PALAEONTOLOGICAL DESKTOP ASSESSMENT OF THE PROPOSED SEEPAGE INTERCEPTION DRAINS AT DUVHA POWER STATION, EMALAHLENI MUNICIPALITY, MPUMALANGA PROVINCE

Compiled for:

NEMAI CONSULTING (PTY) LTD

PO BOX 1673, Sunninghill

2157

18 September 2019

Prepared by:

BANZAI ENVIRONMENTAL (PTY) LTD

Declaration of Independence

General declaration:

- I, Elize Butler, declare that –
- I act as the independent Palaeontologist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting palaeontological impact assessments, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in section 38 of the NHRA when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not
- All the particulars furnished by me in this form are true and correct;
- I will perform all other obligations as expected from a heritage practitioner in terms of the Act and the constitutions of my affiliated professional bodies; and
- I realise that a false declaration is an offence in terms of regulation 71 of the Regulations and is punishable in terms of section 24F of the NEMA.

Disclosure of Vested Interest

I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Regulations;

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CONTACT PERSON: Elize Butler

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Email: elizebutler002@gmail.com

SIGNATURE: 

The Palaeontological Impact Assessment report has been compiled taking into account the National Environmental Management Act (NEMA) Appendix 6 requirements for specialist reports as indicated in the table below.

Table 1: NEMA Requirements

NEMA Regs (2014) - Appendix 6	**Relevant section in report**
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Page ii of Report – Contact details and company and Appendix 1
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Page ii-iii
c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 4 – Objective
(cA) an indication of the quality and age of base data used for the specialist report;	Section 5 – Geological and Palaeontological history
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 9 – Impacts
d) the date, duration and season of the site investigation and the relevance of the season to the outcome of the assessment;	N/A-Desktop study
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 7 – Methodology
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 1 and Section 5
g) an identification of any areas to be avoided, including buffers;	N/A
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 5
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 7.1. – Assumptions and Limitation

j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment or activities;	Section 10
k) any mitigation measures for inclusion in the EMPr;	Section 10
l) any conditions for inclusion in the environmental authorisation;	N/A
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 10
n) a reasoned opinion- i. as to whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Saction 1 and Section 10
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	Not applicable.
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Not applicable. To date not comments regarding heritage resources that require input from a specialist have been raised.
q) any other information requested by the competent authority.	Not applicable.
2) Where a government notice *gazetted* by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Refer to Section 2 and Section 3 compliance with SAHRA guidelines

EXECUTIVE SUMMARY

Nemai Consulting (Pty) Ltd has appointed Banzai Environmental to undertake the Palaeontological Desktop Impact Assessment (DIA) assessing the palaeontological impact of the Proposed Seepage Interception Drains at Duvha Power Station, Emalahleni Municipality, Mpumalanga Province. The National Heritage Resources Act (No 25 of 1999, section 38) (NHRA), states that a Palaeontological Impact Assessment (PIA) is key to detect the presence of fossil material within the planned development footprint. This DIA is thus necessary to evaluate the effect of the construction on the palaeontological resources.

The proposed Seepage Interception Drains at Duvha Power Station, Emalahleni Municipality, Mpumalanga Province is primarily underlain by the metamorphic sediments of the Selons River Formation (Rooiberg Group) and a small area in the south is located in the Vryheid Formation of the Ecca Group (Karoo Supergroup). According to the PalaeoMap of South African Heritage Resources Information System (SAHRIS), the Palaeontological Sensitivity of the metamorphic sediments of Selons River Formation is zero while the Vryheid Formation has a Very High Palaeontological Sensitivity (Almond and Pether 2008, SAHRIS website).

However, the southern portion of the development (2 camp sites, high level ash water return dam (HLAWRD), raw water dam as well as the most southern tip of the cut-off trench) falls in the Vryheid Formation which has a Very High Palaeontological Sensitivity. **But**, this area of the development footprint is very small and disturbed due to the agricultural and previous construction activities in the area. It is therefore considered that the construction and operation of the development may be authorised as the whole extent of the development footprint is not considered sensitive in terms of palaeontological resources.

In the event that fossil remains are discovered during any phase of construction, either on the surface or exposed by fresh excavations, the **Chance Find Protocol** must be implemented by the Environmental Control Officer (ECO) in charge of these developments. This Chance Find Protocol must also be included in the Environmental Management Programme Reports (EMPr). These discoveries ought to be secured (preferably *in situ*) and the ECO ought to alert South African Heritage Resources Agency (SAHRA) so that appropriate mitigation (*e.g.* documented and collection) can be undertaken by a palaeontologist. The specialist would need a collection permit from SAHRA. Fossil material must be curated in an approved collection (museum or university) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA.

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1 INTRODUCTION

The coal-fired power plant, Duvha Power Station, is a operated by Eskom Holdings SOC (Ltd) in Witbank, Mpumalanga Province. Nemai Consulting (Pty) Ltd has been appointed as the independent Environmental Assessment Practitioner (EAP) to obtain the Environmental Authorisation (EA) and Water Use License (WUL) for the Duvha seepage interception drains, located in the Duvha Power Station.

