Palaeontological Desktop Assessment for the Cluster 2 Seismic Survey investigations by Tetra4/Renergen Ltd., on multiple farm portions. Mathjabeng Local Municipality, Lejeweleputswa District Municipality, Free State Province.

Palaeontological Desktop Assessment

Template Number	Document Number	Revision	Date
PGS PJ REP 007 01	942HIA-002	1.0	30 January 2026

PGS HERITAGE
+ 27 (0) 12 332 5305
+27 (0) 86 675 8077
contact@pgsheritage.com
Block D, The Village,
307 Glenwood Drive,
Fearie Glen, 0043

Offices in South Africa, Kingdom of Lesotho, Mozambique and Portugal

Head Office:
Block D
The Village
307 Glenwood Road
Faerie Glen Pretoria,
South Africa

Directors: HS Steyn, PD Birkholtz, W Fourie

REVISION HISTORY

Version	Issue Date	Description of Changes
01	30 January 2026	First draft

Specialist Declaration for assessments undertaken for application for authorisation in terms of the National Environmental Management Act (Act 107 of 1998) as amended and the Environmental Impact Assessment Regulations (Government Notice 982, Government Gazette 38282, 4 December 2014) as amended

I, Elize Butler declare that –

- I act as the independent specialist in this application;
- I am aware of the procedures and requirements for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (Act 107 of 1998) as amended, when applying for environmental authorisation which were promulgated in Government Notice 320 (Government Gazette 43110, 20 March 2020) and in Government Notice 1150 (Government Gazette 43855, 30 October 2020).
- 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 the specialist report relevant to this application, 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 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;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of the Environmental Impact Assessment Regulations (Government Notice R982, Government Gazette 38282, 4 December 2014) as amended and is punishable in terms of section 24F of the National Environmental Management Act (Act 107 of 1998).
- I will take into account, to the extent possible, the matters listed in section 38 of the National Heritage Resources Act (Act 25 of 1999) when preparing the application and any report relating to the application.

HERITAGE CONSULTANT: PGS Heritage (Pty) Ltd

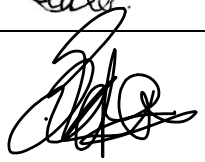
CONTACT PERSON: Elize Butler – Palaeontologist

Tel: +27 (0) 12 332 5305

Email:

SIGNATURE: 

ACKNOWLEDGEMENT OF RECEIPT

Report Title	Palaeontological Desktop Assessment for the Cluster 2 Seismic Survey investigations by Tetra4/Renergen Ltd., on multiple farm portions. Mathjabeng Local Municipality, Lejeweleputswa District Municipality, Free State Province.		
Control	**Name**	**Signature**	**Designation**
Author	Elize Butler		**PGS Heritage** – Associate Palaeontologist
Reviewed	Dr Alexander Andreou		**PGS Heritage** - Heritage Advisory Unit Manager and Senior Heritage Specialist

CLIENT: **Environmental Impact Management Services (Pty) Ltd.**

CONTACT PERSON: **Jessica Jordaan**
Soil Scientist
jessica@eims.co.za

SIGNATURE: _____

This Palaeontological Impact Assessment report (as part of the Heritage Impact Assessment) has been compiled considering the Environmental Impact Assessment Regulations (Government Notice 982, Government Gazette 38282, 4 December 2014) Appendix 6 as amended by Government Notice 326 (Government Gazette 40772, 7 April 2017) requirements for specialist reports as indicated in the table below:

Requirements Environmental Impact Assessment Regulations (Government Notice 982, Government Gazette 38282, 4 December 2014) Appendix 6 as amended	The relevant section in the report
1. (1) (a) (i) Details of the specialist who prepared the report	Page iii and Section 1.2 of the Report – Contact details and company, and Appendix B
(ii) The expertise of that person to compile a specialist report, including a curriculum vitae	Section 1.2 – refer to Appendix B
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page iii of the report
(c) An indication of the scope of, and the purpose for which, the report was prepared	Section 3 – Approach and Methodology
(cA) An indication of the quality and age of the base data used for the specialist report	Section 4.1 – Geological and Palaeontological History of the Baseline Environment
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development, and levels of acceptable change;	Section 3
(d) The duration, date, and season of the site investigation and the relevance of the season to the outcome of the assessment	Desktop Assessment
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process, inclusive of equipment and modelling used	Section 3 – Assessment Methodology
(f) Details of an assessment of the specifically 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;	Sections 3
(g) An identification of any areas to be avoided, including buffers	Executive Summary and Sections 5
(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 4 – Geological and Palaeontological History
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.3 – Assumptions and Limitations
(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	Executive Summary and 5
(k) Any mitigation measures for inclusion in the EMPr	Executive Summary, 5 and 6
(l) Any conditions for inclusion in the environmental authorisation	Executive Summary and 5
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Executive Summary, 5 and 6
(n)(i) A reasoned opinion as to whether the proposed activity, activities, or portions thereof should be authorised and	Executive Summary and 5
(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	Executive Summary and 5
(o) A description of any consultation process that was undertaken during the carrying out of the study	Not applicable. A public consultation process was handled as part of the Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) process.
(p) A summary and copies of any comments that were received during any consultation process	Not applicable. To date, no comments regarding heritage resources that require input from a specialist have been raised.

Requirements Environmental Impact Assessment Regulations (Government Notice 982, Government Gazette 38282, 4 December 2014) Appendix 6 as amended	The relevant section in the report
(q) Any other information requested by the competent authority.	N/A
(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 1.4: Compliance with SAHRA guidelines

EXECUTIVE SUMMARY

PGS Heritage (Pty) Ltd was appointed to conduct the Heritage Impact Assessment (HIA) (archaeology and palaeontology) for the proposed Tetra4 3-D Seismic Survey Project, in the Virginia Region, Free State, South Africa. This study is the Palaeontological Desktop Assessment (PDA) for the proposed project. In compliance with the National Environmental Management Act (Act No. 107 of 1998) (NEMA) and the National Heritage Resources Act (Act No. 25 of 1999, Section 38) (NHRA), this PDA aims to determine the potential presence of fossil material within the proposed development area, assess the likely impact of the project on palaeontological heritage, and recommend appropriate mitigation measures to protect any fossil resources that may be affected.

The proposed Tetra4 3D Seismic Survey Project is underlain by Quaternary alluvium, Superficial sands, the dolerite of the Karoo Igneous Province as well as the Adelaide Subgroup of the Karoo Supergroup. According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments is Moderate, that of the Karoo Igneous Suite is Zero, while that of the Adelaide Subgroup (Beaufort Group) is Very High (Almond and Pether, 2009; Almond *et al*., 2013, Groenewald et al 2014). Palaeontological Sensitivity generated by the Department of Forestry, Fisheries and the Environment National Environmental Web-Based (DFFE) Screening Tool indicates a Very High Palaeontological Sensitivity. Recent research has indicated that the Adelaide Subgroup is represented by the Balfour Formation.

No field-based palaeontological site investigation was undertaken, as the proposed Tetra4 3D seismic survey is non-invasive in nature and will not involve any excavation, drilling or ground penetration. The survey will be undertaken using vibroseis source vehicles and surface-deployed geophones to generate and record controlled seismic vibrations for the purpose of producing a three-dimensional subsurface geological model. All activities will be confined to surface operations along predefined survey lines.

Although the SAHRIS PalaeoMap indicates that the study area falls within a zone of Very High Palaeontological Sensitivity, the significance of potential impacts associated with the proposed survey is assessed as Very Low, owing to the non-invasive nature of the activities. As no vegetation clearance or subsurface disturbance will occur, the proposed survey is not expected to result in any direct impacts on palaeontological heritage resources.

Should any fossil material be encountered during any phase of the project, whether exposed at surface or during unforeseen ground-disturbing activities, the Chance Find Protocol (refer to Section 6 of this report) must be implemented immediately by the Environmental Control Officer (ECO) or the responsible site manager. All fossil discoveries must be protected in situ and reported to the South African Heritage Resources Agency (SAHRA) to ensure that appropriate recording and, where necessary, collection can be undertaken by a qualified palaeontologist.

Prior to the collection of any fossil material, a permit must be obtained from SAHRA by the appointed specialist. All collected material must be curated in an accredited museum or university repository, and all reporting and fieldwork must comply with the minimum standards for palaeontological impact studies as prescribed by SAHRA (2012). It is therefore recommended that no further palaeontological studies, field verification or mitigation measures are required, unless previously unknown fossil material is discovered.

These recommendations should be incorporated into the Environmental Management Programme for the proposed Tetra4 3D Seismic Survey Project near Virginia, in the Free State Province

TABLE OF CONTENT

List of Figures

List of Tables

List of Appendices

ABBREVIATIONS AND TERMINOLOGY

Abbreviations	Description
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
CA	National Competent Authority
CV	Curriculum Vitae
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
ECO	Environmental Control Officer
EJV	Exploration Joint Venture
EMPr	Environmental Management Programme
ESO	Environmental Site Officer
HIA	Heritage Impact Assessment
Ma	Millions of years ago
NEMA	National Environmental Management Act
NHRA	National Heritage Resources Act
PDA	Palaeontological Desktop Assessment
PIA	Palaeontological Impact Assessment
PSSA	Palaeontological Society of South Africa
SAHRA	South African Heritage Resources Agency
SAHRIS	South African Heritage Resources Information System
S&EIA	Scoping & Environmental Impact Assessment
ToR	Terms of Reference

Fossil

A fossil is the preserved remains or traces of an organism that lived in the distant past, typically millions of years ago. These remains may include shells, mineralised bones, and other hard parts of ancient animals and plants, as well as impressions, moulds, and casts left in sedimentary rocks where organic material has decayed. Fossils offer important insights into the history of life on Earth, enabling scientists to study the evolution, diversity, and distribution of past organisms and ecosystems.

