PALAEONTOLOGICAL IMPACT ASSESSMENT FOR THE PROPOSED TETRA 4 GAS GATHERING CLUSTER 2 PROJECT, NEAR VIRGINIA IN THE FREE STATE

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Declaration of Independence

I, Elize Butler, declare that –

General declaration:

- I act as the independent palaeontological specialist 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 favorable 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 consider, 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 favorable 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 a palaeontological specialist in terms of the Act and the constitutions of my affiliated professional bodies; and
- I realize that a false declaration is an offense 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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SIGNATURE: 

ACKNOWLEDGEMENT OF RECEIPT

Report Title	***Palaeontological Impact Assessment for the proposed* Tetra4 Gas Gathering Cluster 2 project near Virginia in the Free State.**		
Control	**Name**	**Signature**	**Designation**
Author	**Elize Butler**		**Palaeontologist**
Reviewed			**Archaeologist – PGS Heritage**
Client			

CLIENT:

CONTACT PERSON:

SIGNATURE: _____

The heritage impact assessment report has been compiled considering the National Environmental Management Act 1998 (NEMA) and Environmental Impact Regulations 2014 as amended, requirements for specialist reports, Appendix 6, as indicated in the table below.

Table 1: NEMA Table

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	**Relevant section in report**	**Comment where not applicable.**
1.(1) (a) (i) Details of the specialist who prepared the report	Page ii and Section 2 of Report – Contact details and company and Appendix A	-
(ii) The expertise of that person to compile a specialist report including a curriculum vita	Section 2 – refer to Appendix A	-
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page ii of the report	-
(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 10	-
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 1 and 11	
(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 Approach and 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 11	
(g) An identification of any areas to be avoided, including buffers	None Section 1 and 11	
(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 – Geological and Palaeontological history	
(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	Section 1 and 11	
(k) Any mitigation measures for inclusion in the EMPr	Section 12	
(l) Any conditions for inclusion in the environmental authorisation	Section 12	
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 12	
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Section 1 and 11	
(n)(iA) A reasoned opinion regarding the acceptability of the proposed activity or activities; and		
(n)(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	Section 1 and 11	-
(o) A description of any consultation process that was undertaken during the course of carrying out the study	N/A	Not applicable. A public consultation process will be conducted as

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	Relevant section in report	Comment where not applicable.
		part of the EIA and EMPr process.
(p) A summary and copies if any comments that were received during any consultation process	N/A	
(q) Any other information requested by the competent authority.	N/A	Not applicable.
(2) Where a government notice 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.	Section 3 compliance with SAHRA guidelines	

EXECUTIVE SUMMARY

Banzai Environmental was appointed by PGS Heritage (Pty) Ltd to conduct the Palaeontological Impact Assessment (PIA) to assess the proposed Tetra 4 Cluster 2 Project, southwest of Matjhabeng (formerly Virginia) in the Free State. In accordance with the National Environmental Management Act 107 of 1998 (NEMA) and to comply with the National Heritage Resources Act (No 25 of 1999, section 38) (NHRA), this PIA is necessary to confirm if fossil material could potentially be present in the planned development area, to evaluate the potential impact of the proposed development on the Palaeontological Heritage and to mitigate possible damage to fossil resources.

The proposed Tetra4 development is underlain by Quaternary sediments as well as Permian aged sandstone and shale of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup). According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments in this area is Moderate, while that of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) is Very High.

A 2-day site-specific field survey of the development footprint was conducted on foot and by a motor vehicle on 26 to 27 February 2021. No visible evidence of fossiliferous outcrops was found in the development footprint and thus an overall medium palaeontological significance is allocated to the development footprint. It is therefore considered that the proposed development will not lead to detrimental impacts on the palaeontological reserves of the area and construction of the development may be authorised in its whole extent.

Recommendations:

- The ECO for this project must be informed that the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) has a **Very High Palaeontological Sensitivity**.

- If Palaeontological Heritage is uncovered during surface clearing and excavations the **Chance find Protocol** attached should be implemented immediately. Fossil discoveries ought to be protected and the ECO/site manager must report to South African Heritage Resources 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) so that mitigation (recording and collection) can be carried out.

- Before any fossil material can be collected from the development site the specialist involved would need to apply for a collection permit from SAHRA. Fossil material must be housed in an official collection (museum or university), while all reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012).

- These recommendations should be incorporated into the Environmental Management Plan for the Tetra4 Development.

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TERMINOLOGY AND ABBREVIATIONS

Archaeological resources

This includes:

- material remains resulting from human activity which are in a state of disuse and are in or on land and which are older than 100 years including artifacts, human and hominid remains, and artificial features and structures.
- rock art is any form of painting, engraving or other graphic representation on a fixed rock surface or loose rock or stone, which was executed by human agency and which is older than 100 years, including any area within 10m of such representation;
- wrecks, being any vessel or aircraft, or any part thereof, which was wrecked in South Africa, whether on land, in the internal waters, the territorial waters or in the maritime culture zone of the Republic as defined in the Maritimes Zones Act, and any cargo, debris or artefacts found or associated therewith, which is older than 60 years or which SAHRA considers to be worthy of conservation.
- features, structures, and artifacts associated with a military history which are older than 75 years and the site on which they are found.

Cultural significance

This means aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance

Development

This means any physical intervention, excavation, or action, other than those caused by natural forces, which may in the opinion of the heritage authority in any way result in a change to the nature, appearance or physical nature of a place or influences its stability and future well-being, including:

- construction, alteration, demolition, removal or change in use of a place or a structure at a place.
- carrying out any works on or over or under a place.
- subdivision or consolidation of land comprising a place, including the structures or airspace of a place.
- constructing or putting up for display signs or boards.
- any change to the natural or existing condition or topography of land; and
- any removal or destruction of trees, or removal of vegetation or topsoil

Fossil

Mineralized bones of animals, shellfish, plants, and marine animals. A trace fossil is the track or footprint of a fossil animal that is preserved in stone or consolidated sediment.

Heritage

That which is inherited and forms part of the National Estate (historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999).

Heritage resources

This means any place or object of cultural significance and can include (but not limited to) as stated under Section 3 of the NHRA,

- places, buildings, structures, and equipment of cultural significance.
- places to which oral traditions are attached or which are associated with living heritage.
- historical settlements and townscapes.
- landscapes and natural features of cultural significance.
- geological sites of scientific or cultural importance.
- archaeological and palaeontological sites.
- graves and burial grounds, and
- sites of significance relating to the history of slavery in South Africa.

Holocene

The most recent geological time period which commenced 10 000 years ago.

Palaeontology

Any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or trace.

Table 2: Abbreviations

Abbreviations	Description
APM	Archaeology, Palaeontology and Meteorites
ASAPA	Association of South African Professional Archaeologists
BAR	Basic Assessment Report
CRM	Cultural Resource Management
DEFF	Department of Environmental Department of Environment, Forestry and Fisheries
DWS	Department of Water and Sanitation
ECO	Environmental Control Officer
EIA practitioner	Environmental Impact Assessment Practitioner
EIA	Environmental Impact Assessment
EPCM	EPCM Bonisana Pty Ltd
ESA	Early Stone Age
GPS	Global Positioning System
HIA	Heritage Impact Assessment
I&AP	Interested & Affected Party
LSA	Late Stone Age
LIA	Late Iron Age
LNG	Liquid Natural Gas
MSA	Middle Stone Age
MIA	Middle Iron Age
NEMA	National Environmental Management Act
NHRA	National Heritage Resources Act
PDA	Palaeontological Desktop Assessment
PIA	Palaeontological Impact Assessment
PHRA	Provincial Heritage Resources Authority
PSSA	Palaeontological Society of South Africa
SADC	Southern African Development Community
SAHRA	South African Heritage Resources Agency
SAHRIS	South African Heritage Resources Information System

1 INTRODUCTION

Banzai Environmental was appointed by PGS Heritage (Pty) Ltd to conduct the PIA (as part of the Heritage Impact Assessment) to assess the proposed Tetra4 Cluster 2 construction project near Virginia in the Free State (**Figure1-2**).

Renergen is an emerging producer of helium and liquefied natural gas (LNG), with existing production and sales of compressed natural gas (CNG). Renergen's principal asset is its 100% shareholding in TETRA4 (Pty) Ltd., hereinafter referred to as Tetra4, which holds the first and only onshore petroleum production right (issued by the Department of Mineral Resources and Energy (DMRE) in South Africa, giving it first mover advantage on distribution of domestic natural gas[1].

The production right covers a large area in Virginia in the Free State (approximately 285 km southwest of Johannesburg) where gas-emitting boreholes have been identified from mineral exploration activity. Several of these boreholes are producing gas at relatively high flow rates and have been doing so for decades. The gas emitting boreholes, or "blowers", were drilled by mining companies to explore for gold in the Witwatersrand Formation that underlies the coal-bearing Karoo and Ventersdorp lavas.

The natural gas contains one of the richest helium concentrations recorded globally - which Tetra4 intends to extract from the gas as liquid natural gas (LNG) and Liquefied Helium (LHe) respectively. The natural gas is also very pure with an average of over 90% methane, and almost zero higher alkanes, which reduces the complexity of liquefication.