Duvha Power Station has been operational for the past 36 years. The Duvha power plant generates wet ash that is pumped to the ash dam (situated approximately 1.7 km east of the Witbank Dam). Settled water is firstly transferred to the low-level ash water return dam (LLAWRD) from where it is returned to the station to generate more wet ash slurry. Currently, the Power Station ash dam is experiencing seepage water that pollutes the groundwater towards the Witbank dam and mitigation measures must be undertaken to prevent the continuous groundwater seepage. A multi-disciplinary concept design to avoid seepage water is compulsory to support the Basic Assessment Report (BAR) and Water Use Licence Application (WULA) Processes as the traverse wetlands and fall within 500m of wetlands. Building of the seepage interception drains at the dams is required as Eskom was instructed by the Department of Water and Sanitation (now the Department of Human Settlements, Water and Sanitation (DHSWS)) to mitigate and prevent groundwater pollution.

To limit groundwater seepage from the existing large Ash Dam, high-level ash water return dam (HLAWRD), LLAWRD and the raw water dam, it is recommended to build cut-off interceptor drains alongside perimeter sections of each of the dams thus conveying the intercepted water to selected discharge points (Figure 1-3).

Figure 1: Site layout of the Duvha Power Station, indicating the location of the affected return water dams in relation to the Ash Dam (Map provided by Escom, 2019

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Figure 2: Google Earth image indicating the proposed servitude footprint areas for the seepage interception drains (blue, green, pink and yellow polygons) (Map provided by Nemai Consulting).

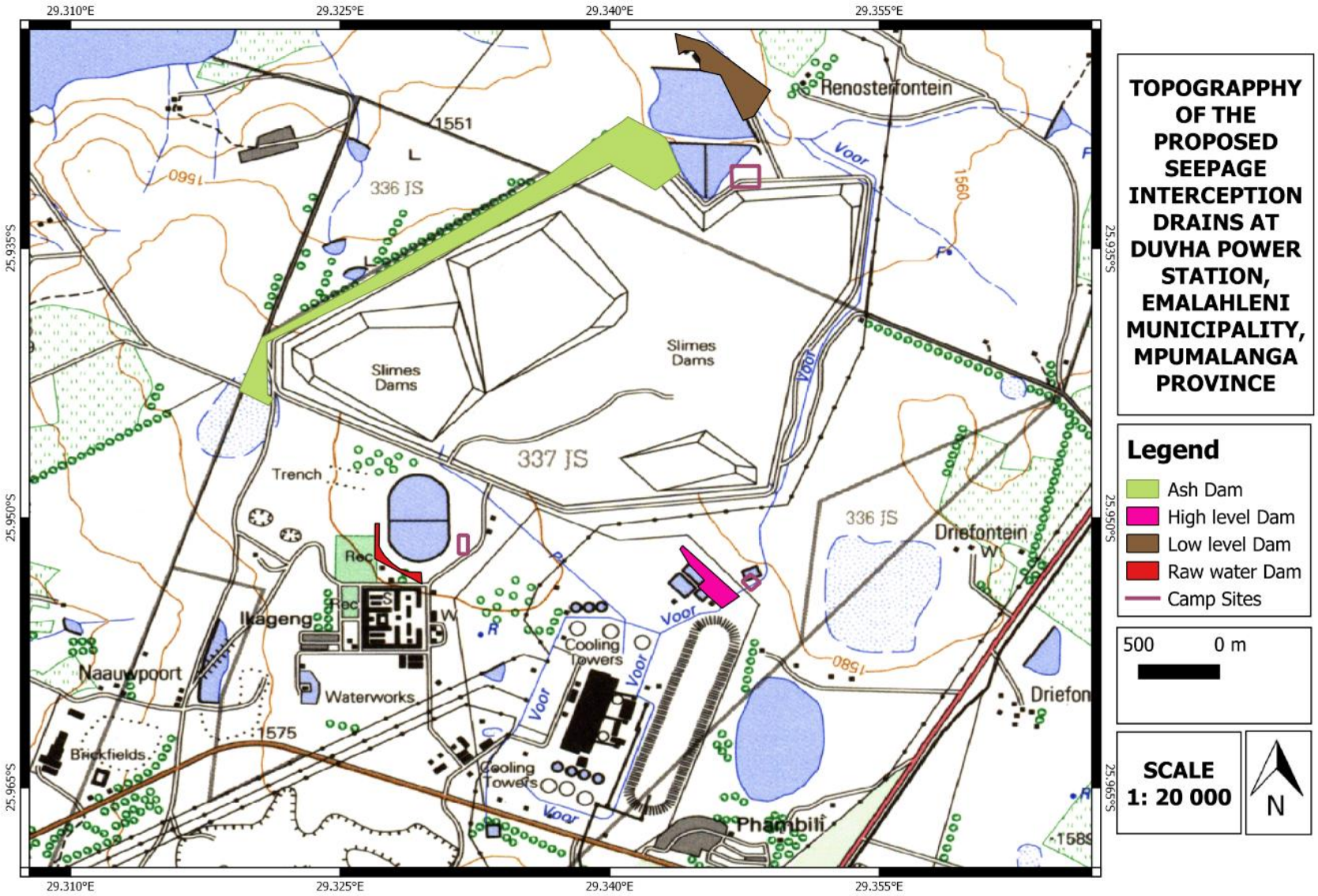

Figure 3: Extract of the 1:50 000 2529 CD topographical map indicating the proposed Duvha Seepage Interception Drains. Map drawn by QGIS 2.18.28.

