APPENDIX I: PALAEONTOLOGICAL IMPACT ASSESSMENT

Palaeontological Impact Assessment for the proposed Rhino Oil and Gas project ER294 Target areas 4 (Steynsrus) and 5 (Petrus Steyn), Free State Province

Desktop Study (Phase 1)

For

SLR Consulting (Pty) Ltd

19 March 2023

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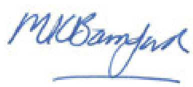
Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, mASSAf
Experience: 34 years research and lecturing in Palaeontology
26 years PIA studies and over 350 projects completed

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by SLR Consulting (Pty) Ltd, Johannesburg, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

A Palaeontological Impact Assessment was requested for the ER294 Target Areas 4 and 5 (around Steynsrus and Petrus Steyn, respectively) for part of the Rhino Oil and Gas drilling project in the Free State Province. Final drill sites have not yet been determined so the general areas were assessed for this report.

To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development.

The proposed sites lie on non-fossiliferous Jurassic dolerite and on potentially very highly fossiliferous Beaufort Group rocks (Adelaide Subgroup and Tarkatad Subgroup) and the Molteno Formation in the eastern part. Therefore, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological impact assessment is required until drill sites have been located based on other criteria. If the final location is on very highly fossiliferous rocks then a palaeontologist should visit the site and remove any fossils, if present, with a relevant SAHRA permit. For ploughed areas and area of moderate sensitivity, the Fossil chance Find Protocol should be followed. Overall, the significance / impact on palaeontology is low pre-mitigation and insignificant post-mitigation.

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1. Introduction

i. Project Background

Rhino Oil and Gas Exploration South Africa (Pty) Ltd. (Rhino Oil & Gas) is a South African registered subsidiary of Rhino Resources Ltd. Rhino Resources Ltd is a technology driven, independent oil and gas exploration and development company focused on Africa. Rhino Oil & Gas has been granted an Environmental Authorisation and Exploration Right, permitting their exploration for natural gas using non-invasive techniques on various farms in the Magisterial District of Frankfort, Harrismith, Heilbron, Kroonstad, Lindley, Reitz, Senekal, Ventersburg and Vrede in the Free State, Mpumalanga and Gauteng Provinces (ER reference: 12/3/294). Exploration was to be undertaken in terms of an approved Exploration Work Programme (EWP), over an initial period of three (3) years.