Heritage

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

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 National Heritage Resources Act (Act 25 of 1999) as amended,

- 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.

Palaeontology

Palaeontology is the scientific study of ancient life through time and entails the examination of fossils—remains, traces, or impressions of organisms preserved in rocks. It seeks to understand the evolution, diversity, and interactions of past life forms, as well as the environmental conditions in which they lived. By integrating geology and biology, palaeontology provides crucial insights into the history of life on Earth over geological time.

The term palaeontology derives from the Latin palaeontologia, which in turn originates from the Greek words palaios (παλαιός), meaning “ancient,” and ontos (ὄντος), meaning “being” or “creature,” combined with the suffix -logia, meaning “study of.” The literal translation is therefore “the study of ancient beings.” In English usage, the classical Latin, British and South African spelling is palaeontology, while the American spelling omits the a after the p, rendering paleontology. In this report the Latin, English and South African spelling of Palaeontology will be used.

1 INTRODUCTION

Tetra4 (Pty) Ltd is a South African natural gas and helium producer that possesses the country's first, and presently only, onshore petroleum production right. The Free State gas fields at Welkom, Virginia, and Theunissen are the primary focus of its operations.

Following the successful commencement of gas production from Cluster 1 in 2022, Tetra4 applied for the required environmental authorisations to expand its natural gas operations within and around the approved production right area, referred to as *Cluster 2*. The Cluster 2 application area covers approximately 27 500 hectares and overlaps substantially with the Cluster 1 area. The Cluster 2 Environmental Authorisation (EA) approved a number of production well transects within which drilling may take place, rather than specifying fixed drilling locations.

As a result, uncertainty has arisen among landowners regarding the potential location of future drilling activities. To address this uncertainty, and to generate a high-resolution subsurface geological model that will enable more accurate identification of drilling locations on individual properties, Tetra4 proposes to undertake a 3D seismic survey across the Cluster 2 area.

Environmental Impact Management Services (EIMS) was appointed by Tetra4 (Pty) Ltd (the Applicant) as the Environmental Assessment Practitioner (EAP) to manage the required environmental authorisation processes. EIMS, in turn, appointed PGS Heritage (Pty) Ltd to undertake the Heritage Impact Assessment (HIA), including the archaeological and palaeontological components, for the proposed 3D seismic survey within the Cluster 2 Project area.

This report constitutes the Palaeontological Desktop Assessment (PDA) for the proposed project.

1.1 Scope of the Study

The aim of the study is to identify palaeontological sites/sensitivity that may occur in the proposed project area. The PDA aims to inform the Environmental Impact Assessment (EIA) to assist the developer in managing the discovered heritage resources in a responsible manner, in order to protect, preserve, and develop them within the framework provided by the National Heritage Resources Act (Act 25 of 1999) as amended (NHRA).

1.2 Specialist Qualifications

This study has been conducted by Elize Butler. She has conducted approximately 900 palaeontological impact assessments for developments in the Free State, KwaZulu-Natal, Eastern, Western, and Northern Cape, Northwest, Gauteng, Limpopo, and Mpumalanga. She has an MSc (cum laude) in Zoology

(specialising in Palaeontology) from the University of the Free State, South Africa and has been working in Palaeontology for more than thirty 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.

A short CV is attached in **Appendix B**, while a detailed CV could be provided on request.

1.3 Assumptions and Limitations

Geological maps primarily focus on the lithology and structural geology of an area, and their accompanying sheet explanations were not intended to emphasise palaeontological heritage. Many remote regions of South Africa remain unexplored by palaeontologists, with available data often derived solely from aerial imagery. Furthermore, fossil locality and geological data stored in museum and university collections are frequently outdated or were historically recorded with limited accuracy.

To supplement these gaps, comparable Assemblage Zones and geological formations from better-studied regions are often referenced to infer the potential for fossil presence in previously undocumented areas. In desktop studies, it is typically assumed that fossil heritage may be present where similar stratigraphy is exposed. However, a field-based assessment is essential to validate and refine these assumptions, thereby enhancing the accuracy of the palaeontological sensitivity rating.

1.3.1 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: 50 000 scale topographic maps.
- Palaeosensitivity map on SAHRIS (South African Heritage Resources Information System) website.
- DFFE Screening Tool of the study area
- A Google Earth kmz files and background information on the proposed development was supplied by PGS Heritage as received from the developer.
- 1:250 000 Winburg 2826 Geological Map (Council for Geosciences, Pretoria).
- Palaeontological Impact Assessments in the same area are studied
- No site investigation was conducted for the Project; however, a site investigation is recommended in this report.

1.4 Legislative Context

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

- Government Notice 320 (Government Gazette 43110, 20 March 2020) (GN 320) - general requirements for undertaking an initial site sensitivity verification where no specific assessment protocol has been identified,
- EIA Regulations (Government Notice 982 (Government Gazette 38282, 4 December 2014)) Appendix 6 (GN 982) as amended by Government Notice 326 (Government Gazette 40772, 7 April 2017) (GN 326),
- NHRA.

Government Notice 320 (Government Gazette 43110, 20 March 2020)

Although minimum standards for Archaeological Impact Assessment (AIA) (2007) and Paleontological Impact Assessment (PIA) (2012) were published by the South African Heritage Resources Agency (SAHRA), GN 320 requires sensitivity verification for a site, for which no specific assessment protocol related to any theme has been identified, on the national web based environmental screening tool. The requirements for GN 320 are listed in **Table 1** and the applicable section in this report noted.

Table 1: Reporting requirements for GN 320.

GN 320	**Relevant section in report**	**Where not applicable in this report**
2.2 (a) a desktop analysis, using satellite imagery;	section 4.1	
2.2 (b) a preliminary on-site inspection to identify if there are any discrepancies with the current use of land and environmental status quo versus the environmental sensitivity as identified on the national web-based environmental screening tool, such as new developments, infrastructure, indigenous/pristine vegetation, etc.	Executive Summary and Section 5	
2.3(a) confirms or disputes the current use of the land and environmental sensitivity as identified by the national web-based environmental screening tool;	Section 1.4	
2.3(b) contains motivation and evidence (e.g. photographs) of either the verified or different use of the land and environmental sensitivity;	Section 1.4	

1.4.1 Environmental Impact Assessment Regulations (Government Notice 982, Government Gazette 38282, 4 December 2014) Appendix 6 as amended by Government Notice 326 (Government Gazette 40772, 7 April 2017) requirements

This HIA report has been compiled considering the GN 326 Appendix 6 requirements for specialist reports.

1.4.2 Heritage screening - Department of Forestry, Fisheries and the Environment

A heritage screening was conducted by means of the Department of Forestry, Fisheries and the Environment (DFFE) National Web-based Environmental Screening Tool as required by GN 982.

DFFE issued guidelines in April 2025 concerning the application of the screening tool in relation to cultural heritage, archaeology, and palaeontological themes. The guidelines indicate that the "theme layer represents a limited number of known" heritage and palaeontological resources. These resources are widely distributed and may be present at any development site within South Africa. The guidelines state the following in terms of -

- HIA "*Therefore, a Heritage Impact Assessment (HIA) must be undertaken for all developments, irrespective of the sensitivity shown on the archaeological and cultural heritage theme layer*"
- PIA "*Therefore, a Palaeontological Impact Assessments (PIAs)* [sic] *must be undertaken for all developments as per the PalaeoSensitivity Map provided on* [South African Heritage Resources Information System] *SAHRIS, irrespective of the sensitivity shown on the palaeontology theme layer."*

The guidelines further stipulate the requirements for both an HIA and PIA must:

HIA	**PIA**
▪ meet the requirements of section 38(3) of the NHRA or section 41(1) of the KwaZulu-Natal Amafa and Research Institute Act, 2018 (Act No. 5 of 2018) (KNARIA), should the development be in KwaZulu-Natal (KZN); ▪ must be undertaken by a qualified heritage specialist; ▪ be undertaken in line with GN 326 Appendix 6; and ▪ for HIA submitted to SAHRA the report must also comply with the requirements of the "2007 Minimum Standards: Archaeological and Palaeontological Components of Impact Assessment Reports", accessible at https://sahris.sahra.org.za.	▪ meet the requirements of section 38(3) of the NHRA or section 41(1) of the KNARIA should the development be in KZN; ▪ must be undertaken by a qualified palaeontological specialist; ▪ be undertaken in line with GN 326 Appendix 6; and ▪ for PIA submitted to SAHRA, the report must comply with the requirements of the "2012 Minimum Standards: Palaeontological Components of Heritage Impact Assessments" [sic], accessible at https://sahris.sahra.org.za.

According to the heritage screening report, the palaeontological sensitivity of the development area is High (red). This High sensitivity classification signifies that a detailed palaeontological desktop assessment is required and based on the outcome a site investigation.

1.4.3 National Heritage Resources Act (Act 25 of 1999) as amended

- Protection of Heritage Resources – sections 34 to 36; and
- Heritage Resources Management – section 38.

The NHRA is utilised as the basis for the identification, evaluation, and management of heritage resources and in the case of Cultural Resources Management (CRM) those resources specifically impacted on by

development as stipulated in section 38 of the NHRA. This study falls under section 38(8) and requires comment from the relevant heritage resources authority.

Section 24(2) of the National Environmental Management Act (Act 107 of 1998) as amended (NEMA) requires environmental authorisation from the environmental authority for certain activities that have been identified and must undergo an EIA or BA process. Similarly, section 38 of the NHRA lists specific development activities that require notice to the heritage resources authority to determine if an HIA process is necessary. Approval from the heritage authority is mandatory before proceeding with the development activities.