Duvha Seepage Interceptor Drain Design

The design and construction of the Seepage Interception Drain will require the following design assumptions:

- Length of trench (Length) = 2400m
- Length of Channel to daylight = 2000m
- Depth of trench (Depth) = 8.0m
- Manning pipe coefficient roughness n = 0.018

Design Approach

Four possible options were evaluated:

- Option 1 – Provision of an HDPE Class C Liner on top of Duvha's Ash Dam;
- Option 2 – Open Cut-off Trench;
- Option 3 – Closed Subsoil Cut-off Drain; and
- Option 4 – Do nothing

The closed subsoil cut-off drain is deemed the best option as Option 1 is unacceptable from a station availability point of view and Option 3 is therefore used for the Concept Design. The design approach is to excavate an open trench down to bedrock and place a drain pipe on the bedrock with an HDPE cut-off curtain on the downstream side to intercept and drain the water. The trench will be backfilled with an open channel on the final surface to drain the stormwater. Two HDPE subsoil drainpipes just above the bedrock will be used, an upper slotted drain pipe and a larger lower unslotted pipe to lead the water away. The pipes will be led into manholes spaced at 200m intervals where the upper pipe's flow will fall by gravity into the lower pipe of the next segment[1].

2 QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

The author (Elize Butler) has an MSc in Palaeontology from the University of the Free State, Bloemfontein, South Africa. She has been working in Palaeontology for more than twenty-four years. She has extensive experience in locating, collecting and curating fossils, including exploration field trips in search of new localities in the Karoo Basin. She has been a member of the Palaeontological Society of South Africa for 13 years. She has been conducting PIAs since 2014.

3 LEGISLATION

3.1 NATIONAL HERITAGE RESOURCES ACT (25 OF 1999)

Cultural Heritage in South Africa, includes all heritage resources, is protected by the National Heritage Resources Act (Act 25 of 1999) (NHRA). Heritage resources as defined in Section 3 of the Act include **"all objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens**".

[1]Information provided by PGS Consulting

Palaeontological heritage is unique and non-renewable and is protected by the NHRA. Palaeontological resources may not be unearthed, broken moved, or destroyed by any development without prior assessment and without a permit from the relevant heritage resources authority as per section 35 of the NHRA.

This DIA forms part of the Heritage Impact Assessment (HIA) and adhere to the conditions of the Act. According to **Section 38 (1)**, an HIA is required to assess any potential impacts to palaeontological heritage within the development footprint where:

- the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length;
- the construction of a bridge or similar structure exceeding 50 m in length;
- any development or other activity which will change the character of a site—
- (exceeding 5 000 m^2 in extent; or
- involving three or more existing erven or subdivisions thereof; or
- involving three or more erven or divisions thereof which have been consolidated within the past five years; or
- the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority
- the re-zoning of a site exceeding 10 000 m^2 in extent;
- or any other category of development provided for in regulations by SAHRA or a Provincial heritage resources authority.

4 OBJECTIVE

The objective of a PIA is to determine the impact of the development on potential palaeontological material at the site.

According to the "SAHRA APM Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports" the aims of the PIA are: 1) to **identify** the palaeontological status of the exposed as well as rock formations just below the surface in the development footprint 2) to estimate the **palaeontological importance** of the formations 3) to determine the **impact** on fossil heritage; and 4) to recommend how the developer ought to protect or mitigate damage to fossil heritage.

The terms of reference of a PIA are as follows:

General Requirements:

- Adherence to the content requirements for specialist reports in accordance with Appendix 6 of the EIA Regulations 2014, as amended;
- Adherence to all applicable best practice recommendations, appropriate legislation and authority requirements;

- Submit a comprehensive overview of all appropriate legislation, guidelines;
- Description of the proposed project and provide information regarding the developer and consultant who commissioned the study,
- Description and location of the proposed development and provide geological and topographical maps
- Provide Palaeontological and geological history of the affected area.
- Identification sensitive areas to be avoided (providing shapefiles/kmls) in the proposed dvelopment;
- Evaluation of the significance of the planned development during the Pre-construction, Construction, Operation, Decommissioning Phases and Cumulative impacts. Potential impacts should be rated in terms of the direct, indirect and cumulative:
    - **Direct impacts** are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity.
    - **Indirect impacts** of an activity are indirect or induced changes that may occur as a result of the activity.
    - **Cumulative impacts** are impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities.
- Fair assessment of alternatives (infrastructure alternatives have been provided):
- Recommend mitigation measures to minimise the impact of the proposed development; and
- Implications of specialist findings for the proposed development (such as permits, licenses etc).