Tetra4 is in the process of developing the gas field using the existing twelve (12) wells – known as the Phase 1 project – in conjunction with a drilling programme for future wells. Construction of the Phase 1 gas gathering pipeline is now underway and due to be completed shortly while the LNG and LHe processing facility is currently undergoing detailed design and is anticipated to turn on in Q3 2021.Once commissioned, Tetra4 will begin producing up to 50 tons of LNG and 375kg of LHe per day under the Phase 1 project plan. The proposed Tetra4 Cluster 2 project will be located adjacent to the Phase 1 development.

The objective is to expand the existing production capabilities through the implementation of the Cluster 2 LNG/LHe processing facility. The overall project consists of two (2) main components namely, gas gathering, and the LNG/LHe process plant.

To date, Tetra4 has endeavoured to implement the strategic development plan as follows:
1) Assign a front-end engineering and design (FEED) scope of work to a potential future engineering, procurement, and construction (EPC) Contractor (the "Contractor") who is suitably qualified to design, procure, test, construct, commission and operate LNG and LHe facilities. The aim of this process is the

utilisation of typical technical solutions available from the Contractor's range of services and deliver a cost-effective and timeous solution (**Complete**).
2) Develop the FEED documentation based on the currently available Project information. This will be done in two stages: 1) Level III cost estimate definition and 2) Detailed FEED completion and EPC Proposal submission (**Partially complete**).
3) Contract the development of the FEED assessment, reimbursable at a lump sum price basis for which the Contractor will be compensated upon (**Yet to commence**) .

Cluster 2 is further elaborated as a targeted total feed gas flow from future wells; with the objective of producing up to 10 tones per day (tpd) LHe by 2025. This will be built in two (2) stages, each producing 5 tpd LHE, the first stage becoming operational in Q2 2023 and the second stage in 2025.

The scope of work associated with this document includes the change in design basis definition used for the LNG/LHe process plant development for the Cluster 2 expansion specifically (the "Project") which consists of processing the feed gas to deliver LNG and LHe products within the anticipated timelines[1].

1.1 Project Background

The Tetra4 project is situated in the Free State, South Africa, and entails the development of a gas gathering and LNG/He process plant. The production project area for the Cluster 2 project is situated in quaternary catchments C42K and C42L near Virginia. Works associated with the project, includes a gas gathering pipeline network that connects the proposed Cluster 2 wellhead locations to blower stations, compressor stations and ultimately the production plant. The gas gathering network is predominantly situated on agricultural land and/or government owned properties.

Whereas Phase 1 consisted primarily of the tying-in of existing wells, the Cluster 2 expansion will encompass an extensive drilling campaign for the establishment of up to circa 260 additional production wells making up the total feed gas supply associated with Cluster 2. With planning and development of this magnitude, various environmental requirements and activities need to be considered. This document serves as a guideline to identify the environmental authorisations that may be required.

The Cluster 2 project will likely require additional environmental authorisations, approvals, or assessments prior to installation. The Employer currently has environmental approvals, in terms of NEMA and MPRDA, to undertake exploration drilling. However, depending on the drilling locations, further approvals may be required from NWA including approvals for dewatering the waterlogged wells. Cluster 2 will require an Environmental Assessment Practitioner (EAP) to complete an Environmental Impact Assessment (EIA) in accordance with the National Environmental Management Act of 1998 (NEMA) and the relevant regulations, as amended. Ultimately to produce an Environmental Impact Assessment report along with all specialist studies and monitoring required for Environmental Authorisation[1].

Cluster 2 gas gathering consists of the following sections:

- Well grouping per Zone – Three (3) zones/areas (Zone 1, 2 and 3)
- Wellheads equipment installations- about 261 wells
- HDPE and Carbon Steel pipelines
- Blower Stations – Each well grouping to have a dedicated blower unit, cooling tower associated with booster pump and heat exchanger[1].

1.2 Operating Philosophy Description

1.3 Wellheads installations

Cluster 2 gas gathering consist of 261 wellheads from three Zones or Areas (Zone 1, Zone 2 and Zone 3) [1].

1.3.1 HPDE Underground Pipeline

The gas from wellheads is routed underground by a network of HDPE pipelines before the ti-in point with the aboveground carbon steel pipeline. The HPDE pipeline is installed with a gas sampling cabinet and isolation valve for maintenance[1].

1.3.2 Carbon Steel Aboveground Pipeline

HDPE will tie-in with the Carbon Steel pipeline aboveground. Each of the gas carbon steel lines are fitted with a manual pressure regulating valve (PRV) which is used to regulate the pressure in each line. The pressure is controlled to ensure positive forward displacement from the underground HDPE pipeline network and aboveground carbon steel pipeline network. Pressure differences at the wells might cause reverse flow and restrictions to flow in the underground HDPE pipeline network. Further the lines are fitted with flowmeters before the common header tie-in. The flowmeters are used to monitor the gas flowrates from individual wellheads. These flowmeters will be used for trouble shouting during the commissioning phase as well as during routine troubleshooting in the event of reduced flowrate within the network[1].

1.3.3 Pressure Indicators (PI)

Each carbon steel pipeline is fitted with local pressure indicators (PI) used to monitor the wellhead pressure before the tie-in point in coordination with manual pressure regulating valves[1].

1.4 Blower Station

1.4.1 Pressure Safety Valves (PSVs)

• Each of the blower suctions are all fitted with pressure safety valves (PSVs) to ensure that the maximum of 3.5 barg is not exceeded inside the line leading up to the blower unit. These safety valves are located upstream of the coalescer filters. These valves will discharge any gas if necessary to keep the pressure below the maximum allowable pressure. Downstream of the PSVs, the suction and discharge lines are fitted with Pressure Indicators and Transmitters (PITs) were the line pressures are monitored are the control room[1].

1.4.2 Coalescer Filters (FL)

The coalescer filter is used to separate any impurities, water, oil, dust etc. from the gas stream by means of coalescence. The filter is fitted with an impingement baffle which removes solids from the entering gas. Liquid is captured in the sump and the rest of the smaller impurities are removed by the coalescent cartridge. The coalescer filter passes the wet gas over high-surface area packing on which the water droplets consolidate. The water droplets are gravity separated down the filter into the sump. The coalescing filter at the blower station is equipped with a local differential pressure indicator transmitter (DPIT) to indicate if the filter requires cartridge cleaning or replacement. The operators are required to monitor the pressure drop readings from the compressor control rooms or central control room[1].

1.4.3 Centrifugal Blower

The Blower is used to increase and balance the incoming gas stream pressure from different wellheads connections. The blower is fitted with hand switches located at the control room for on/off. Further, the blower unit is fitted with a variable speed drive (VSD) to ramp the blower throughput up or down, depending on the pressure inputs from the pressure transmitters located at inlet manifold at distribution line[1].

1.4.4 Heat Exchanger & Cooling Tower

Due to expected temperature increase at the blower discharge (109°C), the Heat Exchanger (Shell and Tube) is used to cool down the gas stream temperature with water from the cooling tower to 50°C .The booster pump at the cooling tower will supply water through the heat exchanger at a rate of 5000 kg/hr. These lines are equipped with temperature and pressure monitoring instruments, which a operator shall monitor for deviations and early warning signs[1].

1.5 Compressor and Separation Station

1.5.1 Main Line

The gas from the wells, after filtration and through the blower unit will then be transported to the compression- and separation station. The line will be fitted with an emergency shut-down (ESD) valve which will be triggered in the case of an emergency shutdown or presence entrained oxygen. The flowmeter will be used for monitoring purposes and gas leak detection[1].

- Further the line is fitted with various instrumentation such as pressure indicators and transmitters, temperature indicators and transmitters which are used to monitor the compressor unit inlet and outlet conditions.
- Compressor and Separation Units – Each Zone to have a dedicator compressor and separation stations

1.5.2 Knockout Drum

The vertical knockout drum is used to remove any water particles still suspended in the gas stream. The operating principle of the knockout drum is to physically knock out most of the fluid. This is done through the following steps:

- Expand – the gas is expanded causing the velocity of the gas to slow and water droplets to fall.
- Baffle Plates – the gas strikes a series of baffle plates causing abrupt change in direction, forcing water droplets to be knocked out.
- Orientation – gas enters the knockout drum in the middle and the outlet is at the top. This uses gravity to pull liquid particles down, and gas will continue upwards.
- Demister - a demister located at the outlet of the knockout drum will remove any mist that might still be carried by the gas stream.

The knockout drum is installed to ensure the safe operation of the compressor immediately downstream. The liquid is collected in the liquid collection and drain zone and is then discharged accordingly to the sump tank.

1.5.3 Pressure Safety Valves (PSVs)

The outlet gas stream from the compressor (which is the inlet of the separation unit) is fitted with a pressure safety valve. This valve will be triggered once critical pressures are reached to ensure that the separation unit is not damaged. The set pressure will be defined in accordance with the compressor that will be procured, while the current design pressure is 30 barg.