To avoid redundancy and facilitate co-ordination between NEMA and NHRA requirements, section 38(8) of the NHRA states that if the development activities listed in section 38(1) require an EIA under NEMA; a separate HIA and approval from the heritage resources authority are unnecessary. However, the environmental authority must ensure that the heritage resources authority's requirements for HIA are fulfilled and that its comments and recommendations are considered before granting environmental authorisation.

Therefore, if a NEMA EIA is required for the development activities listed under section 38 of the NHRA, separate HIA and EIA processes may not be followed, and different decisions may not be issued under NHRA and NEMA. The EIA process will be followed, and if the heritage resources authority requires a HIA, it must be conducted as one of the EIA specialist studies.

The environmental authority must ensure that the heritage resources authority's requirements for the assessment are met. A separate heritage approval may not be issued, but the environmental authority must consider the heritage resources authority's comments and recommendations before granting or refusing environmental authorisation.

It must however be noted that if no environmental process is required, but the proposed development still triggers the requirements for and HIA under section 38(1) of the NHRA, SAHRA or the relevant provincial heritage authority will be the authorising authority. This entity could then require a full HIA taking into account the requirements for public participation and stakeholder engagement as stipulated by the regulations of the NHRA.

2 TECHNICAL DETAILS OF THE PROJECT

2.1 Locality

The proposed project falls within the Masilonyana and Matjhabeng Local Municipalities, in the Lejweleputswa District Municipality, Free State Province. The site boundary is ~5km southwest of the town of Virginia, ~9km south the town of Welkom and ~16km north of the town of Theunissen. The application area covers approximately 27 500 hectares, and the approximate centre point of the site is located at 28°10'20.47"S and 26°43'50.79"E. A locality map is included herewith for ease of reference (**Figure 1-2).**

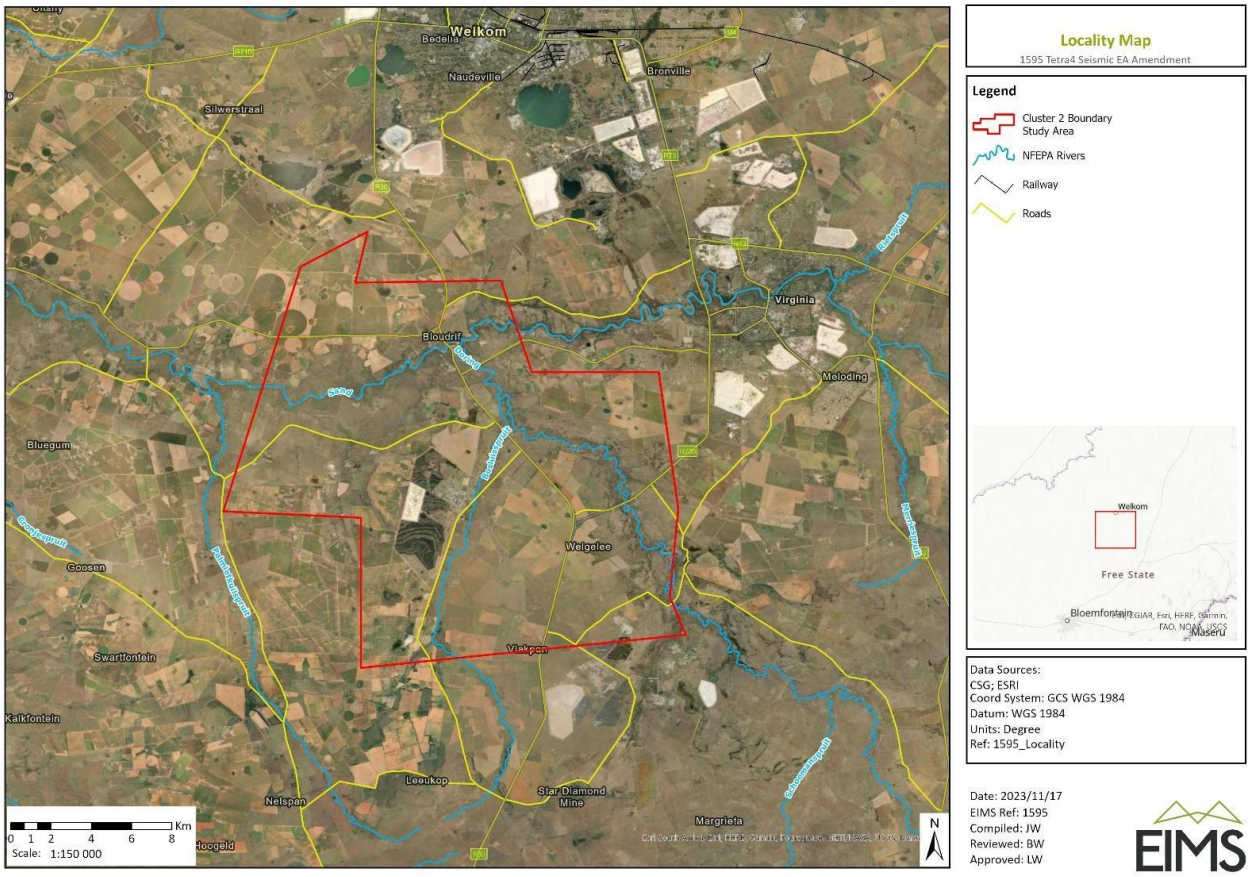


Figure 1 – Locality Map.

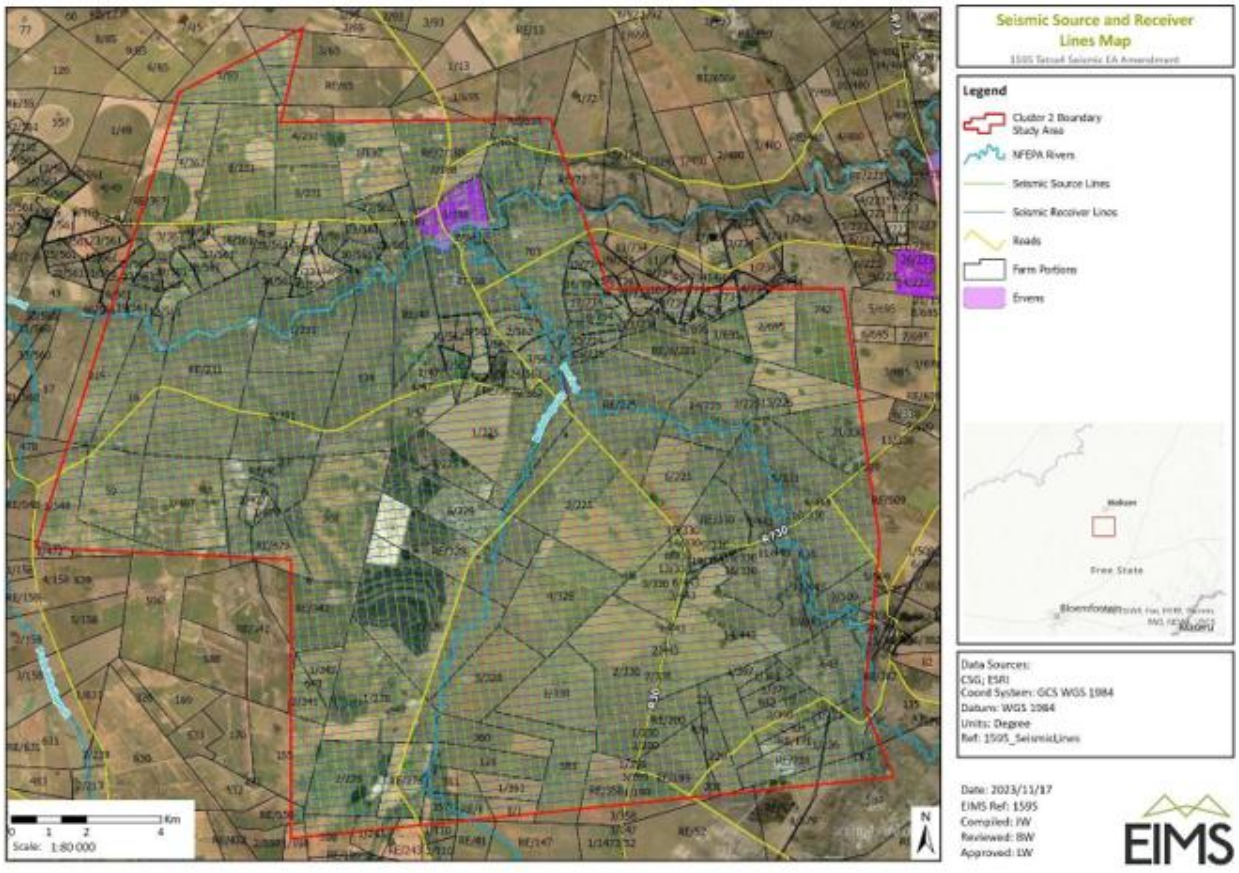


Figure 2 – Seismic Source and Receiver Lines Map.

2.2 Technical Project Description

2.2.1 Project description

Tetra4 obtained a Cluster 2 Environmental Authorisation for production well transects rather than fixed drilling locations, which has resulted in uncertainty for landowners; consequently, Tetra4 proposes to undertake a 3D seismic survey across the Cluster 2 area to generate a high-resolution subsurface geological model and to enable more accurate identification of drilling locations on individual properties.

The Cluster 2 Project will be approximately 27 500 ha and overlaps substantially with the Cluster 1 area.

3 ASSESSMENT METHODOLOGY

The section below outlines the assessment methodologies utilised in the study.

3.1 Methodology for Assessing Heritage Site significance

This study forms part of the Heritage Impact Assessment Report. According to the "SAHRA APM Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports" the purpose of the PIA is:

- to identify the palaeontological importance of the rock formations in the footprint;
- to evaluate the palaeontological magnitude of the formations;
- to clarify the **impact** on fossil heritage; and
- 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.