5 GEOLOGICAL AND PALAEONTOLOGICAL HERITAGE

The proposed Seepage Interception Drains at Duvha Power Station, Emalahleni Municipality, Mpumalanga Province is primarily underlain by the metamorphic sediments of the Selons River Formation (Rooiberg Group) and a small area in the south is located in the Vryheid Formation of the Ecca Group (Karoo Supergroup). According to the PalaeoMap of South African Heritage Resources Information System (SAHRIS), the Palaeontological Sensitivity of the metamorphic sediments of Selons River Formation is zero while the Vryheid Formation has a Very High Palaeontological Sensitivity (Almond and Pether 2008, SAHRIS website).

The southern portion of the development (2 camp sites, high level ash water return dam (HLAWRD), raw water dam as well as the most southern tip of the cut-off trench) falls in the Vryheid Formation which has a Very High Palaeontological Sensitivity and the Low level ash water return dam, most of the proposed cut-off trensh as well as the northern camp site falls in the Selons river Formation of the Rooiberg Group (Figure 4).

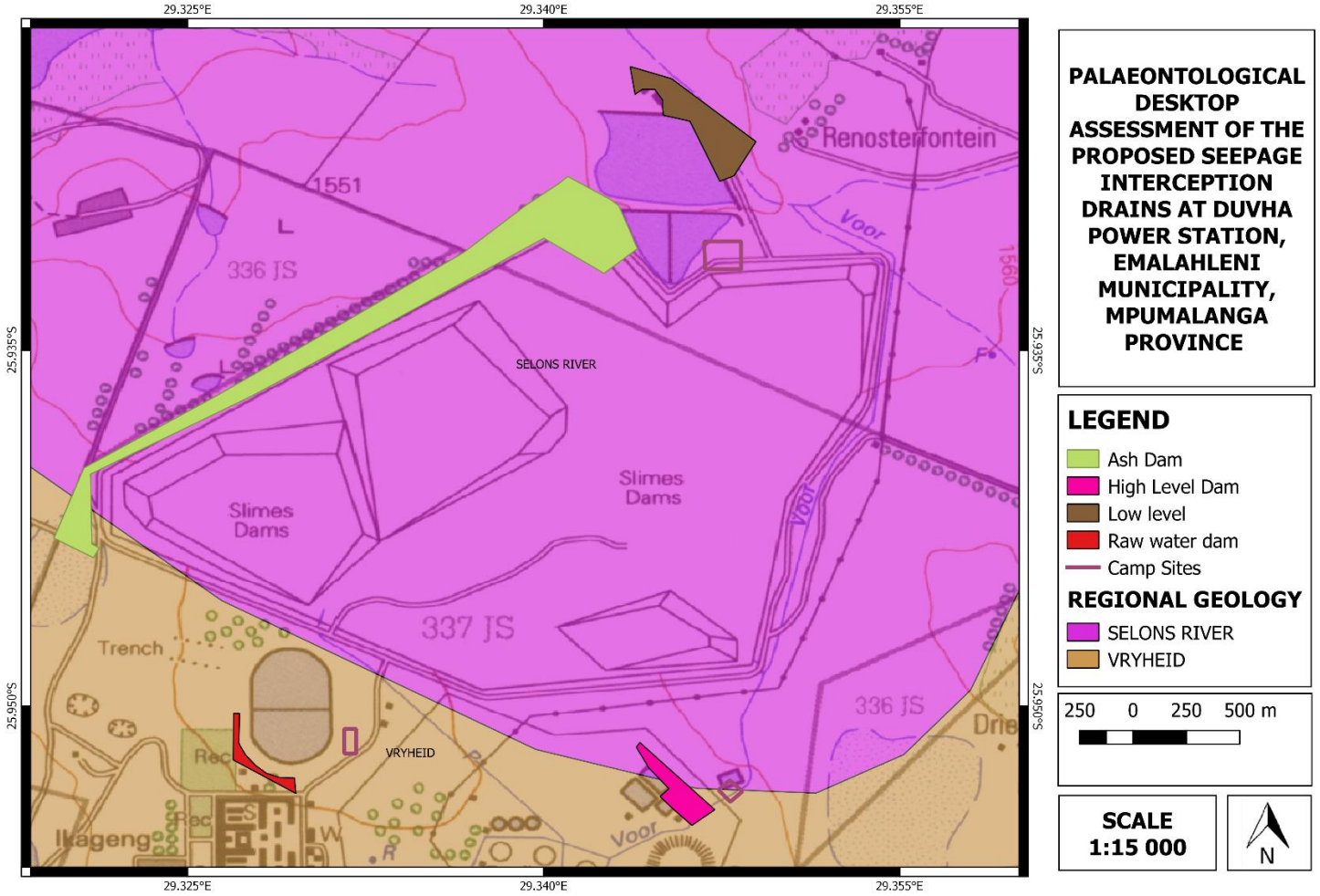

Figure 4: Surface geology of the proposed Duvha Seepage Interception Drains is primarily underlain by the Selons River Formation and the Vryheid Formation, Ecca Group (Karoo Supergroup).: Map was drawn by QGIS 2.18.28.