1.5.4 Vendor Black Box Items

The black box items will be designed and manufactured by the suppliers/vendors. The inlet conditions will be specified by EPCM project team as well as the required outlet conditions. It will be the

responsibility of the vendors to ensure that the designed item will deliver the required outlet conditions. Datasheets for all the items will be available with the required conditions or information.
The intermediate piping, valves and instrumentation (pressure relief valves, pressure indicators and transmitters etc.) is designed and specified by EPCM.

The vendor black box items for the Compression and Separation Station includes the following:

- o The Compressor unit - used to compress the gas to 24 bar gauge;
- o A heat exchanger – used to cool the gas flow temperature to below 30ºC, knocking out water in the process.
- o Particle filter - used to remove the solid particulate from the gas line. This filter is rated to 0.1 micron.

Knockout drum: As described above, The vertical knockout drum is used to remove any water particles still suspended in the gas stream. The operating principle of the knockout drum is to physically knock out most of the fluid. This is done through the following steps:

This will be done by means of the following operation:
The water stream removed is routed to the site sump tank.
Oxygen Analyser (QAT): The gas stream will be analysed to measure the oxygen content of the gas. The gas is analysed to identify whether there is any oxygen ingress into the gas gathering system that can be harmful to the downstream equipment or the inherent safe design of the network. The oxygen content allowance for the helium plant is 0.8. The oxygen analyser is connected to the control system of the plant. The control system of the plant is detailed in the Control Philosophy document. 21001-VP4-PR-RPT-012.

1.5.5 Pressure Regulating and Control Valve

The pressure of the system from the compressor/separation units will then be regulated down to the allowable operating pressure of the trunk line, 24 bar gauge. A pressure control valve is added in parallel to allow for duty stand-by and maintenance procedures is dedicated for this purpose. These control valves will have a set pressure of 24 barg.

1.5.6 Pressure Safety Valve (PSV)

After the oxygen analyser, the line is fitted with a pressure safety valve to purge of gas when necessary to lower the pressure in the event of emergencies. The purged gas will be vented to the atmosphere at a safe location. All purge streams (or vent flows) conditions will be monitored with a vent flowmeter installed at the common vent stack. The readings will be monitored at the control room.

1.5.7 Flowmeter

• The flowmeter is fitted after the PSV in order to monitor the gas stream feeding the LNG/LHe plant. The readings are monitored at the control room and used for leak detection.

[1]Information provided by Renergen

2 QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

This present study has been conducted by Mrs Elize Butler. She has conducted approximately 300 palaeontological impact assessments for developments in the Free State, KwaZulu-Natal, Eastern, Central, and Northern Cape, Northwest, Gauteng, Limpopo, and Mpumalanga. She has an MSc (*cum laude*) in Zoology (specializing in Palaeontology) from the University of the Free State, South Africa and has been working in Palaeontology for more than twenty-five years. She has 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 (PSSA) since 2006 and 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**".

The identification, evaluation and assessment of any cultural heritage site, artefact or finds in the South African context is required and governed by the following legislation:

- National Environmental Management Act (NEMA) Act 107 of 1998
- National Heritage Resources Act (NHRA) Act 25 of 1999
- Notice 648 of the Government Gazette 45421- general requirements for undertaking an initial site sensitivity verification where no specific assessment protocol has been identified.

The next section in each Act is directly applicable to the identification, assessment, and evaluation of cultural heritage resources.

GNR 982 (Government Gazette 38282, 14 December 2014) promulgated under the National Environmental Management Act (NEMA) Act 107 of 1998

- Basic Assessment Report (BAR) – Regulations 19 and 23

- Environmental Impacts Assessment (EIA) – Regulation 23
- Environmental Scoping Report (ESR) – Regulation 21
- Environmental Management Programme (EMPr) – Regulations 19 and 23

National Heritage Resources Act (NHRA) Act 25 of 1999

- Protection of Heritage Resources – Sections 34 to 36
- Heritage Resources Management – Section 38

The NEMA (No 107 of 1998) states that an integrated EMP should (23:2 (b)) "…*identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage*".

In agreement with legislative requirements, EIA rating standards as well as SAHRA policies the following comprehensive and legally compatible PIA report have been compiled.

Figure 1: Location of the Tetra4 Gas Gathering Cluster 2 near Virginia in the Free State.

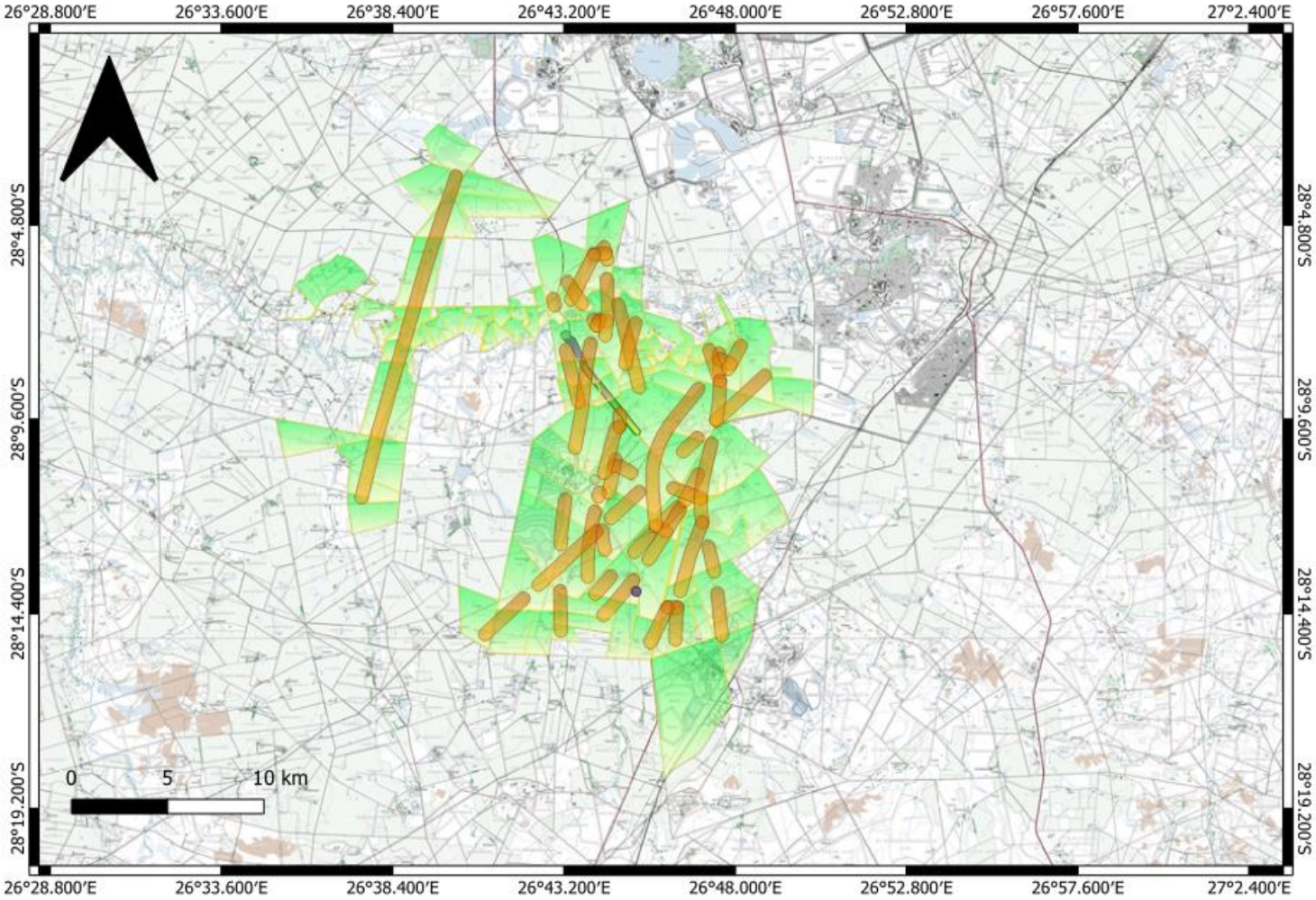


Figure 2: Locality Map of the proposed development.

Palaeontological heritage is exceptional and non-renewable and is protected by the NHRA. Palaeontological resources and 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 Palaeontological Impact assessment 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 aim of a PIA is to decrease the effect of the development on potential fossils at the development site.

According to the "SAHRA Archaeology, Palaeontology and Meteorites (APM) Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports" the purpose of the PIA is: **1)** to identify the palaeontological importance of the rock formations in the footprint; **2)** to evaluate the palaeontological magnitude of the formations; **3)** to clarify the **impact** on fossil heritage, and **4)** to suggest how the developer might protect and lessen possible damage to fossil heritage.

The palaeontological status of each rock section is calculated as well as the possible impact of the development on fossil heritage by a) the palaeontological importance of the rocks, b) the type of development and c) the quantity of bedrock removed.