All possible information is consulted to compile a scoping report, and this includes the following: SAHRIS Palaeosensitivity map, Provisional DFFE Screening Tool, all Palaeontological Impact Assessment reports in the same area; aerial photos and Google Earth images, topographical and geological maps as well as scientific articles of specimens from the development area and Assemblage Zones.

A field-based assessment is necessary when the development footprint has a Very High to High paleontological sensitivity. 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 destroy or permanently seal in fossils at or below the ground surface. Fossil Heritage will then no longer be accessible for scientific research.

During a site investigation, the palaeontologist surveys the development and tries to determine the density and diversity of fossils in the development area. Rock exposures that are investigated usually contain a large portion of the stratigraphic unit, can be accessed easily and comprise of unweathered (fresh) exposed rock. These exposures may be natural (rocky outcrops in streams or riverbanks, cliffs, dongas) but could also be artificial (quarries, open building excavations, and even railway and road cuttings). It is common practice for palaeontologists to log well-preserved fossils (GPS, and stratigraphic data) during field assessment studies.

Mitigation usually precedes 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 SAHRA approved fossil repository. When mitigation is applied correctly, a positive impact is possible as knowledge of local palaeontological heritage may be increased.

When a Site investigation is conducted, the fossil potential of the site will be determined by cross-crossing the development footprint and physically investigating bedrock outcrops to determine the lithology and fossil content of the outcrops. Fossils occurring at the surface are very unpredictable, and a **representative sample size** of the area has been investigated. However, it is important to note that the absence of fossils in a development footprint does not necessarily mean that palaeontological significant material is not present on site (on or beneath ground surface).

The terms of reference of a PIA are as follows:

General Requirements:

- Adherence to the content requirements for specialist reports following 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 the palaeontological and geological history of the affected area.
- Identification of sensitive areas to be avoided (providing shapefiles/kmls) 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 place as 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** 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).

3.2 Methodology used in determining the significance of environmental impacts

The methodology used to determine the environmental impact significance is that by PGS, and is explained in **Appendix A**.

4 CURRENT STATUS QUO

4.1 Baseline Description of the Receiving Environment

The study area is situated within the Grassland Biome as defined by Rutherford and Westfall, and more specifically within the Central Free State Grassland vegetation type (Rutherford & Westfall, 1994; Mucina & Rutherford, 2006). This vegetation unit is characterised by a dominance of perennial C_4 grasses with a generally low shrub and tree component, occurring on flat to gently undulating terrain under semi-arid climatic conditions. Typical species include *Themeda triandra*, *Eragrostis curvula*, and *Aristida* spp., with local variation influenced by soil depth, grazing pressure, and land-use history (Mucina & Rutherford, 2006). Much of the natural vegetation in the area has been transformed or degraded by agriculture, grazing, and associated infrastructure, resulting in secondary grassland and disturbed vegetation along access routes (Rutherford et al., 2012).

The topography of the project area and surrounding landscape is generally flat to gently undulating, characteristic of the central Free State interior plateau (Partridge et al., 2010). Elevation changes are subtle, with broad plains locally dissected by shallow drainage lines and minor seasonal watercourses. Slopes are generally low and uniform, and no prominent ridgelines or steep terrain features occur along the proposed access road alignment. This subdued relief reflects long-term erosional processes acting on relatively homogeneous sedimentary geology and underpins the dominance of extensive agricultural land use across the region (Partridge et al., 2010).

4.1.1 Geological and Palaeontological History

The proposed Tetra4 3D Seismic Survey Project near Virginia, in the Free State Province is indicated on the 1: 250 000 Winburg 2826 Geological Map (Council for Geosciences, Pretoria). The proposed development is underlain by Quaternary alluvium (yellow, single bird figure), Superficial sands (Qs, yellow) the Jurassic dolerite of the Karoo Igneous Province (Jd, red) as well as the Adelaide Subgroup of the Karoo Supergroup (Pa, green) (**Figure 4, Table 2**). According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments is Moderate (green), that of the Karoo Igneous Suite is Zero (grey), while that of the Adelaide Subgroup (Beaufort Group) is Very High (red) (Almond and Pether, 2009; Almond *et al*., 2013, Groenewald et al 2014) (**Figure 5, Table 3**). Palaeontological Sensitivity generated by the Department of Forestry, Fisheries and the Environment National Environmental Web-Based (DFFE) Screening Tool indicates a Very High Palaeontological Sensitivity (deep red, **Figure 6**). No Site investigation was conducted for this project, but is recommended in this report. Recent research has indicated that the Adelaide Subgroup is represented by the Balfour Formation.

Underlying the superficial deposits are sedimentary rocks of the Adelaide Subgroup (Beaufort Group), consisting predominantly of sandstones, mudstones, and shales deposited in fluvial environments. The

Beaufort Group represents the third major subdivision of the Karoo Supergroup, overlying the Ecca Group, and was deposited from the Middle Permian to the early Middle Triassic. It constitutes the first fully continental succession of the Karoo Basin and covers approximately 200 000 km² in South Africa. The Beaufort Group is subdivided into the lower Adelaide Subgroup and the overlying Tarkastad Subgroup (Figure 8). Sedimentation within the Adelaide Subgroup occurred under humid climatic conditions on wet floodplains with high water tables and is interpreted as fluvio-lacustrine in origin. The subgroup reaches thicknesses of up to 5 000 m in the southeastern Karoo Basin, thinning to approximately 800 m in the basin centre and to 100–200 m toward the northern margins.

The Adelaide Subgroup is characterised by alternating greyish-red, bluish-grey, and greenish-grey mudrocks interbedded with very fine- to medium-grained lithofeldspathic sandstones. Thicker sandstone units are commonly multistorey and exhibit cut-and-fill architectures. Internal sedimentary structures include horizontal lamination, parting lineation, trough cross-bedding, and ripple lamination, with ripples typically confined to thinner sandstones near the tops of thicker units. Mudrocks generally weather to massive, blocky forms and may preserve desiccation cracks and raindrop impressions. Calcareous nodules and concretions are widespread throughout Beaufort Group mudstones.

The floodplain deposits of the Beaufort Group are internationally renowned for documenting the early diversification of terrestrial vertebrates and provide the most complete fossil record globally of the transition from early reptiles to mammals. The Beaufort Group is subdivided into a series of vertebrate assemblage zones based on faunal content (Kitching, 1977, 1978; Keyser et al., 1977; Rubidge, 1995; Smith et al., 2020; Viglietti, 2020; Figure 7). A portion of the proposed development area is underlain by the Balfour Formation, which falls within the *Daptocephalu*s Assemblage Zone (DAZ). This Assemblage Zone is further subdivided into the lower *Dicynodon–Theriognathus* Subzone and the upper *Lystrosaurus maccaigi–Moschorhinus kitchingi* Subzone.

The dicynodont *Daptocephalus leoniceps* is the index fossil defining the *Daptocephalus* Assemblage Zone. This Assemblage Zone is characterised by the co-occurrence of *Daptocephalus leoniceps*, the therocephalian *Theriognathus microps*, and the cynodont *Procynosuchus delaharpeae*. The lower *Dicynodon–Theriognathus* Subzone contains *Dicynodon* and *Theriognathus* in association with *Daptocephalus*, while the upper *Lystrosaurus maccaigi–Moschorhinus kitchingi* Subzone is defined by the presence of *Lystrosaurus maccaigi*, *Daptocephalus*, and *Moschorhinus*. The *Daptocephalus* Assemblage Zone displays the highest vertebrate diversity within the Beaufort Group and includes numerous well-preserved dicynodonts, biarmosuchians, gorgonopsians, therocephalians, and cynodont therapsids. Captorhinid reptiles are also present, while eosuchian reptiles, amphibians, and fish are comparatively rare. Trace fossils and *Glossopteris* flora have also been documented.

The *Daptocephalus* Assemblage Zone extends into the lower Palingkloof Member of the Upper Balfour Formation. This interval is of particular significance as it immediately precedes the Permo–Triassic mass extinction event, which resulted in the collapse of terrestrial vertebrate ecosystems and the extinction of

glossopterid plant communities. The overlying *Lystrosaurus declivis* Assemblage Zone forms part of the Katberg Formation and records a marked reduction in faunal diversity. Fossil assemblages from this interval are dominated by *Lystrosaurus* and *Procolophon*, with reduced representation of other therapsids. Large amphibians are characteristic of this interval, and fossil fish, millipedes, and diverse trace fossils have also been recorded.

The study area (**Figure 3**) is partially underlain by rocks of the Karoo Igneous Province, one of the world's classic continental flood basalt provinces. This province comprises extensive intrusive and extrusive igneous rocks emplaced over a large area of southern Africa (Duncan et al., 2006). Flood basalts typically formed through repeated fissure eruptions, producing sub-horizontal lava flows, sills, and dykes of variable thickness rather than prominent volcanic edifices. These lavas once formed a near-continuous cap across much of southern Africa but are now preserved as erosional remnants. The present outcrop area of Karoo lavas is approximately 140 000 km², although they are estimated to have originally covered up to 2 000 000 km² (Cox, 1970, 1972).

In addition to basaltic lavas, the Karoo Igneous Province includes significant volumes of silicic volcanic rocks composed of rhyodacitic and rhyolitic magmas, particularly along the Lebombo monocline. Individual silicic units may extend for up to 60 km and often display massive pyroclastic textures, leading to their classification as rheoignimbrites. The basal lavas generally lie conformably on the Clarens Formation, although localised pre-volcanic erosion of Clarens sandstones has been documented. Early stages of volcanism involved interaction between magma and groundwater, resulting in volcaniclastic deposits and phreatic to phreatomagmatic diatremes (Lock et al., 1974). Additional evidence for aqueous environments during early volcanism includes pillow lavas, hyaloclastite breccias, and thin lenses of fluviatile sandstones interbedded with the lowermost lava flows (Eales et al., 1984). As igneous rocks, these units are unfossiliferous.