According to SACS (1980), the Rooiberg Group consisted of the Selons River Formation, which was divided in the Klipnek Member and the Doornkloof Member. Schweitzer *et al*. (1995) correlated the Doornkloof and Klipnek Members of the Selons River Formation (SACS, 1980) with the Schrikkloof and Kwaggasnek Formations respectively, thus rendering the Selons River Formation and its members redundant. The Kwaggasnek, Schrikkloof, Damwal and Dullstroom Formations are now known as the Rooiberg Group and comprises of volcanic units. Metamorphosed sediments of quartzites, sandstones, mudrocks and cherts are present which is mainly fluvial in origin.

As already mentioned, the Rooiberg Group comprises of volcanic units. The Rooiberg Group is known not to be fossiliferous.

Ecca Group

Table 2: Ecca Group and Formations. (Modified from Johnson et al, 2006).

<table>
<tr><th>Period</th><th>Supergroup</th><th>Group</th><th>Formation West of 24º E</th><th>Formation East of 24º E</th><th>Formation Free State / KwaZulu-Natal</th></tr>
<tr><td rowspan="8">Permian</td><td rowspan="8">Karoo Supergroup</td><td rowspan="8">Ecca Group</td><td>Waterford Formation</td><td>Waterford Formation</td><td rowspan="2">Volksrust Formation</td></tr>
<tr><td>Tierberg / Fort Brown Formation</td><td>Fort Brown Formation</td></tr>
<tr><td>Laingsburg / Rippon Formation</td><td>Rippon Formation</td><td>Vryheid Formation</td></tr>
<tr><td>Collingham Formation</td><td>Collingham Formation</td><td rowspan="3">Pietermaritzburg Formation</td></tr>
<tr><td>Whitehill Formation</td><td>Whitehill Formation</td></tr>
<tr><td>Prince Albert Formation</td><td>Prince Albert Formation</td></tr>
<tr><td colspan="2"></td><td>Mbizane Formation</td></tr>
</table>

The **Vryheid Formation** of the Ecca Group comprises mudrock, rhythmite, siltstone and fine- to coarse-grained sandstone (pebbly in places). The Formation contains up to five (mineable) coal seams. The different lithofacies are mainly arranged in upward-coarsening deltaic cycles (up to 80m thick in the southeast). Fining-upward fluvial cycles, of which up to six are present in the east, are typically sheet-

like in geometry, although some form valley-fill deposits. They comprise coarse-grained to pebbly, immature sandstones - with an abrupt upward transition into fine-grained sediments and coal seams.

The Vryheid Formation is known to contain a rich assemblage of Glossopteris flora which is the source vegetation for the Vryheid Formation. Gymnospermous glossopterids dominated the peat and non-peat accumulating of Permian wetlands after continental deglaciation took place (Falcon, 1986c, Greb *et al*., 2006).

Recent paleobotanical studies include that of Adenforff (2005), Bordy and Prefec (2008) and Prefec *et al.* (2008, 2009, 2010) and Prevec, (2011). Bamford (2011) described numerous plant fossils from this formation (e.g. *Azaniodendron fertile*, *Cyclodendron leslii, Sphenophyllum hammanskraalensis, Annularia sp., Raniganjia sp., Asterotheca spp., Liknopetalon enigmata, Hirsutum* sp., *Scutum* sp., *Ottokaria* sp., *Estcourtia* sp., *Arberia* sp., *Lidgetonnia* sp., *Noeggerathiopsis* sp., *Podocarpidites* sp as well as more than 20 Glossopteris species.

In the past, palynological studies have focused on the coal bearing successions of the Vryheid Formation and include articles by Aitken (1993, 1994, 1998), and Millsteed (1994, 1999), while recent studies were conducted by Götz and Ruckwied, 2014).

Bamford (2011) is of the opinion that only a small amount of data have been published on these potentially fossiliferous deposits and that most likely good material are present around coal mines and in other areas the exposures are poor and of little interest. When plant fossils do occur, they are usually abundant. According to Bamford it is not feasible to preserve all the sites but in the interests of science these sites ought to be well documented, researched and the collected fossils must be housed in an accredited institution.

To date, no fossil vertebrates have been collected from the Vryheid formation. The occurrence of fossil insects are rare, while palynomorphs are diverse. Non-marine bivalves and fish scales have also been reported from this formation. Trace fossils are abundantly found but the diversity is low. The mesosaurid reptile, *Mesosaurus* has been found in the southern parts of the basin but may also be present in other areas of the Vryheid formation. Regardless of the rare and irregular occurrence of fossils in this biozone, a single fossil may be of scientific importance as many fossil taxa are known from a single fossil.