When the development footprint has a moderate to high palaeontological sensitivity a field-based assessment is necessary. The desktop and the field survey of the exposed rock determine the impact significance of the planned development and recommendations for further studies or mitigation are made. Destructive impacts on palaeontological heritage usually only occur during the construction phase while the excavations will change the current topography and destruct or permanently seal-in fossils at or below the ground surface. Fossil Heritage will then no longer be accessible for scientific research.

Mitigation usually precede construction or may occur during construction when potentially fossiliferous bedrock is exposed. Mitigation comprises the collection and recording of fossils. Preceding excavation of any fossils a permit from SAHRA must be obtained and the material will have to be housed in a permitted institution. When mitigation is applied correctly, a positive impact as possible because our knowledge of local palaeontological heritage may be increased
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/kml's) in the proposed development.
- 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:
    a. **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.
    b. **Indirect impacts** of an activity are indirect or induced changes that may occur as a result of the activity.
    c. Cumulative impacts 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 HISTORY

The proposed Tetra4 Gas Gathering Cluster 2 project near Virginia in the Free State is depicted on the 1:250 000 Winburg 2826 Geological map (1998) Geological map (1989) (Council of Geoscience, Pretoria) (**Figure 3; Table 4**).The proposed Tetra4 development is underlain by Quaternary sediments (Qs, yellow), as well as Permian aged sandstone and shale of the Adelaide Subgroup (Pa, green) (Beaufort Group, Karoo Supergroup). According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments is Moderate, while that of the Adelaide Subgroup (Beaufort Group) is Very High (Almond and Pether, 2009; Almond *et al*., 2013, Groenewald et al 2014).

The Shape files (Council of Geosciences, Pretoria; **Figure 4**) refines the geology of the 1998 Geological Map and indicates that the proposed development is mainly underlain by alluvium, colluvium, eluvium, gravel, scree, sand, soil and debris while the Adelaide Subgroup is represented by the Balfour Formation. According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments is Moderate, while that of the Balfour Formation, Adelaide Subgroup, (Beaufort Group, Karoo Supergroup) is Very High (Almond and Pether, 2009; Almond *et al*., 2013, Groenewald et al 2014).

The Virginia/Welkom District is known for the presence of fluvial deposits along the present river courses that are terrestrial sediments and includes diatomite (diatom deposits), calcareous tufa, pedocretes, peats, spring deposits, soils and gravel and other Tertiary calcrete deposits, that is very important for understanding the Early and Late Pliocene period in this region (De Ruiter et al, 2010)..

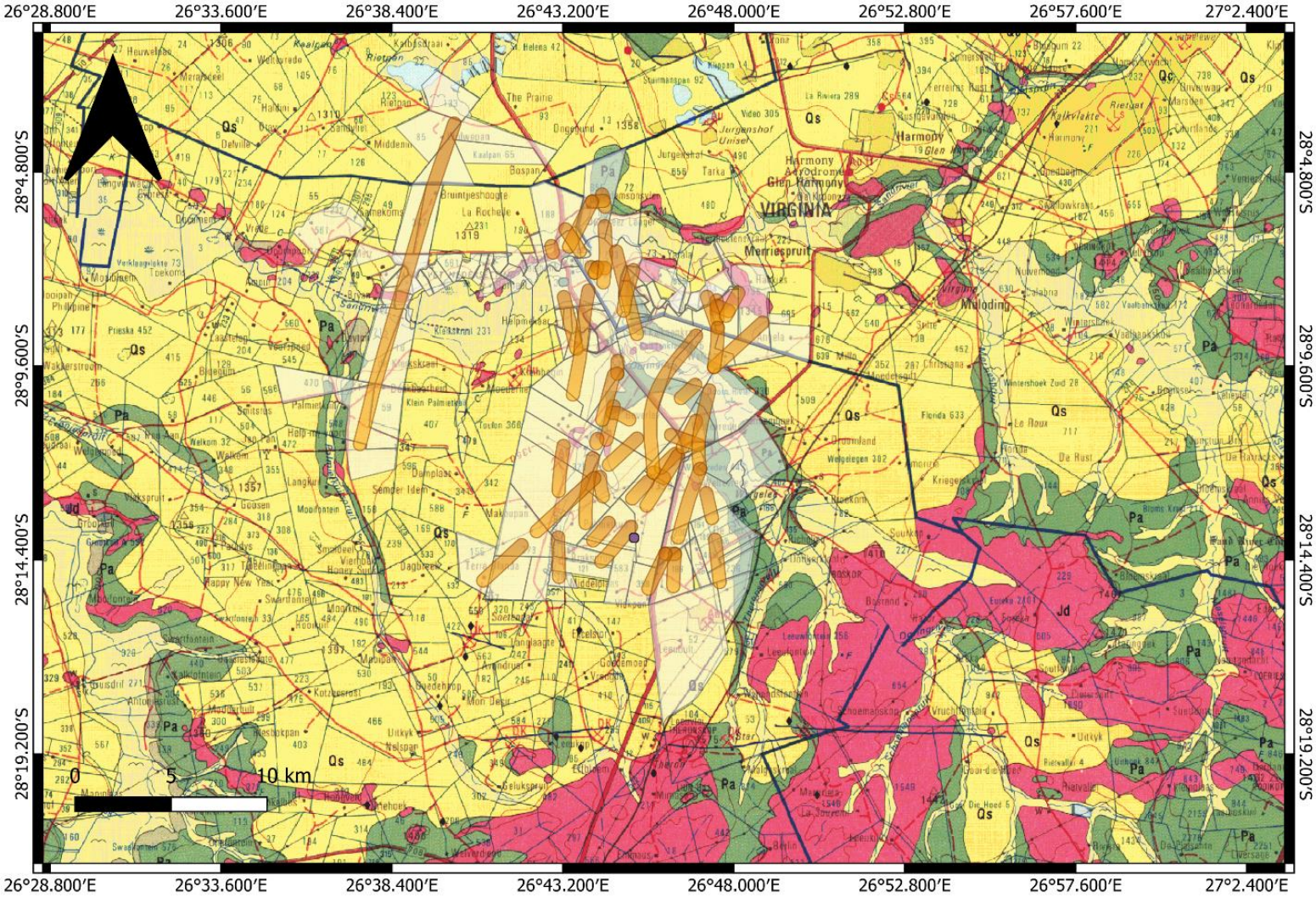
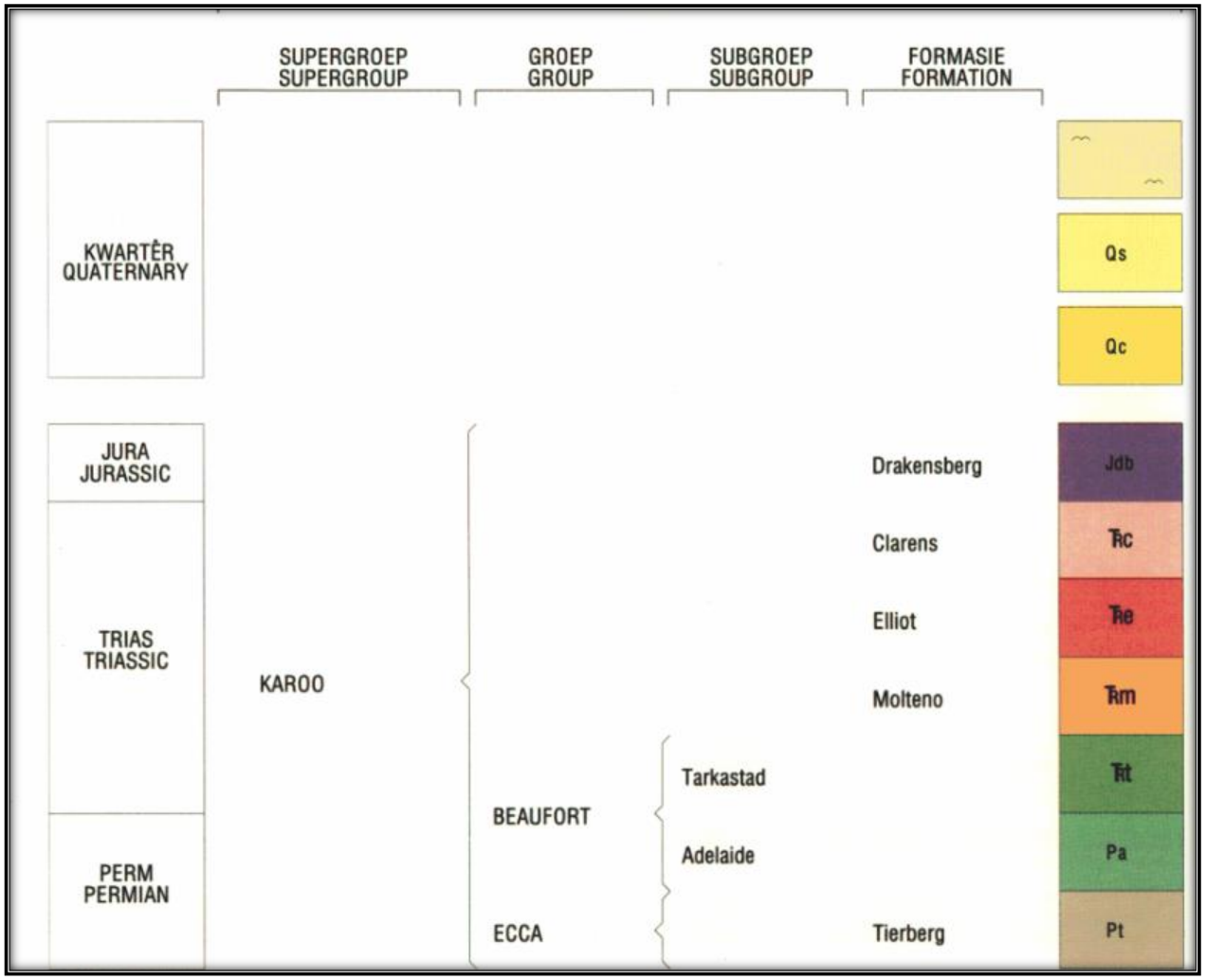


Figure 3: Extract of the 1:250 000 Winburg 2826 Geological map (1998) (Council of Geoscience, Pretoria) indicating the surface geology of the proposed development. The development is mainly underlain by Quaternary sediments (Qs, yellow) with a portion underlain by the Adelaide Subgroup (Pa) of the Beaufort Group (Karoo Supergroup).

