Seam in the Carletonville Goldfield, with native gold visible to the naked eye. Very large stromatolites can be found in the Campbell Rand Subgroup in the North West Province (Groenewald and Groenewald 2014).

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

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| KAROO | ECCA (P; Pe) (Undifferentiated) | | Vryheid (Pv) | | Deltaic sandstones, shales and coals, with minor conglomerates<br><br>Early to Middle Permian | Rich assemblages of plant fossils (Glossopteris Flora), including tree trunks, stumps and roots, palynomorphs, rare insects, conchostracans, low diversity trace fossil assemblages. Very rich and historically important plant fossil collections from Vryheid Formation at Vereeniging | N.B. Important plant fossils has the Lawley may be equivalent to the Late Permian Estcourt Formation (i.e. Upper Ecca or Lower Beaufort Group) rather than the Middle Ecca, but are mapped as Vryheid Formation. |
| | DWYKA (C-Pd) | | Probably Mbizana | | Glacial to fluvioglacial diamictites, conglomerates, sandstones, shales<br>Late Carboniferous to Early Permian in age | Possibility of interglacial or post-glacial trace fossil assemblages, fossil plants, shelly invertebrates – but these fossils not yet recorded from Gauteng | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| VENTERSDORP | PLATBERG (R-Vp) | | Ra; Rb; Rm; Rma; Rgb; Rka; Rkm; Rka1; Rka2 | | Basic and acid volcanics with subordinate siliciclastic sediments (breccias, conglomerates, sandstones, mudrocks), with minor limestones and cherts in upper part of succession<br>Late Archaean<br>Randian 2.7-2.5 | Lacustrine stromatolites and possible microfossils. | Fossils recorded from sediments of Platberg Group elsewhere (Northern Free State) and therefore might also be present in Gauteng |
| | | | Rietgat (Rr; Rrg; Rrg2) | | Predominantly lavas with minor metasediments (fluvial and lacustrine conglomerates, breccias, minor shales, stromatolitic carbonates, cherts) | Lacustrine stromatolites reported in carbonates,of Rietgat Formation (Platberg Group); possible organic-walled microfossils in cherts. LIP (Large Igneous Province) with voluminous eruptions of basaltic and other lavas. | Stromatolites recorded from borehole cores. Any surface occurrences would be of considerable interest. |
| | | | Rm; Rgb; Rkm | | | Possible stromatolites | |
| | KLIPRIVIERSBERG (Rk) | | Ra; Rw; Ral; Rwe; | | Basic and acid volcanics with subordinate siliciclastic sediments | No fossils recorded | |
| WITWATERSRAND (Rw) | CENTRAL RAND | Turffontein (Rt) | Klerksdorp (Rkl) Elsburg (Re) | | Mainly quartzites conglomerates (braided fluvial), pyritic sands, minor shales, volcanics, debris-flow diamictites | Thin layers of carbonaceous material (kerogen / bitumen) possibly represent ancient microbial mats, but this material probably has an abiogenic origin (e.g. precipitation of inorganic carbon due to irradiation by radioactive uranium minerals) Main source of Wits gold (beds of quartzose, pyritic fluvial conglomerates or "banket" that are known as "reefs") Evidence for earliest known glaciations on Earth (Government Subgroup (Rg) Archaean / Randian c. 2.9-2.7 Ga | |
| | | | Booyens (Rbo) | | Shale | | |
| | | Johannesburg (Rjo) | | | Mainly quartzites conglomerates (braided fluvial), pyritic sands, minor shales, volcanics, debris-flow diamictites | | |
| | WEST RAND | Rj; Rg; Rh | Rc; Ro | | Marine shelf quartzites, shales, rare conglomerates, banded iron formation (BIF), volcanics, fluvial sediments, several diamictites | | |

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.

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

| Rock Unit | Significance/vulnerability | Recommended Action |
|---|---|---|
| Vryheid Formation (Pv) (Pe) | **Very High** | Field assessment and protocol for finds is required |
| Dwyka Group (C-Pd) | **Moderate** | Desktop assessment is required |
| Klipriviersberg Group | **Low** | Protocol for Finds |
| Central Rand Group | **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).

**H. Description of the Methodology (1e)**

The palaeontological impact assessment field study was undertaken on 11 and 18 September 2019. The walk through and drive through of the affected portion were done and photographs (in 20 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 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.

Outcrops were found, but no fossils. 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. An archaeozoologist can be called upon to survey for more recent fossils in the Quaternary and Tertiary deposits, if present.

Assumptions and Limitations (**1i**):-

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)**

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 and **MODERATE** for the Dwyka 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 occur also in other parts of the Karoo stratigraphy. 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. The pollen of the Greenside Colliery near Witbank also on the Vryheid Formation was the focus of a Ph.D study. 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 (Vryheid Formation) provides palaeontologists with fantastic access to coal-associated plant fossils, while simultaneously resulting in the destruction of important National Palaeontological Heritage.

The threats to the National Palaeontological Heritage 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.