6 GEOGRAPHICAL LOCATION OF THE SITE

The Duvha Power Station is situated approximately 13km south-east of Witbank, between the R544 and the R575 roads. The planned seepage drains will be built in the servitude areas around the ash dam and accompanying return water dams and the raw water dam within the Duvha Power Station boundary. The development area for all four dams, and the area between the dams, has been previously disturbed by the construction of the dams and associated infrastructure.

The surrounding area consists of slightly to moderately undulating plains of degraded grassland (Moist Sandy Highveld Grassland), with wetlands, pans and rivers. The Witbank Dam is approximately 1,7km north-west of the development area. The surrounding land use comprises mines, quarries and commercial cultivated land, scattered with small villages associated with the mines and well-developed road and rail infrastructure.

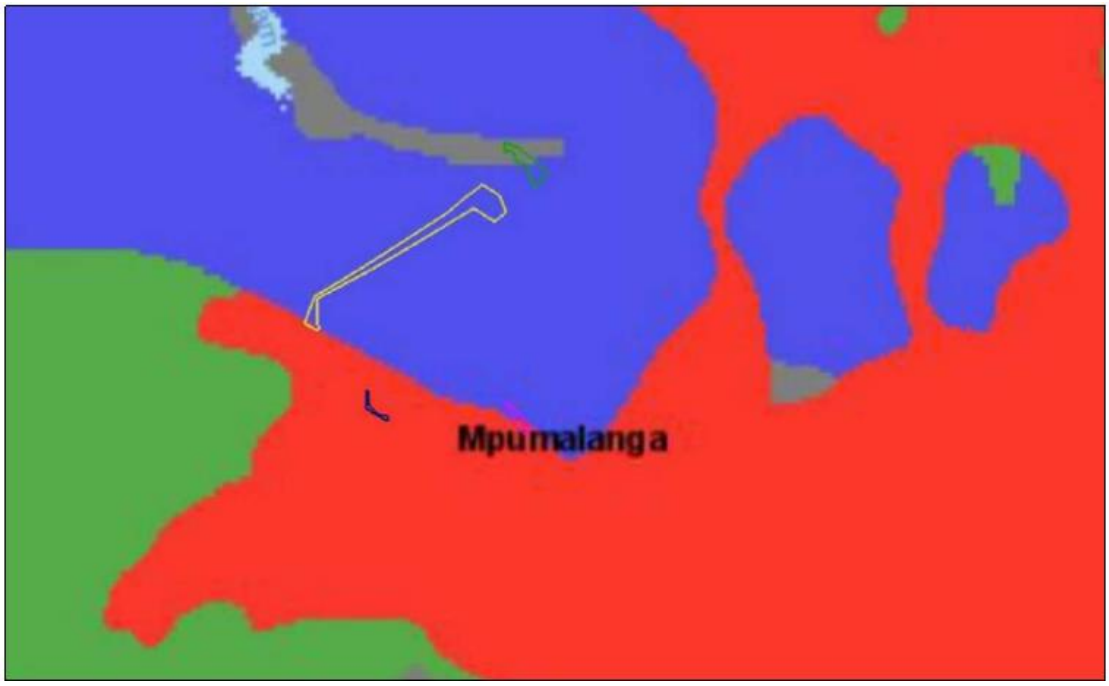

Figure 5: Extract of the 1 in 250 000 SAHRIS PalaeoMap map (Council of Geosciences) indicating the location of the proposed development.

Table 3: Explanation of PalaeoMap

Colour	Sensitivity	Required Action
RED	VERY HIGH	field assessment and protocol for finds is required
ORANGE/YELLOW	HIGH	desktop study is required and based on the outcome of the desktop study, a field assessment is likely
GREEN	MODERATE	desktop study is required
BLUE	LOW	no palaeontological studies are required however a protocol for finds is required
GREY	INSIGNIFICANT/ZERO	no palaeontological studies are required
WHITE/CLEAR	UNKNOWN	these areas will require a minimum of a desktop study. As more information comes to light, SAHRA will continue to populate the map.

According to the SAHRIS palaeosensitivity map (Figure 5), there is very little chance of finding fossils in this blue and grey area but a very high chance of finding fossils in the red area (Raw water dam and HLWRD).

7 METHODS

A desktop study was assembled to evaluate the possible risk to palaeontological heritage (this includes fossils as well as trace fossils) in the proposed development area. In compiling the desktop report, aerial photos, Google Earth 2018, topographical and geological maps and other reports from the same area as well as the author's experience were used to assess the proposed development footprint. No consultations were undertaken for this Impact Assessment.

7.1 Assumptions and limitations

The accuracy of Desktop Palaeontological Assessment is reduced by several factors which may include the following: the databases of institutions are not always up to date and relevant locality and geological information were not accurately documented in the past. Various remote areas of South Africa have not been assessed by palaeontologists and data is based on aerial photographs alone. Geological maps concentre on the geology of an area and the sheet explanations were never intended to focus on palaeontological heritage.

Similar Assemblage Zones, but in different areas is used to provide information on the presence of fossil heritage in an unmapped area. Desktop studies of similar geological formations and Assemblage Zones generally **assume** that exposed fossil heritage is present within the development area. The accuracy of the Palaeontological Impact Assessment is thus improved considerably by conducting a field-assessment.