Table 3: Legend of the 1:250 000 Winburg 2826 (1998) Geological map (Council of Geoscience, Pretoria)



The late Cenozoic (Plio-Pleistocene) floodplain deposits (overbank sediments) found near the Sand-, Doring-, Vals- and Vet River systems including pan sites, contain confined but abundant mammal vertebrate fossil sites. In 1955, Meiring, described an *in situ* proboscidian fossil (mammoth), comprising of a lower molar, large part of a tusk as well as a proximal portion of an ulna from the Sand River near Virginia. This specimen was found in pebbly channel-fill sediments about 40m above the current riverbed. This specimen was originally described as *Archidiskodon scotti* (Meiring 1955) but was later assigned to the Pliocene species *Mammuthus subplanifrons* (Coppens et al. 1978). Later investigations uncovered a diverse fauna that include amphibians, birds, fish, reptiles, as well as several proboscideans, perissodactyls and artiodactyls from the same site (De Ruiter 2010).

Terrace gravels above the Vet River, southwest of Welkom have uncovered Pliocene fossils while surveys along the Doring, Vals, Sand and Vet Rivers produced moderately fossiliferous overbank sediments and erosional gullies that comprise of a variety of Quaternary-aged mammals (Brink et al. 1999; De Ruiter et al. 2011) Ancient pan sites, for example near Whites produced rich Quaternary-aged mammal fossil remains.

South of the development is an extensive area underlain by Jurassic dolerite (Jd, red, **Figure 3-4**) The Jurassic dolerite present in the development form part of the Karoo Igneous Province is one of the worlds classic continental flood basalt (CFB) provinces. This Suite was formed approximately 183 million years ago and consists of intrusive and extrusive rocks that occur over a large area (Duncan et al, 2006). Generally, the flood basalts do not contribute to prominent volcanic structures but instead are formed by successive eruptions from a set of fissures that form sub-horizontal lava flows (sills and dikes) varying in thickness. This lava caps the landscape on which they erupted. As the Karoo is an old flood basalt province it is today preserved as erosional fragments of a more extensive lava cap that covered much of southern Africa in the geological past. It is estimated that the Karoo lava outcrop currently covered at least 140 000 km^2 while it was larger in the past [~2 000 000 km^2 (Cox 1970, 1972)]. The Karoo Igneous Province can be divided into the Lebombo and the Drakensberg Groups. This Igneous Province contains a large volume of flood basalts as well as silicic volcanic rocks. These units consist of hyodacite and rhyolitic magma and crops out along the Lebombo monocline. Individual units span up to 60 km and sometimes show massive pyroclastic structures and are thus classified as rheoignimbrites. The basal lavas lie conformably on the Clarens Formation but in specific localities, sandstone erosion occurred before the volcanic eruptions took place. Lock *et al* (1974) found evidence in the Eastern Cape that in the early stages of volcanism magma interacted with ground water to produce volcaniclastic deposits as well as phreatic and phreatomagmatic diatremes. Eales *et al* (1984) also found evidence of aqueous environments during early volcanism by the existence of pillow lavas and associated hyaloclastite breccias and thin lenses of fluviatile sandstones interbedded with the lowermost magmas.

Table 4: Legend of the 1:250 000 Winburg 2826 (1998) (Council of Geoscience, Pretoria)

Symbol	Age	Group/Formation		Lithology	Palaeontological Sensitivity
Qs	Quaternary	Quaternary		Alluvium, colluvium, eluvium, gravel, scree, sand, soil and debris	Moderate
Qc	Tertiary			Calcrete	High
Jd	Jurassic			Dolerite	Zero
Pa	Permian	Adelaide Subgroup	Beaufort Group Karoo Supergroup	Grey and brownish-red mudstone, subordinate sandstone	Very High
T_{RT}	Triassic	Tarkastad Subgroup		Brownish-red and grey mudstone, sandstone	Very High

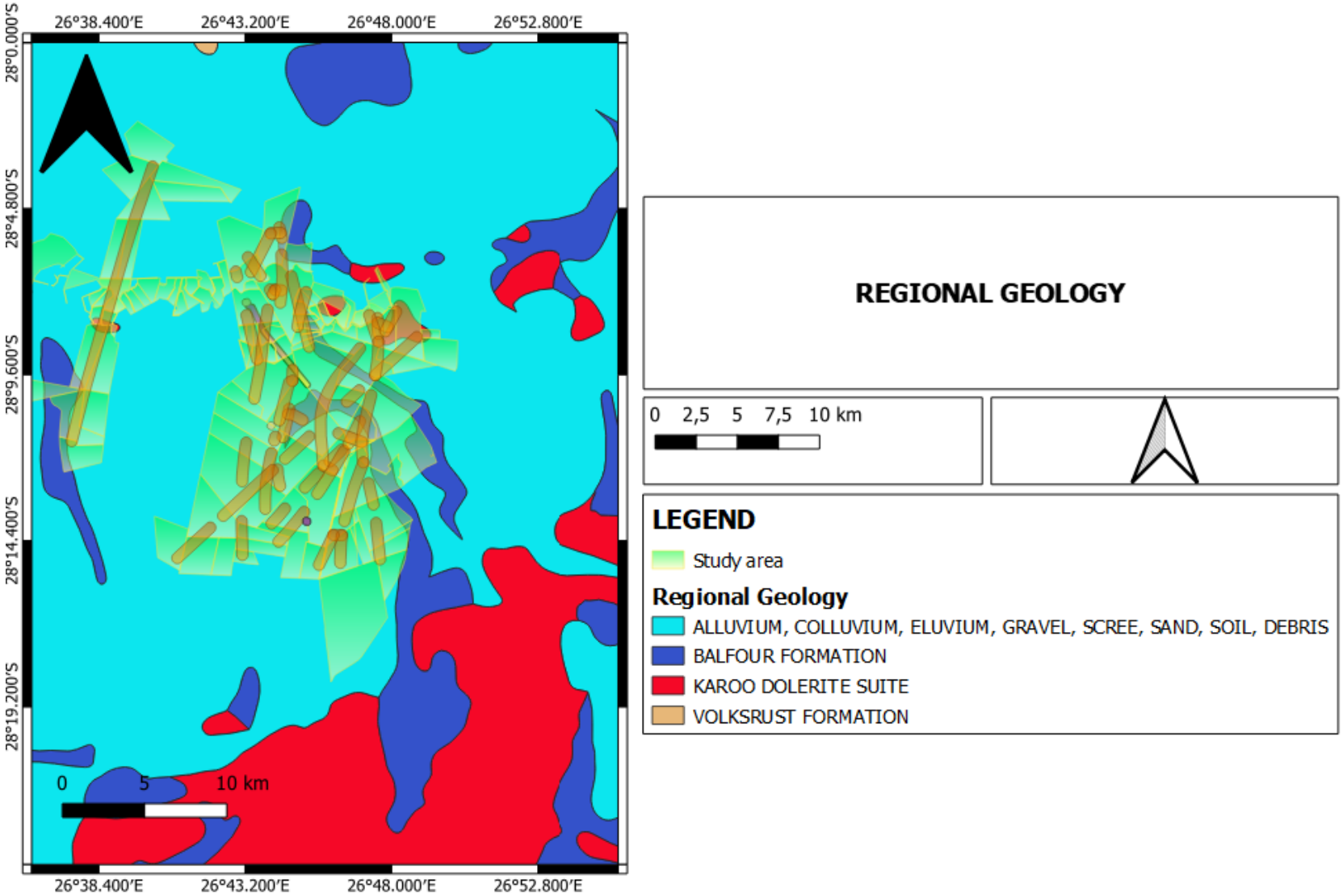


Figure 4: Surface Geology of the proposed mainly underlain by alluvium, colluvium, eluvium, gravel, scree, sand, soil and debris while the Adelaide Subgroup is represented by the Balfour Formation, Beaufort Group, Karoo Supergroup).