**J. Recommendation (1j,1l)**

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** and **MODERATE**. 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 construction excavations and blasting. Fossils were not found during the walk through. The Protocol for Chance Finds and Management Plan is attached (Appendix 2) for the ECO.
b. This project will benefit the environment, economy, and social development of the community.
c. Preferred choice: Two Alternatives are presented, both 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 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 Exigo Sustainability (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.

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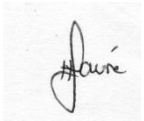
**Declaration (disclaimer) 1(b)**

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
2019/09/19

Appendix 1: Examples of Vryheid Formation fossils (MacRae 1999).

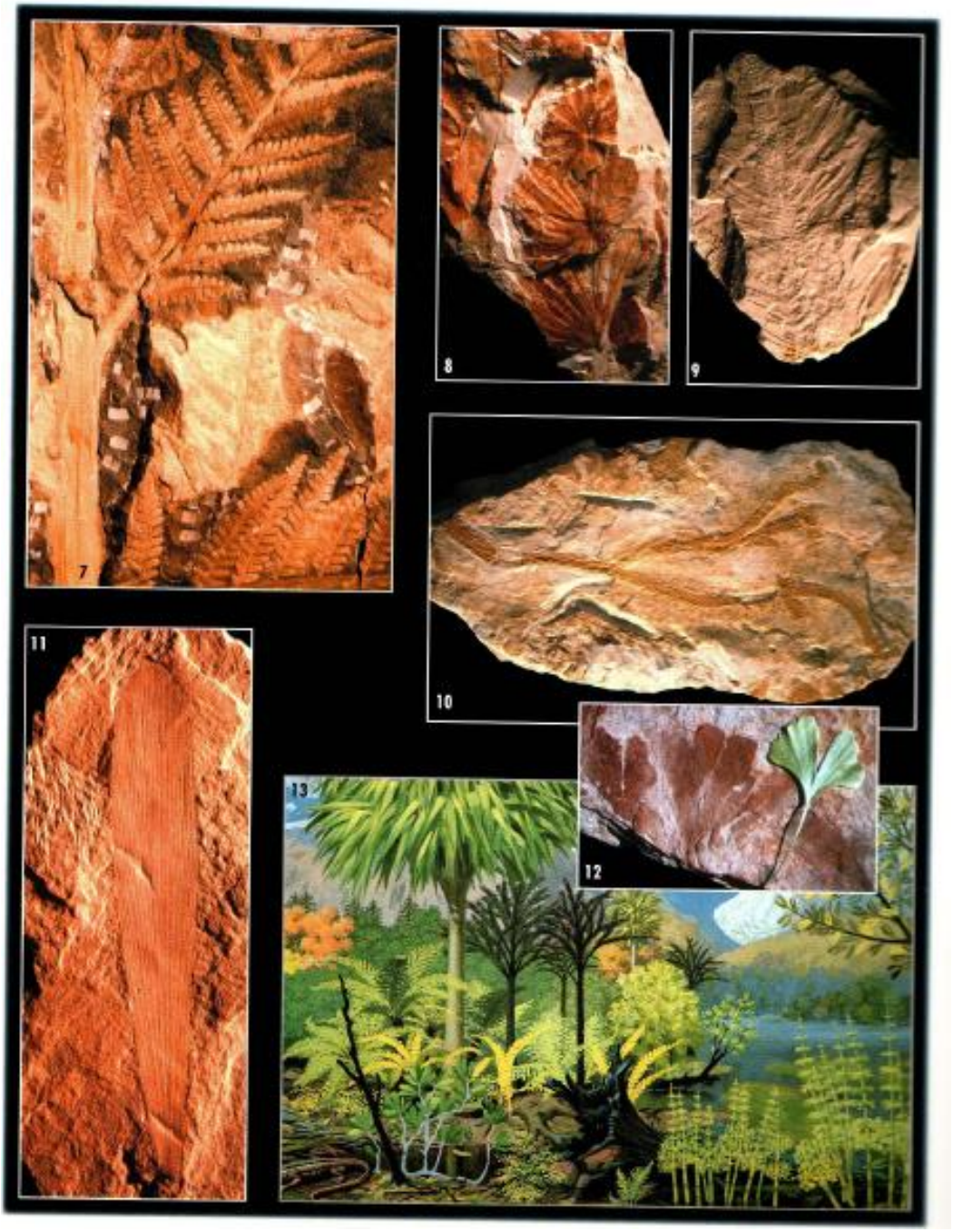
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**Figure 13:** Example of a plant fossil (courtesy of the ESI). *Glossopteris* leave.

Appendix 2 (**1k,1m,1q**): **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.