8 ADDITIONAL INFORMATION CONSULTED

In compiling this report the following sources were consulted:

- The Palaeosensitivity Map from the SAHRIS website.
- A Google Earth map with polygons of the proposed development was obtained from Nemai Consulting (Pty) Ltd.
- 2529 CD Topographical Map.
- Palaeontological Impact Assesssments in close proximity to the development area found on the internet are included in the reference list and include: Bamford, 2011; 2018 and Butler 2017a, 2017b, 2018.
- The HIA of the development area by PGS Heritage:
    - Kitto, J. 2019. Heritage Impact Assessment for the proposed Seepage Interception Drains at Duvha Power Station, Emalahleni Municipality, Mpumalanga Province.

9 IMPACT ASSESSMENT METHODOLOGY

Impact assessment must take account of the nature, scale and duration of impacts on the environment whether such impacts are positive or negative. Each impact is also assessed according to the following project phases:

- Construction;

- Operation; and
- Decommissioning.

Where necessary, the proposal for mitigation or optimisation of an impact should be detailed. A brief discussion of the impact and the rationale behind the assessment of its significance should also be included. The rating system is applied to the potential impacts on the receiving environment and includes an objective evaluation of the mitigation of the impact. In assessing the significance of each impact the following criteria is used:

Table 4: The rating system

Relevant impacts to the proposed development is indicated in yellow

NATURE		
Include a brief description of the impact of environmental parameter being assessed in the context of the project. This criterion includes a brief written statement of the environmental aspect being impacted upon by a particular action or activity. The Nature of the Impact is the possible descruction of fossil heritage		
GEOGRAPHICAL EXTENT		
This is defined as the area over which the impact will be experienced.		
1	Site	The impact will only affect the site.
2	Local/district	Will affect the local area or district.
3	Province/region	Will affect the entire province or region.
4	International and National	Will affect the entire country.
PROBABILITY		
This describes the chance of occurrence of an impact.		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
DURATION		
This describes the duration of the impacts. Duration indicates the lifetime of the impact as a result of the proposed activity.		
1	Short term	The impact will either disappear with mitigation or will be mitigated through natural processes in a span shorter than the construction phase (0 – 1 years), or the impact will last for the period of a relatively short construction

		period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 30 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered indefinite.
INTENSITY/ MAGNITUDE		
Describes the severity of an impact.		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).
3	High	Impact affects the continued viability of the system/ component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired. Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
REVERSIBILITY		
This describes the degree to which an impact can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures.

2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.
CUMULATIVE EFFECT		
This describes the cumulative effect of the impacts. A cumulative impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		
1	Negligible cumulative impact	The impact would result in negligible to no cumulative effects.
2	Low cumulative impact	The impact would result in insignificant cumulative effects.
3	Medium cumulative impact	The impact would result in minor cumulative effects.
4	High cumulative impact	The impact would result in significant cumulative effects
SIGNIFICANCE		
Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The calculation of the significance of an impact uses the following formula: (**Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity.** The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.		
Points	Impact significance rating	Description
6 to 28	Negative low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive low impact	The anticipated impact will have minor positive effects.
29 to 50	Negative medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.

29 to 50	Positive medium impact	The anticipated impact will have moderate positive effects.
51 to 73	Negative high impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive high impact	The anticipated impact will have significant positive effects.
74 to 96	Negative very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive very high impact	The anticipated impact will have highly significant positive

9.1 SUMMARY OF IMPACT TABLES

Only the site of the Seepage Interception Drains at Duvha Power Station will be affected by the proposed development. The expected duration of the impact on fossil heritage is assessed as potentially permanent to long term. According to the SAHRIS PalaeoMap there is a possibility that the impact will most likely happen as the sensitivity is very high. But, this area of the development footprint is very small and disturbed due to the agricultural and previous construction activities in the area and thus the magnitude of the impact occurring is medium due to the very small area affected and disturbance of the land. Without mitigation there will be a irriversable and irreplacable loss of fossil Heritage. The significance of the impact will be a negative medium impact.

10 FINDINGS AND RECOMMENDATIONS

The proposed Seepage Interception Drains at Duvha Power Station, Emalahleni Municipality, Mpumalanga Province is primarily underlain by the metamorphic sediments of the Selons River Formation (Rooiberg Group) and a small area in the south is located in the Vryheid Formation of the Ecca Group (Karoo Supergroup). According to the PalaeoMap of South African Heritage Resources Information System (SAHRIS), the Palaeontological Sensitivity of the metamorphic sediments of Selons River Formation is zero while the Vryheid Formation has a Very High Palaeontological Sensitivity (Almond and Pether 2008, SAHRIS website).

However, the southern portion of the development (2 camp sites, high level ash water return dam (HLAWRD), raw water dam as well as the most southern tip of the cut-off trench) falls in the Vryheid Formation which has a Very High Palaeontological Sensitivity. **But**, this area of the development **footprint is very small** and **disturbed due** to the agricultural and previous construction activities in the area. It is therefore considered that the construction and operation of the development may be

authorised as the whole extent of the development footprint is not considered sensitive in terms of palaeontological resources.