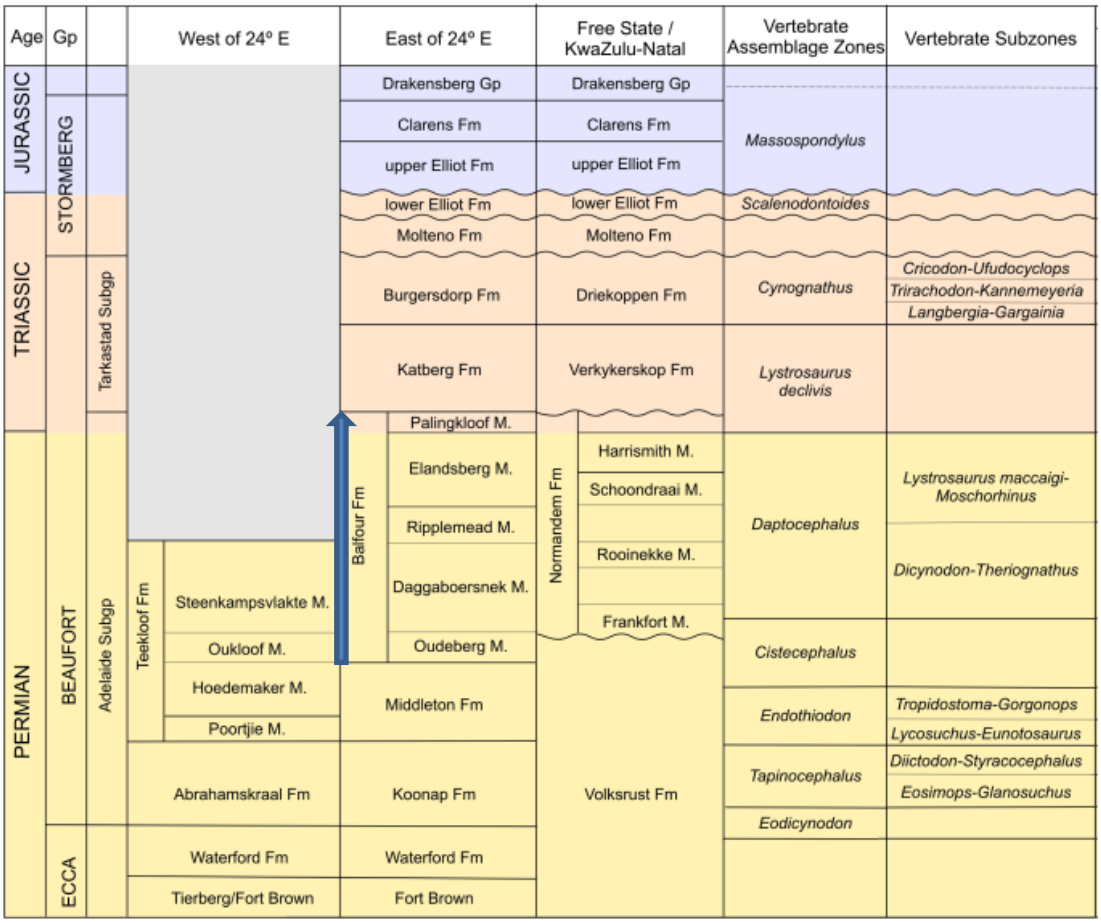


Figure 5: Vertebrate biozonation range chart for the Main Karoo Basin of South Africa. Solid lines indicate known ranges, dotted lines indicate suspected but not confirmed ranges, single dot represents the stratigraphic position of the taxa that have only been recovered from a single bed.

Wavy lines indicate unconformities. (PLYCSR=Pelycosauria and MAMMFMES+Mammaliaformes. Gp=group, Subgp-Supbroup, Fm=Formation, M=Member

The proposed cemetery development is indication by the blue arrow

The proposed development is underlain by a series of Karoo sandstones, mudstones, and shales, deposited under fluvial environments of the Adelaide Subgroup that forms part of the Beaufort Group (**Figure 5**). The Beaufort Group is the third of the main subdivisions of the Karoo Supergroup. The Beaufort group overlays the Ecca Group and consists essentially of sandstones and shales, deposited in the Karoo Basin from the Middle Permian to the early part of the Middle Triassic periods and was deposited on land through alluvial processes. The Beaufort Group covers a total land surface area of approximately 200 000 km^2 in South Africa and is the first fully continental sequence in the Karoo Supergroup and is divided into the Adelaide subgroup and the overlying Tarkastad subgroup. The Adelaide subgroup rocks are deposited under a humid climate that allowed for the establishment of wet floodplains with high water tables and are interpreted to be fluvio-lacustrine sediments.

In the south-eastern portion of the Karoo Basin, the Adelaide Subgroup consists of the Koonap, Middleton and Balfour Formations. West of 24° the Adelaide Subgroup is represented by the Teekloof and Abrahamskraal Formations and in the north, the Group (**Figure 5)** is represented by the Normandien Formation. The Adelaide Subgroup is approximately 5 000 m thick in the southeast, but this decreases to about 800m in the centre of the basin which decreases to about 100 to 200m in the north. The Koonop Formation is about 1 300 m, Middleton 1 600 m and the Balfour Formation approximately 200 m thick. The Abrahamskraal Formation is about 2 500 m thick and the Teekloof Formation 1 000 m. The Normandien Formation is only about 320 m thick.

The Adelaide Subgroup contains alternating greyish-red, bluish-grey, or greenish grey mudrocks in the southern and central parts of the Karoo Basin with very fine to medium-grained, grey lithofeldspathic sandstones. In the northern Normandien formation the basin consists of course to very coarse sandstones and granulostones. Coarsening–upward cycles are present in the lower part of the Normandien Formation while the mudrocks and sandstone units usually form fining-upward cycles. These cycles are positioned on erosion surfaces which is overlain by a thin intraformational mud-pellet conglomerate and vary in thickness from a few meters to tens of meters. Singular sandstone units could vary from 6m to 60m in the south thinning northwards, but thick sandstone units are also present in the northern Normandien Formation.

Thicker sandstones of the Adelaide are usually multi-storey and usually have cut-and-fill features. The sandstones are characterized internally by horizontal lamination together with parting lineation and less frequent trough crossbedding as well as current ripple lamination. The bases of the sandstone units are extensive beds, while ripple lamination is usually confined to thin sandstones towards the top of the thicker units.

The mudrocks of the Adelaide Subgroup usually have massive and blocky weathering apart from in the Normandien and Daggaboersnek Member. Sometimes desiccation cracks and impressions of raindrops are present. In the mudstones of the Beaufort Group calcareous nodules and concretions occur throughout.

The flood plains of the Beaufort Group (Karoo Supergroup) are internationally renowned for the early diversification of land vertebrates and provide the worlds' most complete transition from early "reptiles" to mammals. The Beaufort Group is subdivided into a series of biostratigraphic units based on its faunal content (Kitching1977, 1978; Keyser *et al*, 1977, Rubidge 1995, Smith *et al,* 2020; Viglietti 2020)). The portion if the proposed development is underlain by the Balfour Formation which is divided in the *Daptocephalus* (DAZ) which in turn is divided in the upper (younger) *Lystrosaurus maccaigi - Moschorhinus* and lower (older) *Dicynodon-Theriognathus Subzones* (Figure 5) (Viglietti, 2020).

The Upper Adelaide Subgroup consists of the following formation:

The *Daptocephalus* Assemblage Zone (AZ) expands into the lower Palingkloof of the Upper Balfour Formation. This Zone is characterized by the occurrence of the two therapsids namely *Dicynodon* and *Theriognathus*. The *Daptocephalus* Assemblage Zone of the Beaufort Group shows the greatest vertebrate diversity and includes numerous well-preserved genera and species of dicynodonts, biarmosuchians, gorgonopsian, therocephalian and cynodont therapsid Synapsida. Captorhinid Reptilia are also present while eosuchian Reptilia, Amphibia and Pisces are rarer in occurrence. Trace fossils of vertebrates and invertebrates as well as *Glossopteris* flora plants have also been described.

The lower Palingkloof Member is of special importance as it precedes the Permo-Triassic Extinction Event which destroyed the vertebrate fauna and extinguished the diverse glossopterid plants. The lower *Lystrosaurus* declivis AZ forms part of the Katberg Formation. Fauna and flora from this assemblage zone is rare as few genera survived the Permo-Triassic Extinction Event. The *Lystrosaurus* declivis AZ is characterized by the dicynodont, *Lystrosaurus*, and captorhinid reptile, *Procolophon,* biarmosuchian and gorgonopsian Therapsida did not survive into the *Lystrosaurus* Assemblage Zone although the therocephalian and cynodont Therapsida are present in moderate quantities. Captorhinid Reptilia is reduced, but this interval is characterised by a unique diversity of oversize amphibians while fossil fish, millipedes and diverse trace fossils have also been recorded.

In 2016, Shango developed a 3D geological model of the underlying hard-rocks in the Virginia study area. **Figure 6** indicates a cross section through the centre of the project and shows that the formations of the Karoo Supergroup expands to about 380m. According to this reports the latter forms aquifers from which groundwater are extracted.