The EMPr already covers the conservation of heritage and palaeontological material 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 and the construction workers must be informed that this is a no-go area. The ECO should familiarise him- or herself with the fossiliferous formations and its fossils. A bi-weekly site visit is recommended and the keeping of a photographic record. A regular monitoring presence over the period during which excavations are made, by a palaeontologist, is generally not practical. 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 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 (if present). 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 fossil 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 (if applicable)/ 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 for example the 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 (if applicable) 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 | Point in Act | Heading |
|---|---|---|
| B | 1(c) | Outline of development project |
| | 1(d) | Summary of findings |
| | 1(g) | Concerns/threats |
| | 1(n)i | Concerns/threats |
| | 1(n)ii | Concerns/threats |
| | 1(o) | Concerns/threats |
| | 1(p) | Concerns/threats |
| 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) | Recommendation |
| | 1(m) | Sampling and collecting |
| | 1(k) | Sampling and collecting |
| Declaration | 1(b) | Declaration |
| Appendix | 1(k) | Protocol for finds |
| | 1(m) | Protocol for finds |
| | 1(q) | Protocol for finds |

**APPENDIX 4: IMPACT SIGNIFICANCE RATING**

Excavations may result in a negative direct impact on the possible fossil content of the affected subsurface. Fossils and significant observations may be lost in the absence of management actions to mitigate such loss. This loss of the opportunity to recover fossils and their contexts when exposed at a particular site is irreversible.

**Construction of 710 mm high-density polyethylene (HDPE) class 12.5 PE100 line and steel pipes with a diameter of 600 mm.**

| | **Without mitigation** | **With mitigation** |
|---|---|---|
| ***Impact*** | Destruction of fossils. | |
| ***Extent*** | Local (1) | Local (1) |
| ***Duration*** | Permanent (5) | Permanent (5) |
| ***Magnitude*** | High (2) | Low (2) |
| ***Probability*** | Highly Probable (4) | Probable (2) |
| ***Significance*** | **Moderate (56)** | **Negligible (16)** |
| ***Nature (Negative or Positive Impact)*** | Negative | Negative |
| ***Reversibility*** | Irreversible | Reversible |
| ***Irreplaceable loss of resources?*** | Yes | Partly |
| ***Can impacts be mitigated?*** | Yes, but only partial mitigation is possible. Valuable fossils may be lost in spite of management actions to mitigate such loss. | |

***Mitigation:***

- » If any palaeontological material is exposed during digging, excavating, drilling or blasting SAHRA must be notified immediately. All construction activities must be stopped and a palaeontologist should be called in to determine proper mitigation measures.
- » 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.
- » The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction 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 (pre-construction training of ECO) during the digging and excavation phase of the development.
- » The ECO should familiarise him- or herself with the fossiliferous formations and its fossils.
- » A bi-weekly site visit is recommended and the keeping of a photographic record. A regular monitoring presence over the period during which excavations are made, by a palaeontologist, is generally not practical.
- » Mitigation will involve recording, rescue and judicious sampling of the fossil material present in the layers sandwiched between the geological / coal layers (if present). It must include information on number of taxa, fossil abundance, preservational style, and taphonomy.

***Cumulative impacts:***

The inevitable and permanent loss of fossils and associated scientific implications.

***Residual Impacts:***

The discovery and rescue of fossils has ongoing scientific significance.

Should excavations result in fossil finds, the impact is positive for palaeontology, provided that efforts are made to watch out for and rescue the fossils.

***Construction of 710 mm high-density polyethylene (HDPE) class 12.5 PE100 line and steel pipes with a diameter of 600 mm.***

| | **Without mitigation** | **With mitigation** |
|---|---|---|
| ***Impact*** | Preservation of fossils. | |
| ***Extent*** | Local (1) | Local (1) |
| ***Duration*** | Permanent (5) | Permanent (5) |
| ***Magnitude*** | Low (2) | Medium (6) |
| ***Probability*** | Improbable (1) | Highly Probable (4) |
| ***Significance*** | **Negligible + (8)** | **Moderate +** (**48)** |
| ***Nature (Negative or Positive Impact)*** | Positive | Positive |
| ***Reversibility*** | Positive Impact | Positive Impact |
| ***Irreplaceable loss of resources?*** | Yes | Partly |
| ***Can impacts be mitigated?*** | This is a positive impact. | |

***Mitigation:***

- » If any palaeontological material is exposed during digging, excavating, drilling or blasting SAHRA must be notified immediately. All construction activities must be stopped and a palaeontologist should be called in to determine proper mitigation measures.
- » 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.
- » The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction 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 (pre-construction training of ECO) during the digging and excavation phase of the development.
- » The ECO should familiarise him- or herself with the fossiliferous formations and its fossils.
- » A bi-weekly site visit is recommended and the keeping of a photographic record. A regular monitoring presence over the period during which excavations are made, by a palaeontologist, is generally not practical.
- » Mitigation will involve recording, rescue and judicious sampling of the fossil material present in the layers sandwiched between the geological / coal layers (if present). It must include information on number of taxa, fossil abundance, preservational style, and taphonomy.

***Cumulative impacts:***

N/A

***Residual Impacts:***

The discovery and rescue of fossils has ongoing scientific significance.