The Quaternary Period, often referred to as the "Age of Mammals," is preserved in South Africa across a range of depositional environments, including coastal plains (e.g. Langebaanweg), cave systems (e.g. Makapan), river gravel terraces (e.g. Cornelia), and other sedimentary basins. African Quaternary deposits are subdivided into six Land Mammal Ages: Recent, Florisian, Cornelian, Makapanian, Langebaanian, and Namibian (MacRae, 1999). In the Free State Province, Quaternary fossil assemblages are best documented from the Florisbad and Cornelia localities, where fossils include mammalian teeth and bones, fish, reptiles, freshwater molluscs, trace fossils, fossil wood, rhizoliths, and diatom floras (Groenewald & Groenewald, 2014).

The Virginia–Welkom District is well known for fluvial deposits associated with present-day river systems. These terrestrial sediments include diatomite, calcareous tufa, pedocretes, peats, spring deposits, soils, gravels, and other Tertiary calcrete deposits, which are important for reconstructing Early to Late Pliocene environments in the region (De Ruiter et al., 2010). Late Cenozoic (Plio-Pleistocene) floodplain deposits and pan sites associated with the Sand, Doring, Vals, and Vet river systems have yielded confined but locally abundant vertebrate fossil assemblages. In 1955, Meiring described an in-situ proboscidean fossil recovered

from pebbly channel-fill sediments along the Sand River near Virginia, approximately 40 m above the modern riverbed. The specimen comprised a lower molar, part of a tusk, and a proximal portion of an ulna. Initially described as *Archidiskodon scotti* (Meiring, 1955), it was subsequently reassigned to the Pliocene species *Mammuthus subplanifrons* (Coppens et al., 1978). Later investigations documented a diverse associated fauna, including amphibians, birds, fish, reptiles, and several proboscideans, perissodactyl, and artiodactyl taxa (De Ruiter, 2010).

Terrace gravels above the Vet River southwest of Welkom have yielded Pliocene fossil material, while surveys along the Doring, Vals, Sand, and Vet rivers recorded moderately fossiliferous overbank sediments and erosional gullies containing a variety of Quaternary-aged mammal fossils (Brink et al., 1999; De Ruiter et al., 2011). Ancient pan sites, such as those near Whites, have produced rich Quaternary mammal assemblages. Although Quaternary fossils are generally rare and discontinuous, they may include mammalian teeth and bones, ostrich eggshell fragments, tortoise remains, ostracods, diatoms, reptile skeletons, and a range of trace fossils, including burrows, vertebrate tracks, rhizoliths, and calcretised termite mounds. Plant remains may include leaves, seeds, wood fragments, and pollen. Microfossils and vertebrate remains are most commonly associated with Quaternary deposits near drainage lines and watercourses.

The superficial deposits represent the youngest geological materials, formed during approximately the last 2.6 million years. These deposits are typically unconsolidated and consist of clay, gravel, sand, and silt, occurring as thin, discontinuous patches or more extensive sedimentary spreads. They include channel, floodplain, stream, talus, and glacial drift deposits. Quaternary sediments are of particular scientific importance as they record palaeoclimatic fluctuations and associated geomorphological changes. Most present-day landforms in southern Africa developed during the Quaternary in response to alternating climatic conditions (Hunter et al., 2006; Maud, 2012). Barnosky (2005) demonstrated that Quaternary climate variability, particularly over the last 1.8 million years, was more pronounced than during earlier periods, resulting in significant changes in river dynamics, sedimentation patterns, and vegetation distribution (Tooth et al., 2004).

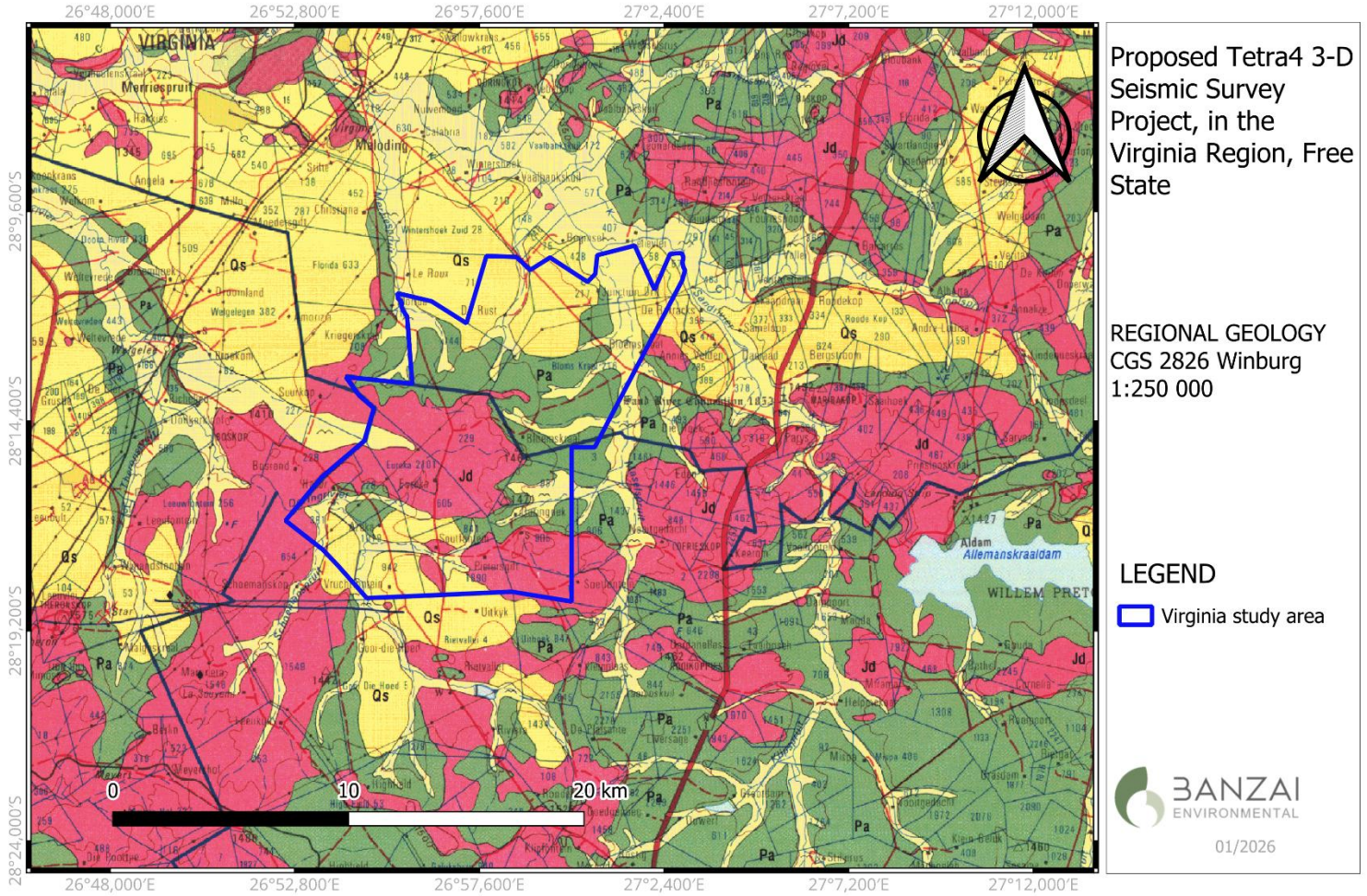


Figure 3 – Extract of the 1:250 000 000 Winburg 2826 Geological Map (Council for Geosciences, Pretoria) indicates that the study area is underlain by Quaternary alluvium (yellow, single bird figure), Quaternary sand (Qs, yellow), Dolerite (Jd, red; Karoo Igneous Province) as well as the Adelaide Subgroup (Beaufort Group, Karoo Supergroup).