- The Sand and Doring River floodplains comprise of alluvium that could be up to 20m thick but are generally about 5m thick. The alluvium comprise of gravel and sand interbedded with clay material lenses.
- The majority of the development is underlain by aeolian sands that are reddish in colour and are interspersed with ferricrete and calcrete.
- Karroo dolerite intrusions in the Virginia area comprise of sills and dikes. These intrusions are generally found in the arenaceous layers of the Adelaide Subgroup compared to the argillaceous Volksrust Formation. If dolerite intrusions are present in the shales of the Volksrust Formation it has a tendency to follow the base of the shales. While some dikes are several km long, they are generally steep-dipping and thin (thinner than 5m). Exploration information proposes that dolerite sills may be more than 100m thick.

Exploration drilling indicates that the Karoo Supergroup in the development area is underlain by the Witwatersrand Supergroup that comprises of the quartzite and shales and contains the gold-bearing reefs of the surrounding mines. The Witwatersrand Supergroup is represented by

the older West Rand Group and the younger Central Rand Group. The West Rand Group in the Welkom Goldfield has largely been unstudied. The Central Rand Group comprise of conglomerates and quartzites and includes the EA – ED, Rosedale, VS5, Steyn, Beatrix, B, and Basal gold reefs. In the Welkom Goldfield the Central Rand Group sediments is thicker than 2000m

The Ventersdorp Supergroup consist of the Klipriviersberg and Platberg Groups as well as the sedimentary Bothaville and volcanic Allenridge Formations. The Klipriviersberg Group is volcanic in nature and generally comprise of tuff, lava and is about 1700m at its thickest. The Platberg Group, contains clastic, chemical sediments to mafic and felsic volcanics. This Group is more than 6800m at its thickest. The sedimentary Bothaville Formation, overlies the Platberg Group with an unconformity. This Formation comprises of quartzites and conglomerate, while it has a maximum thickness of more than 400m. The Allanridge Formation is volcanic in nature and comprises mainly of pyroclastic rocks as well as dark-green amygdaloidal lava. This Formation reaches a maximum thickness of about 750m.

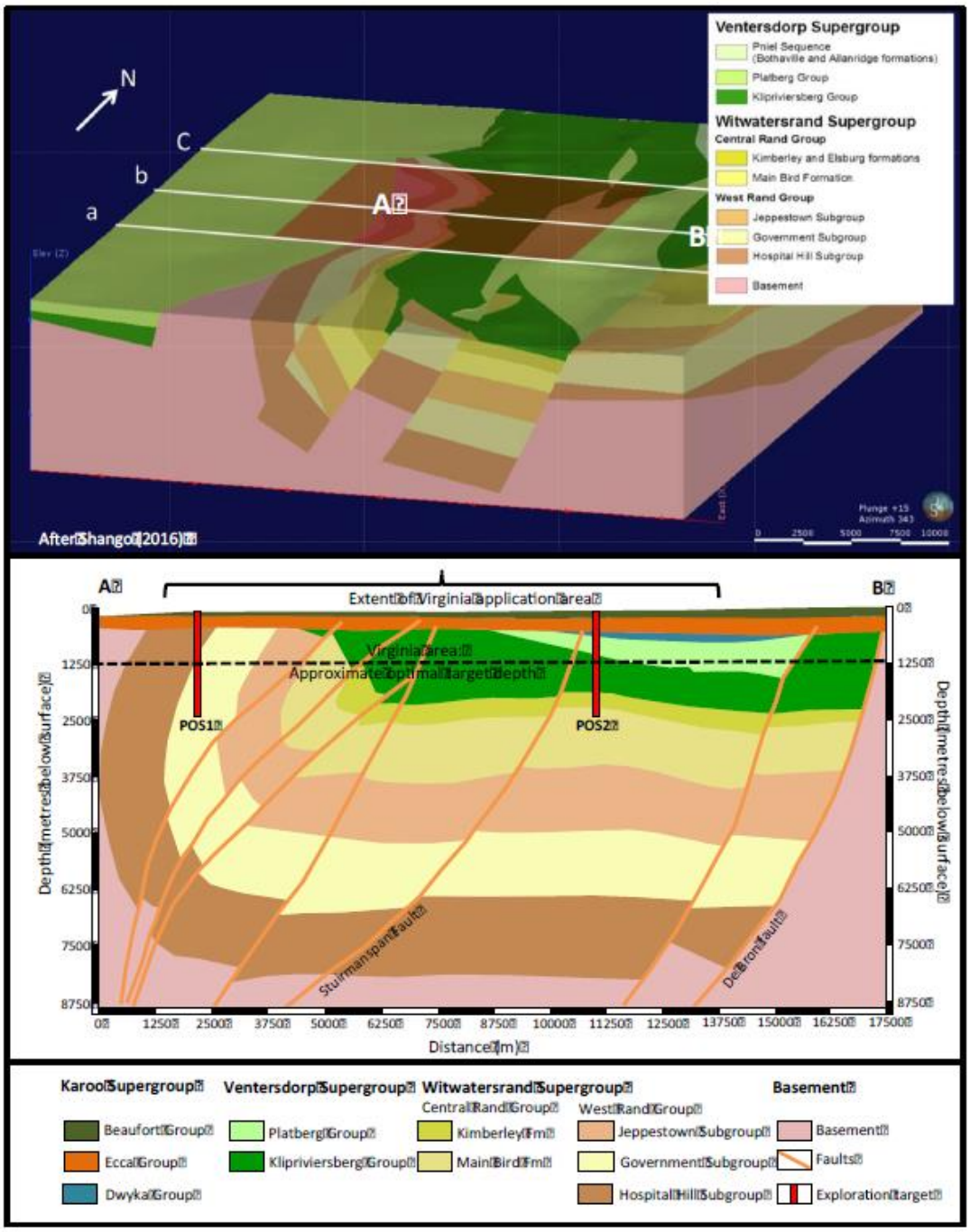


Figure 6*: Cross section of the regional geology of the Virginia area (Shango, 2016.)*

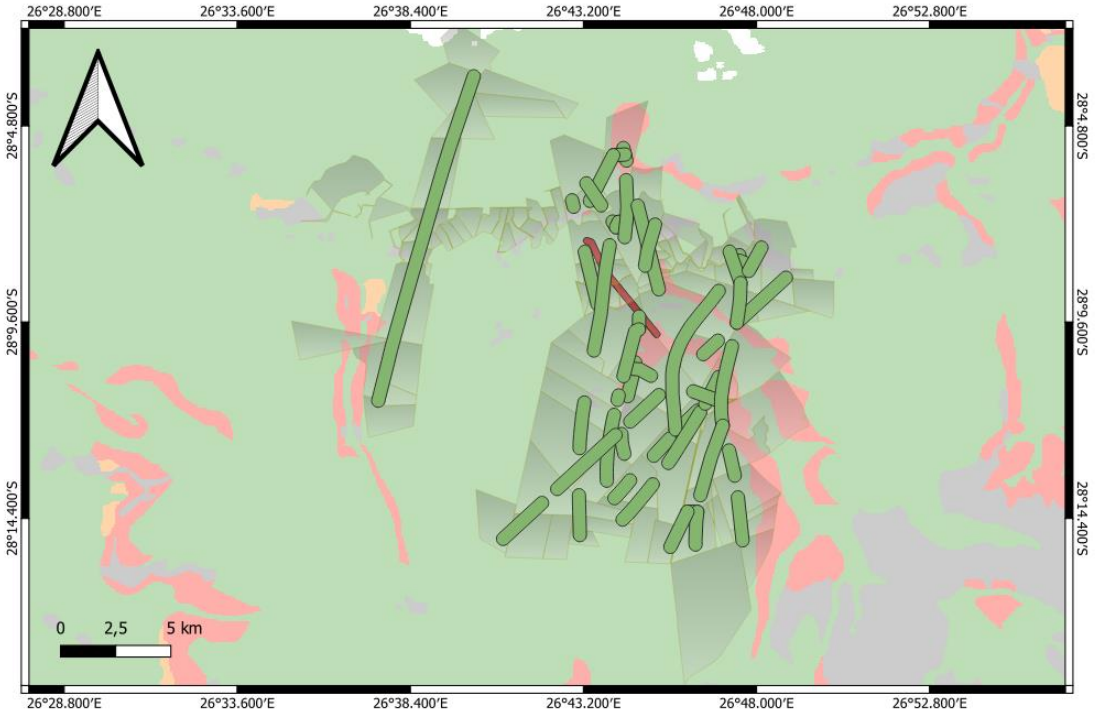


Figure 7: Extract of the 1 in 250 000 SAHRIS PalaeoMap map (Council of Geosciences) indicating the proposed development in red and green.

According to the SAHRIS Palaeosensitivity map (**Figure 7)** the proposed development is underlain by sediments with a Very High (red), and Moderate (green) Palaeontological Sensitivity.

Table 5: Palaeontological Sensitivity on SAHRIS

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.