In the event that fossil remains are discovered during any phase of construction, either on the surface or exposed by fresh excavations, the **Chance Find Protocol** must be implemented by the Environmental Control Officer (ECO) in charge of these developments. This Chance Find Protocol must also be included in the Environmental Management Programme Reports (EMPr). These discoveries ought to be secured (preferably *in situ*) and the ECO ought to alert South African Heritage Resources Agency (SAHRA) so that appropriate mitigation (*e.g.* documented and collection) can be undertaken by a palaeontologist. The specialist would need a collection permit from SAHRA. Fossil material must be curated in an approved collection (museum or university) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA.

11 CHANCE FINDS PROTOCOL

The following procedure will only be followed in the event that fossils are uncovered during any stage of excavation.

11.1 LEGISLATION

Cultural Heritage in South Africa (includes all heritage resources) is protected by NHRA. According to Section 3 of the Act, all Heritage resources include “all objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens”.

Palaeontological heritage is unique and non-renewable and is protected by the NHRA and are the property of the State. It is thus the responsibility of the State to manage and conserve fossils on behalf of the residents of South Africa. Palaeontological resources may not be broken or destroyed, excavated or moved by any development without prior assessment and without a permit from the applicable heritage resources authority as per section 35 of the NHRA.

11.2 BACKGROUND

A fossil is the naturally preserved remains (or traces) of plants or animals embedded in rock. These plants and animals lived in the geologic past. Fossils are extremely rare and irreplaceable. By studying fossils, it is possible to determine the environmental conditions that existed in a specific geographical area millions of years ago.

11.3 INTRODUCTION

This informational document is intended for workmen and foremen on construction sites. It describes the actions to be taken when mining or construction activities accidentally uncovers fossil material.

It is the responsibility of the ECO of the project to train the workmen and foremen in the procedure to follow when a fossil is accidentally uncovered. In the absence of the ECO, a member of the staff must be appointed to be responsible for the proper implementation of the chance find protocol as not to compromise the conservation of fossil material.

11.4 CHANCE FIND PROCEDURE

- If a chance find is made, the person responsible for the find must immediately **stop working** and all work must cease in the immediate vicinity of the find.
- The person who made the find must immediately **report** the find to his/her direct supervisor which in turn must report the find to his/her manager and the ECO or site manager. The ECO must report the find to the relevant Heritage Agency (South African Heritage Research Agency, SAHRA). (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). The information to the Heritage Agency must include photographs of the find, from various angles, as well as the GPS co-ordinates.
- A preliminary report must be submitted to the Heritage Agency within **24 hours** of the find and must include the following: 1) date of the find; 2) a description of the discovery and a 3) description of the fossil and its context (depth and position of the fossil), GPS co-ordinates.
- Photographs (the more the better) of the discovery must be of high quality, in focus, accompanied by a scale. It is also important to have photographs of the vertical section (side) where the fossil was found.

Upon receipt of the preliminary report, the Heritage Agency will inform the ECO (site manager) whether a rescue excavation or rescue collection by a palaeontologist is necessary.

- The site must be secured to protect it from any further damage. **No attempt** should be made to remove material from their environment. The exposed finds must be stabilized and covered by a plastic sheet or sand bags. The Heritage agency will also be able to advise on the most suitable method of protection of the find.
- In the event that the fossil cannot be stabilized the fossil may be collected with extreme care by the ECO (site manager). Fossils finds must be stored in tissue paper and in an appropriate box while due care must be taken to remove all fossil material from the rescue site.
- Once Heritage Agency has issued the written authorization, the developer may continue with the development.

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Appendix: 1: CV

ELIZE BUTLER

PROFESSION: Palaeontologist

YEARS' EXPERIENCE: 25 years in Palaeontology

EDUCATION:

B.Sc Botany and Zoology, 1988
University of the Orange Free State

B.Sc (Hons) Zoology, 1991
University of the Orange Free State

Management Course, 1991
University of the Orange Free State

M. Sc. *Cum laude* (Zoology), 2009
University of the Free State

Dissertation title: The postcranial skeleton of the Early Triassic non-mammalian Cynodont *Galesaurus planiceps*: implications for biology and lifestyle

Registered as a PhD fellow at the Zoology Department of the UFS
2013 to current

Dissertation title: A new gorgonopsian from the uppermost D*aptocephalus Assemblage Zone*, in the Karoo Basin of South Africa

MEMBERSHIP

Palaeontological Society of South Africa (PSSA) 2006-currently

EMPLOYMENT HISTORY

Part time Laboratory assistant	Department of Zoology & Entomology University of the Free State Zoology 1989-1992
Part time laboratory assistant	Department of Virology University of the Free State Zoology 1992
Research Assistant	National Museum, Bloemfontein 1993 – 1997
Principal Research Assistant and Collection Manager	National Museum, Bloemfontein 1998–currently

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