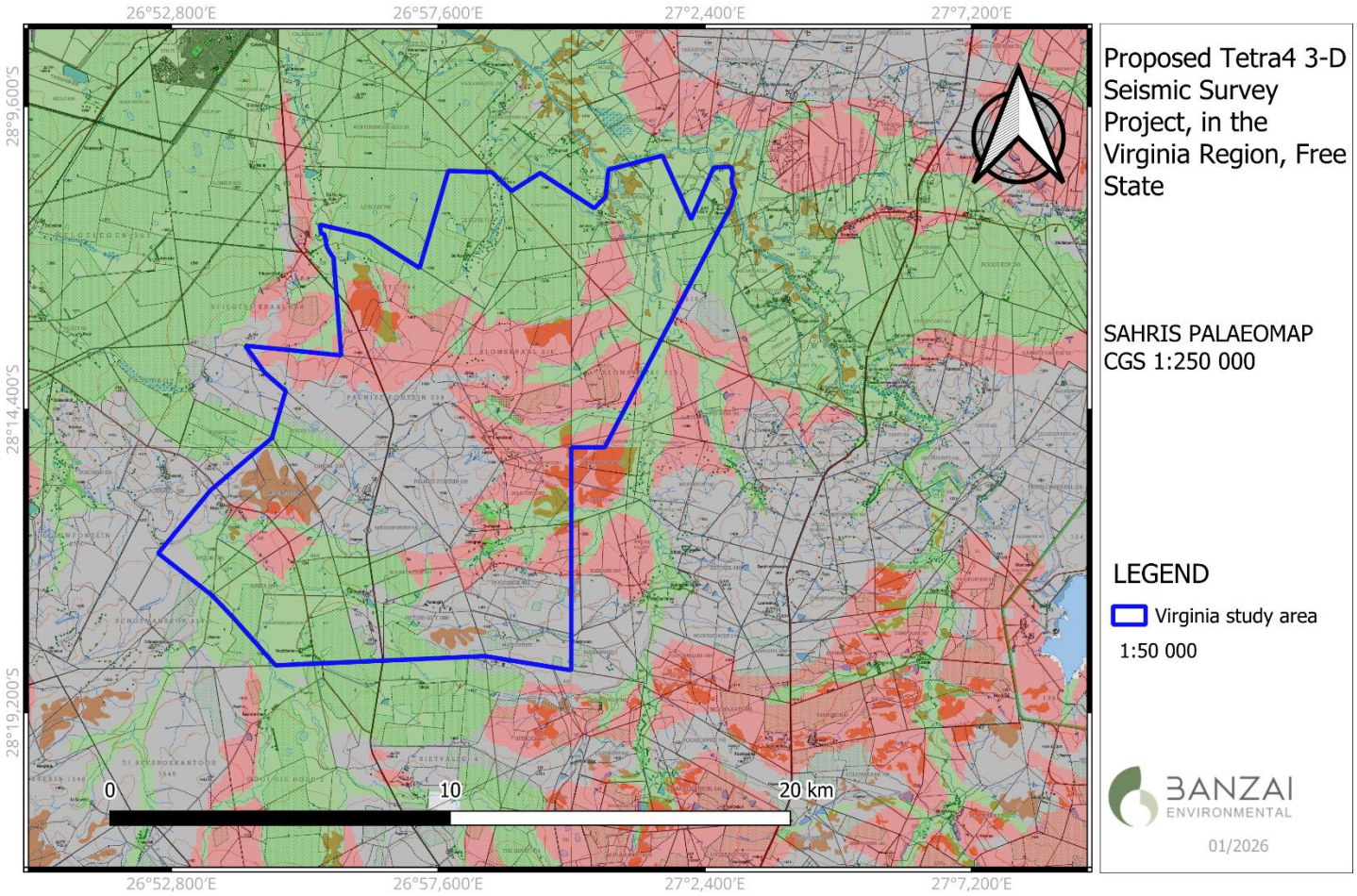


Figure 4 – Extract of the SAHRIS PalaeoMap (Council for Geosciences, Pretoria) indicates that the study area is underlain by sediments with a Very High (red), Moderate (green) and Zero (grey) Palaeontological Sensitivity.

4.1.2 SAHRIS Palaeomap and the National Web-based Screening Tool

Table 2: Palaeontological Sensitivity according to the SAHRIS PalaeoMap (Almond et al, 2013; SAHRIS website.

Colour	Sensitivity	Required Action
RED	VERY HIGH	Field assessment and protocol for finds are required
ORANGE/YELLOW	HIGH	A desktop study is required, and based on the outcome of the desktop study, a field assessment is likely.
GREEN	MODERATE	A 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 overall Palaeontological Sensitivity of the area is classified as Very **High**, as indicated by the SAHRIS Palaeomap (**Figure 4; Table 2**).

The SAHRIS PalaeoMap (red, **Figure 4, Table 2**) and the National Environmental Web-based Screening Tool (deep red, **Figure 5**) both classify the development area as having Very High Palaeontological Sensitivity. No field-based Palaeontological investigation was conducted for the site, however a site investigation is recommended in this report.

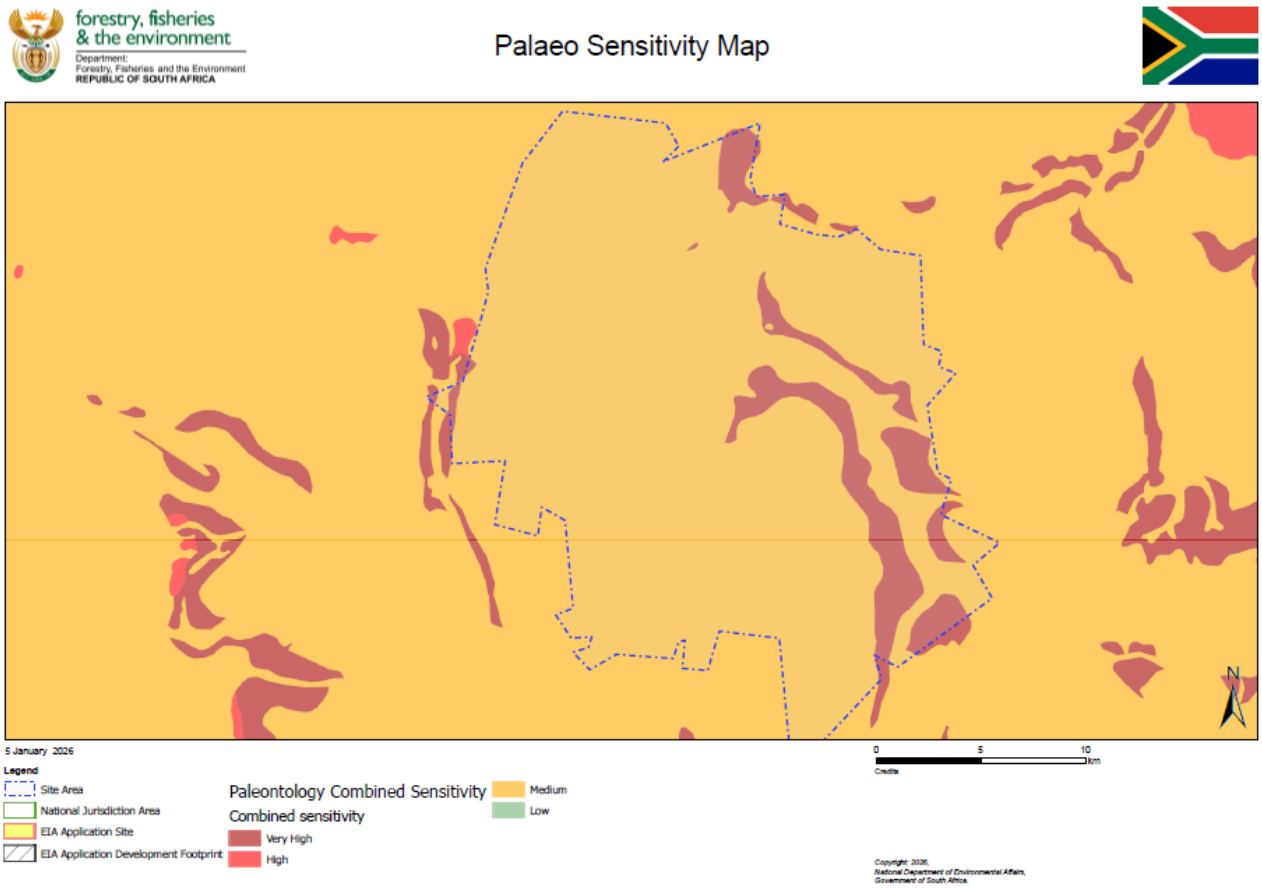


Figure 5 - Palaeontological Sensitivity of the study area by the National Environmental Web-based Screening Tool indicates a Very High (deep red) Sensitivity, while areas with a Medium (yellow) is also crossed.

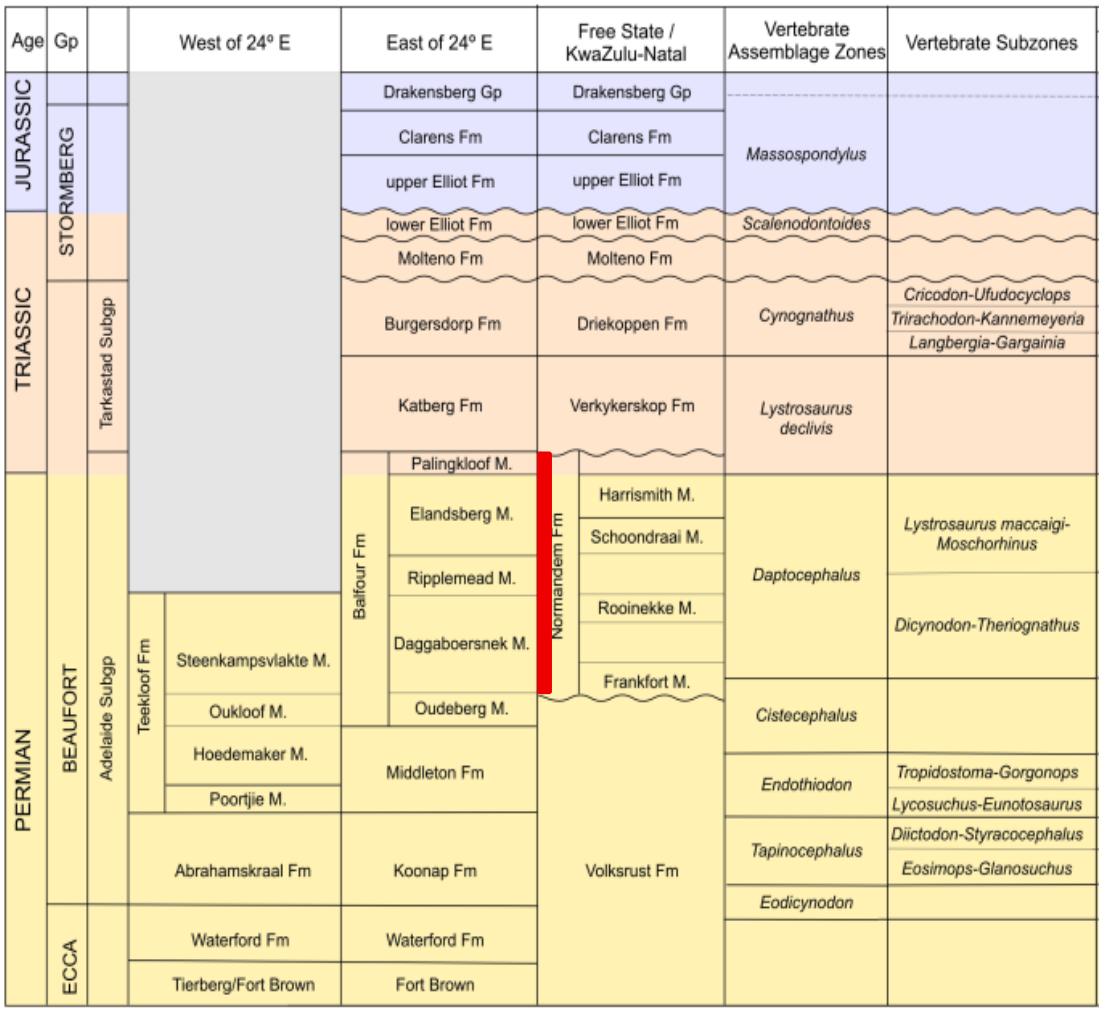


Figure 6 – Vertebrate biozonation range chart for the Main Karoo Basin of South Africa.