The colours on the PalaeoMap indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

6 GEOGRAPHICAL LOCATION OF THE SITE

The project area for the Tetra4 Cluster 2 is situated about 12km south-west of Virginia and 10 Km south of Welkom. The gas gathering network is mostly on agricultural land and/or government owned properties.

7 METHODS

The aim of a desktop study is to evaluate the risk to palaeontological heritage in the proposed development. This includes all trace fossils and fossils. All available information is consulted to compile a desktop study and includes PIA reports in the same area, aerial photos, and Google Earth images, topographical as well as geological maps.

7.1 Assumptions and Limitations

When conducting a PIA several factors can affect the accuracy of the assessment. The focal point of geological maps is the geology of the area and the sheet explanations were not meant to focus on palaeontological heritage. Many inaccessible regions of South Africa have not been reviewed by palaeontologists and data is generally based on aerial photographs. Locality and geological information of museums and universities databases have not been kept up to date or data collected in the past have not always been accurately documented.

Comparable Assemblage Zones in other areas is used to provide information on the existence of fossils in an area which was not yet been documented. When similar Assemblage Zones and geological formations for Desktop studies is used it is generally **assumed** that exposed fossil heritage is present within the footprint.

8 ADDITIONAL INFORMATION CONSULTED

In compiling this report the following sources were consulted:

- Geological map 1:100 000, Geology of the Republic of South Africa (Visser 1984)
- 1: 250 000 Winburg 2826 Geological map (1998) (Council of Geoscience, Pretoria)
- A Google Earth map with polygons of the proposed development was obtained from PGS Consultants.

9 SITE VISIT

A 2-day site-specific field survey of the development footprint was conducted on foot and by a motor vehicle on 26 to 27 February 2021. The Adelaide Subgroup of the Proposed development was investigated for possible fossiliferous outcrops as it has a Very High Palaeontological Sensitivity. It is important to note that the central parts of the country experienced an exceptional wet season and the whole development is covered by lush vegetation. **No** visible evidence of fossiliferous outcrops was found in the development footprint.

Figure 8: View from the north overlooking the proposed development

GPS coordinates -28.089722*;* 26.730556

Figure 9: The banks of the Sand River

GPS coordinates- -28.106389° 26.736111°

Figure 10: Lush Vegetation without any visible outcrop

GPS Coordinates - 8.123056, 26.747500

Figure 11: Vegetation in the centre of the development .

GPS Coordinates -28.125278, 26.751667

Figure 12: Proposed power line locality and corridor is covered by grass and small bushes

GPS coordinates -31.638333; 23.205000

Figure 13: Lush vegetation in the development footprint
GPS coordinates -31.638333; 23.205000

10 IMPACT ASSESSMENT METHODOLOGY

10.1 Introduction

11 IMPACT ASSESSMENT METHODOLOGY

The following section provides an analysis of the proposed development on heritage resources within the study area.

The impact significance rating methodology, as provided by EIMS, is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S). possible, mitigation measures will be recommended for the impacts identified.

11.1 DETERMINATION OF ENVIRONMENTAL RISK

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER). The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. The consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology, the consequence of the impact is represented by:

$$\boldsymbol{C = \underline{(E+D+M+R) \times N}}$$
$$\boldsymbol{4}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in **Table 6** below.

Table 6: Criteria for Determining Impact Consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact

Aspect	Score	Definition
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined, the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/ scored as per Table 7.

Table 7: Probability Scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur)

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

ER= C x P

Table 8: Determination of Environmental Risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
	0	1	2	3	4	5
	Probability					

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in **Table 9**.

Table 9: Significance Classes

Environmental Risk Score	
Value	**Description**
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk).
≥9 - <17	Medium (i.e. where the impact could have a significant environmental risk),
≥17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post-implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

11.2 IMPACT PRIORITISATION

Further to the assessment criteria presented in the section above, it is necessary to assess each potentially significant impact in terms of:

1. Cumulative impacts; and
2. The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 10: Criteria for Determining Prioritisation

Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/ definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable Loss of Resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 11. The impact priority is therefore determined as follows:

Priority = CI + LR

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (Refer to **Table 11**).

Table 11: Determination of Prioritisation Factor

Priority	Ranking	Prioritisation Factor
2	Low	**1**
3	Medium	**1.125**
4	Medium	**1.25**
5	Medium	**1.375**
6	High	**1.5**

In order to determine the final impact significance, the PF is multiplied by the ER of the post-mitigation scoring. The ultimate aim of the PF is an attempt to increase the post-mitigation environmental risk rating by a full ranking class if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential and significant potential for irreplaceable loss of resources, then the net result would be too upscale the impact to a high significance).

Table 12: Final Environmental Significance Rating

Environmental Significance Rating	
Value	**Description**
< -17	High negative (i.e. where the impact must have an influence on the decision process to develop in the area).
≥ -17 ≤ -9	Medium negative (i.e. where the impact could influence the decision to develop in the area).
> -9, <0	Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).
0	No impact
<0, <9	Low positive (i.e. where this impact would not have a direct influence on the decision to develop in the area).
≥ 19 ≤ 17	Medium positive (i.e. where the impact could influence the decision to develop in the area).
≥ 217	High positive (i.e. where the impact must have an influence on the decision process to develop in the area).

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.

Table 13: Impact rating for heritage resources

IMPACT DESCRIPTION			Pre-Mitigation							Post Mitigation								Priority Factor Criteria			
Identifier	Impact	Nature	Extent	Duration		Magnitude	Reversibility	Probability	Pre-mitigation ER	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Post-mitigation ER	Confidence	Cumulative Impact	Irreplaceable loss	Priority Factor	Final score
10.1.1	Impact on palaeontology	-1	4	5		4	5	4	-18	-1	4	5	2	5	2	-8	Medium	2	3	1.375	-11

Impact of the development will be regional. The proposed development will have a negative impact on Fossil Heritage. The expected duration of the impact is assessed as potentially permanent to long term. The impact could occur. The significance of the impact occurring will be Very High. As fossil heritage will be destroyed the impact is irreversible. The impact on fossil heritage will be Very High pre-mitigation and Moderate post-mitigation.

12 FINDINGS AND RECOMMENDATIONS

Banzai Environmental was appointed by PGS Heritage (Pty) Ltd to conduct the Palaeontological Impact Assessment (PIA) to assess the proposed Tetra 4 Cluster 2 Project, southwest of Matjhabeng (formerly Virginia) in the Free State. In accordance with the National Environmental Management Act 107 of 1998 (NEMA) and to comply with the National Heritage Resources Act (No 25 of 1999, section 38) (NHRA), this PIA is necessary to confirm if fossil material could potentially be present in the planned development area, to evaluate the potential impact of the proposed development on the Palaeontological Heritage and to mitigate possible damage to fossil resources.

The proposed Tetra4 development is underlain by Quaternary sediments as well as Permian aged sandstone and shale of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup). According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments in this area is Moderate, while that of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) is Very High.

A 2-day site-specific field survey of the development footprint was conducted on foot and by a motor vehicle on 26 to 27 February 2021. No visible evidence of fossiliferous outcrops was found in the development footprint and thus an overall medium palaeontological significance is allocated to the development footprint. It is therefore considered that the proposed development will not lead to detrimental impacts on the palaeontological reserves of the area and construction of the development may be authorised in its whole extent.

Recommendations:

- The ECO for this project must be informed that the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) has a **Very High Palaeontological Sensitivity**.

- If Palaeontological Heritage is uncovered during surface clearing and excavations the **Chance find Protocol** attached should be implemented immediately. Fossil discoveries ought to be protected and the ECO/site manager must report to South African Heritage Resources 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) so that mitigation (recording and collection) can be carried out.

- Before any fossil material can be collected from the development site the specialist involved would need to apply for a collection permit from SAHRA. Fossil material must be housed in an official collection (museum or university), while all reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012).
- These recommendations should be incorporated into the Environmental Management Plan for the Tetra4 Development.

13 CHANCE FINDS PROTOCOL

A following procedure will only be followed if fossils are uncovered during excavation.

13.1 Legislation

Cultural Heritage in South Africa (includes all heritage resources) is protected by the **National Heritage Resources Act (Act 25 of 1999) (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 citizens of South Africa. Palaeontological resources may not be excavated, 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.

13.2 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 millions of years ago. 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.

13.3 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 Environmental Site Officer (ESO) or site manager 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 ESO, 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.

13.4 Chance Find Procedure

- If a chance find is made the person responsible for the find must immediately **stop working** and all work that could impact that finding 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 ESO or site manager. The ESO or site manager 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 coordinates.
- 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 ESO (or 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 ESO (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 on the affected area.

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APPENDIX A – ELIZE BUTLER CV

ELIZE BUTLER

PROFESSION:	Palaeontologist
YEARS' EXPERIENCE:	26 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

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

TECHNICAL REPORTS

Butler, E. 2014. Palaeontological Impact Assessment of the proposed development of private dwellings on portion 5 of farm 304 Matjesfontein Keurboomstrand, Knysna District, Western Cape Province. Bloemfontein.

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