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 development is indication by the red polygon (Figure taken from Smith et al., 2020).

4.2 Findings

The proposed development is underlain by Quaternary alluvium (yellow, single bird figure), Superficial sands (Qs, yellow) the Jurassic dolerite of the Karoo Igneous Province (Jd, red) as well as the Adelaide Subgroup of the Karoo Supergroup (Pa, green) (**Figure 4, Table 2**). According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments is Moderate (green), that of the Karoo Igneous Suite is Zero (grey), while that of the Adelaide Subgroup (Beaufort Group) is Very High (red) (Almond and Pether, 2009; Almond *et al.*, 2013, Groenewald et al 2014) (**Figure 5, Table 3**). Palaeontological Sensitivity generated by the Department of Forestry, Fisheries and the Environment National Environmental Web-Based (DFFE) Screening Tool indicates a Very High

Palaeontological Sensitivity (deep red, **Figure 6**). No Site investigation was conducted for this project, but is recommended in this report. Recent research has indicated that the Adelaide Subgroup is represented by the Balfour Formation.

Implementing the impact assessment methodology, Error! Reference source not found. and Error! Reference source not found. provides quantitative assessment of the impacts of the proposed project on the Palaeontological Resources (directly impacted).

	Identifier
Palaeontology	**Discipline**
Loss of fossil Heritage	**Impact**
No	**Alternative**
Construction	**Phase**
Normal Operation	**Event**
- 1	**Pre-Nature**
1	**Pre-Extent**
5	**Pre-Duration**
5	**Pre-Magnitude**
5	**Pre-Reversibility**
- 4	**Consequence**
4	**Pre-Probability**
-16	**Pre-Mitigation Significance Score**
- High	**Pre-Mitigation Significance**
-1	**Post-Nature**
1	**Post-Extent**
5	**Post-Duration**
2	**Post-Magnitude**
2	**Post-Reversibility**
-2.5	**Consequence2**
2	**Post-Probability**
-5	**Post-mitigation Significance Score**
- Medium to Low	**Post-Mitigation Significance**
	Confidence
1	**Cumulative Impact**
3	**Irreplaceable loss**
-1.25	**Priority Factor**
-6.25	**Final score**
- Medium to Low	**Post-Mitigation Significance**

Table 3: Summary of Impact Tables

5 CHANCE FINDS PROTOCOL

The following procedure will only be followed if fossils are uncovered during the excavation phase of the development.

5.1 Legislation

Cultural Heritage in South Africa (includes all heritage resources) is protected by the **National Heritage Resources Act (Act No 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.

5.2 Background

A fossil is the naturally preserved remains (or traces thereof) of plants or animals embedded in rock. These organisms lived 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.

5.3 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.

5.4 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 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 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.

If the fossil cannot be stabilized the fossil may be collected with extreme care by the ESO. 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 the Heritage Agency has issued the written authorization, the developer may continue with the development on the affected area.

6 CONCLUSIONS AND RECOMMENDATIONS

The proposed Tetra4 3D Seismic Survey Project is underlain by Quaternary alluvium, Superficial sands, the dolerite of the Karoo Igneous Province as well as the Adelaide Subgroup of the Karoo Supergroup. According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of Quaternary sediments is Moderate, that of the Karoo Igneous Suite is Zero, while that of the Adelaide Subgroup (Beaufort Group) is Very High (Almond and Pether, 2009; Almond *et al*., 2013, Groenewald et al 2014). Palaeontological Sensitivity generated by the Department of Forestry, Fisheries and the Environment National Environmental Web-Based (DFFE) Screening Tool indicates a Very High Palaeontological Sensitivity. Recent research has indicated that the Adelaide Subgroup is represented by the Balfour Formation.

No field-based palaeontological site investigation was undertaken, as the proposed Tetra4 3D seismic survey is non-invasive in nature and will not involve any excavation, drilling or ground penetration. The survey will be undertaken using vibroseis source vehicles and surface-deployed geophones to generate and record controlled seismic vibrations for the purpose of producing a three-dimensional subsurface geological model. All activities will be confined to surface operations along predefined survey lines.

Although the SAHRIS PalaeoMap indicates that the study area falls within a zone of Very High Palaeontological Sensitivity, the significance of potential impacts associated with the proposed survey is assessed as Very Low, owing to the non-invasive nature of the activities. As no vegetation clearance or subsurface disturbance will occur, the proposed survey is not expected to result in any direct impacts on palaeontological heritage resources.

Should any fossil material be encountered during any phase of the project, whether exposed at surface or during unforeseen ground-disturbing activities, the Chance Find Protocol (refer to Section 6 of this report) must be implemented immediately by the Environmental Control Officer (ECO) or the responsible site manager. All fossil discoveries must be protected in situ and reported to the South African Heritage Resources Agency (SAHRA) to ensure that appropriate recording and, where necessary, collection can be undertaken by a qualified palaeontologist.

Prior to the collection of any fossil material, a permit must be obtained from SAHRA by the appointed specialist. All collected material must be curated in an accredited museum or university repository, and all reporting and fieldwork must comply with the minimum standards for palaeontological impact studies as prescribed by SAHRA (2012). It is therefore recommended that no further palaeontological studies, field verification or mitigation measures are required, unless previously unknown fossil material is discovered.

These recommendations should be incorporated into the Environmental Management Programme for the proposed Tetra4 3D Seismic Survey Project near Virginia, in the Free State Province

7 REFERENCES

Almond, J., Pether, J, And Groenewald, G. 2013. South African National Fossil Sensitivity Map. SAHRA and Council for Geosciences.

Almond, J.E., Pether, J., Groenewald, G.H., 2013. Regional Palaeontological Sensitivity of South African Geological Formations. Pretoria: South African Heritage Resources Information System.

Barnosky, A.D., 2005. Effects of Quaternary climatic fluctuations on mammalian evolution and distributions. Annual Review of Ecology, Evolution, and Systematics, 36, pp. 105–136.

Coppens, Y., Maglio, V.J. & Howell, F.C., 1978. Pliocene proboscidean remains from South Africa. Journal of Human Evolution, 7(2), pp. 123–138.

Cox, K.G., 1970. The extent and evolution of the Karoo Flood Basalt Province. Earth and Planetary Science Letters, 9(3), pp. 283–290.

Cox, K.G., 1972. Aspects of Karoo volcanism. South African Journal of Geology, 75, pp. 25–40.

De Ruiter, D.J., Brink, J.S., Werdelin, L., 2010. Late Cenozoic vertebrate fossil sites of the Free State: Overview and significance. Palaeontologia Africana, 45, pp. 1–22.

De Ruiter, D.J., Brink, J.S., Werdelin, L., 2011. Quaternary floodplain deposits and vertebrate fossils in the Free State Province. South African Journal of Science, 107(9/10), pp. 1–10.

Duncan, A.R., Smith, M., Thoburn, P., 2006. The Karoo Igneous Province: Volcanism and geodynamic context. In: Eriksson, P.G., et al. (eds.), The Karoo Basin: Palaeontology and Geology. Johannesburg: Council for Geosciences, pp. 145–162.

Groenewald, G.H. & Groenewald, J., 2014. Quaternary fossil sites of South Africa: Distribution and palaeontological importance. Palaeontologia Africana, 49, pp. 25–42.

Hunter, D.R., Beaumont, P.B., & Partridge, T.C., 2006. Geomorphology of the South African Quaternary: Implications for fossil preservation. Quaternary International, 150, pp. 3–17.

Keyser, A.W., Kitching, J.W. & Rubidge, B.S., 1977. Biozonation of the Adelaide Subgroup, Beaufort Group, Karoo Supergroup. South African Journal of Science, 73, pp. 88–91.

Kitching, J.W., 1977. Biostratigraphy of the Beaufort Group. Geological Society of South Africa Transactions, 80, pp. 1–24.

MacRae, R.A., 1999. African Land Mammal Ages of the Quaternary. South African Journal of Science, 95, pp. 199–207.

Maud, R.R., 2012. Geomorphology and Quaternary landscape evolution in southern Africa. Transactions of the Royal Society of South Africa, 67(2), pp. 1–21.

Mucina, L. & Rutherford, M.C. (eds.), 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. Pretoria: South African National Biodiversity Institute (SANBI).

Mucina, L. & Rutherford, M.C., 2006. The Vegetation of South Africa, Lesotho and Swaziland. Pretoria: South African National Biodiversity Institute.

Partridge, T.C., Dollar, E.S.J., Moolman, J. & Dollar, L.H., 2010. The geomorphic provinces of South Africa, Lesotho and Swaziland: A physiographic subdivision for earth and environmental scientists. Transactions of the Royal Society of South Africa, 65(1), pp.1–47.

Rubidge, B.S., 1995. Biostratigraphy of the Karoo Supergroup: Vertebrate fossil evidence. In: Hancox, P.J. & Rubidge, B.S. (eds.), The Karoo Basin: Palaeontology and Sedimentology. Pretoria: Council for Geosciences, pp. 21–42.

Rutherford, M.C. & Westfall, R.H., 1994. Biomes of southern Africa: An objective categorisation. Memoirs of the Botanical Survey of South Africa No. 63. Pretoria: National Botanical Institute.

Tooth, S., McCarthy, T.S. & Ellery, W.N., 2004. Quaternary environmental change and fluvial dynamics in southern Africa. Earth-Science Reviews, 66, pp. 49–93.

Viglietti, P.A., 2020. Biostratigraphy and vertebrate palaeontology of the Balfour Formation, Adelaide Subgroup. Palaeontologia Africana, 55, pp. 1–40.

APPENDIX A

ENVIRONMENTAL IMPACT METHODOLOGY

EIMS: IMPACT ASSESSMENT METHODOLOGY

The impact significance rating methodology, as presented herein and utilised for all EIMS Impact Assessment Projects, is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The approach may be altered or substituted on a case-by-case basis if the specific aspect being assessed requires such- such instances require prior EIMS Project Manager approval. The broad approach to the significance rating methodology is to determine the significance (S) of an environmental risk or impact by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relating this to the probability/ likelihood (P) of the impact occurring. The S is determined for the pre- and post-mitigation scenario. 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 S to determine the overall final significance rating (FS). The impact assessment will be applied to all identified alternatives.

Determination of Significance

The final significance (FS) of an impact or risk is determined by applying a prioritisation factor (PF) to the post-mitigation environmental significance. The significance is dependent on the consequence (C) of the particular impact and the probability

(P) of the impact occurring. 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:

$$C = \frac{(E + D + M + R) * N}{4}$$

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

Criteria for Determining Impact Consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)
	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site).
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site).
Duration	1	Immediate (<1 year, quickly reversible)
	2	Short term (1-5 years, less than project lifespan)
	3	Medium term (6-15 years)
	4	Long term (15-65 years, the impact will cease after the operational life span of the project)
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction/ operation/ decommissioning).
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, or affected environmental components are already degraded)
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; moderate improvement for +ve impacts; or where change affects area of potential conservation or other value, or use of resources).
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease; high improvement for +ve impacts; or where change affects high conservation value areas or species of conservation concern)

	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts; or disturbance to pristine areas of critical conservation value or critically endangered species)
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 very high time and cost.
	5	Irreversible Impact.

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

It is noted that both environmental risks as well as environmental impacts should be identified and assessed. Environmental Risk can be regarded as the potential for something harmful to happen to the environment, and in many instances is not regarded as something that is expected to occur during normal operations or events (e.g. unplanned fuel or oil spills at a construction site). Probability and likelihood are key determinants or variables of environmental risk. Environmental Impact can be regarded as the actual effect or change that happens to the environment because of an activity and is typically an effect that is expected from normal operations or events (e.g. vegetation clearance from site development results in loss of species of concern). Typically, the probability of an unmitigated environmental impact is regarded as highly likely or certain (management and mitigation measures would ideally aim to reduce this likelihood where possible). In summary, environmental risk is about what could happen, while environmental impact is about what does happen.

Probability/ Likelihood Scoring

Probability	1	Improbable (Rare, the event may occur only in exceptional circumstances, the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <5% chance).
	2	Low probability (Unlikely, impact could occur but not realistically expected; >5% and <20% chance).
	3	Medium probability (Possible, the impact may occur; >20% and <50% chance).
	4	High probability (Likely, it is most probable that the impact will occur- > 50 and <90% chance).
	5	Definite (Almost certain, the impact is expected to, or will, occur, >90% chance).

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

$$S = C \times P$$

Determination of Significance

	5- Very High[1]	5	10	15	20	25
	4- High	4	8	12	16	20

	3- Medium	3	6	9	12	15
	2- Low	2	4	6	8	10
	1- Very low	1	2	3	4	5

[1] In the event that an impact or risk has very high or catastrophic consequences, but the likelihood/ probability is low, then the resultant significance would be Low-medium. This does in certain instances detract from the relative important of this impact or risk and must consequently be flagged for further specific consideration, management, mitigation, or contingency planning

		1- Improbable	2- Low	3- Medium/ Possible	4- High/ Probable	5- Highly likely/ Definite
	Probability					

The outcome of the significance assessment will result in a range of scores, ranging from 1 through to 25. These significance scores are then grouped into respective classes as described in Tablebelow.

Significance Scores

S Score	Description
≤4.25	Low (i.e. where this impact is unlikely to be a significant environmental risk/ reward).
>4,25, ≤8.5	Low-Medium (i.e. where the impact could have a significant environmental risk/ reward).
>8.5, ≤13.75	High-Medium (i.e. where the impact could have a significant environmental risk/ reward).
>13.75	High (i.e. where the impact will have a significant environmental risk/ reward).

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

Impact Prioritization

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

Cumulative impacts; and

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 impacts' post-mitigation significance (post-mitigation). This prioritisation factor does not aim to

detract from the significance 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 post-mitigation significance based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 5: 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.
	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
Irreplaceable Loss of Resources (LR)	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 5. The impact priority is therefore determined as follows:

$$\boldsymbol{Priority = CI + LR}$$

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from

1 to 1.5 (Refer to Table below).

Determination of Prioritisation Factor

Priority	Prioritisation Factor
2	1
3	1.125
4	1.25
5	1.375
6	1.5

In order to determine the final impact significance (FS), the PF is multiplied by the post-mitigation significance scoring. The ultimate aim of the PF is an attempt to increase the post mitigation

environmental risk rating by a factor of 0.5, if all the priority attributes are high (i.e. if an impact comes out with a high 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 to upscale the impact to a higher significance).

Final Environmental Significance Rating

Significance Rating	Description
<-25	**Very High (Impacts in this class are extremely significant and pose a very high environmental risk. In certain instances these may represent a fatal flaw. They are likely to have a major influence on the decision and may be difficult or impossible to mitigate. Offset's may be necessary.**
<-13.75 to -25	High negative (These impacts are significant and must be carefully considered in the decision-making process. They have a high environmental risk or impact and require extensive mitigation measures).
-8.5 to -13.75	Medium-High negative (i.e. Impacts in this class are more substantial and could have a significant environmental risk. They may influence the decision to develop in the area and require more robust mitigation measures).
<-4.25 to <-8.5	Medium- Low negative (i.e. These impacts are slightly more significant than low impacts but still do not pose a major environmental risk. They might require some mitigation measures but are generally manageable).

Significance Rating	Description
-1 to -4.25	Low negative (i.e. Impacts in this class are minor and unlikely to have a significant environmental risk. They do not influence the decision to develop in the area and are typically easily mitigated.
0	No impact
1 to 4.25	Low positive
>4.25 to <8.5	Medium-Low positive
8.5 to 13.75	Medium-High positive
>13.75	High positive

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.

Nature	-1	Likely to result in a negative/ detrimental impact	CONSEQUENCE	ENVIRONMENTAL
	1	Likely to result in a positive/ beneficial impact		
Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)		

	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)		
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)		
	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site).		
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site).		
Duration	1	Immediate (<1 year, quickly reversible)		
	2	Short term (1-5 years, less than project lifespan)		
	3	Medium term (6-15 years)		
	4	Long term (15-65 years, the impact will cease after the operational life span of the project)		
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction/ operation/ decommissioning).		
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, or affected environmental components are already degraded)		
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; moderate improvement for +ve impacts; or where change affects area of potential conservation or other value, or use of resources).		
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease; high improvement for +ve impacts; or where change affects high conservation value areas or species of conservation concern)		
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts; or disturbance to pristine areas of critical conservation value or critically endangered species)		
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		
Probability	1	Improbable (Rare, the event may occur only in exceptional circumstances, the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <5% chance).	PROBABILITY	
	2	Low probability (Unlikely, impact could occur but not realistically expected; >5% and <20% chance).		
	3	Medium probability (Possible, the impact may occur; >20% and <50% chance).		
	4	High probability (Likely, it is most probable that the impact will occur- > 50 and <90% chance).		

	5	Definite (Almost certain, the impact is expected to, or will, occur, >90% chance).		
Cumulative Impact	1	Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.	PRIORITISATION FACTOR	
	2	Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.		
	3	High: 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	1	Low: Where the impact is unlikely to result in irreplaceable loss of resources.		
	2	Medium: 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.		
	3	High: Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).		
Degree of Confidence	Low	<30% certain of impact prediction		

APPENDIX B

PGS TEAM CVs

ELIZE BUTLER

Associate

Palaeontologist

PROFILE

Elize has conducted approximately 900 Paleontological Impact Assessments for developments in the Free State, KwaZulu-Natal, Eastern, Northern and Western 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. She has experience in locating, collecting, and curating fossils. She has been a member of the Paleontological Society of South Africa (PSSA) since 2006 and has been conducting PIAs since 2014.

CONTACT

PHONE NUMBER:
+27 (84) 447-8759

WEBSITE:
www.pgsheritage.com

EMAIL ADDRESS:
elize@pgsheritage.com

PGS HERITAGE

EDUCATION

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

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

University of the Orange Free State
2009
M. Sc. Cum laude (Zoology)
Dissertation title: The postcranial skeleton of the Early Triassic non-mammalian Cynodont Galesaurus planiceps: implications for biology and lifestyle.

WORK EXPERIENCE

PGS Heritage Group of Companies

Associate – Palaeontologist
2025 - present
Appointed as Associate - Palaeontologist responsible for palaeontological impact studies

Banzai Environmental - Palaeontologist
2016 - present
Palaeontologist and Director responsible for palaeontological impact studies

National Museum, Bloemfontein - Principal Research Assistant and Collection Manager
1998 - 2022

National Museum, Bloemfontein - Research Assistant
1993-1997

PROFESSIONAL AFFILIATION

Professional Palaeontologist
Paleontological Society of South Africa (PSSA) – since 2006