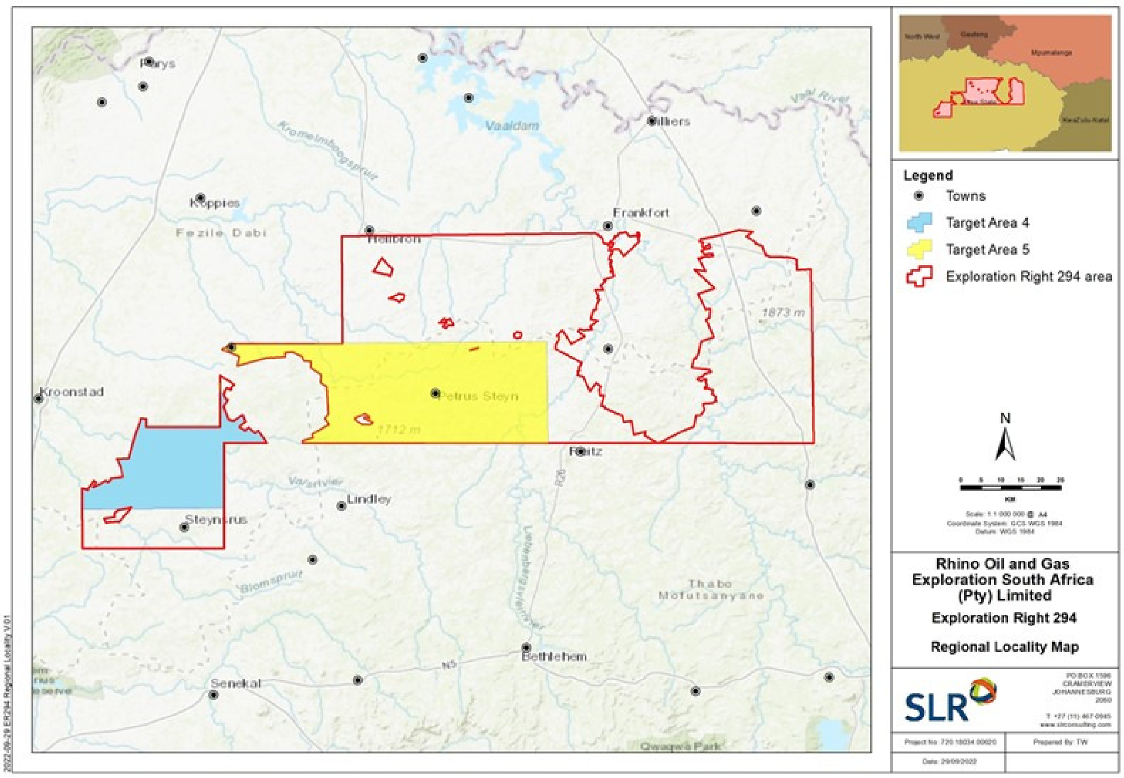

Figure 1: Locality Map showing extent of 294

Source-SLR Consulting

ii. Requirements for Specialist Reports

The National Environmental Management Act, 1998 requires for specialists reports to contain certain information in order to be credited. Information regarding the requirements for specialist reports is tabulated below.

Table 1: Requirements for Specialist Reports

National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report,	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section **Error! Reference source not found.**
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 0
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 3
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 0
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 **Error! Reference source not found.**
k	Any mitigation measures for inclusion in the EMPr	Section 8, Appendix A

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
l	Any conditions for inclusion in the environmental authorisation	Section 8 Appendix A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
nii	If the opinion is that the proposed activity 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	Sections 6, 8
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A
p	A summary and copies of any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A
2	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

2. Project Description

i. Project Location

The extent of ER 294 includes ~ 3 000 properties (farms and portions) over an area of ~ 6 600 ha (See Figure 1 for the entire project, west, central and east sectors.).

Based on the outcome of prior exploration, Rhino Oil and Gas has identified two (2) Target Areas within which the updated well drilling EWP intends to focus. The Target Areas include:

- **Target Area 4** extends for an area of ~550 km2, approximately 10 km north of Steynrus and 10 km east of Kroonstad. The Target Area 4 includes ~ 300 properties; and
- **Target Area 5** of ~1 300 km2, which is in the central part of ER294, with Petrus Steyn right in its centre. Target Areas 5 extends across ~ 1 000 properties.

The location of well drilling sites is subject to a process of geological review, landowner consent and environmental considerations. Areas that are unsuitable will be eliminated from further consideration. Rhino Oil and Gas is currently busy with the well site identification process.

ii. Main Project Components

The main project components, including the following:

- Onshore Drill Rig;
- Exclusion Zone;
- Local logistics base;
- Supply trucks;
- Personnel;
- Crew transfer; and
- Infrastructure and services.

A Palaeontological Impact Assessment was requested for the Rhino Oil and Gas Project for the ER294 areas. To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development and is reported herein.

3. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.
The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

4. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the dolomites, sandstones, shales and sands are typical for the country and some may contain fossil plant, insect, invertebrate and vertebrate material. It should be noted that within the Adelaide and Tarkastad Subgroups, no formations have been recognised because of a lack of rocky outcrop and therefore a lack of index fossils. (Note the low resolution geological map reproduced in this report only lacks the dolerite outcrops when compared with the higher resolution geological maps that were also consulted). The sands of the Quaternary period would not preserve fossils.

5. Legal Requirements

i. Minerals and Petroleum Resources Development Act, 2002

The MPRDA is the principal legislation governing prospecting and mining and the exploration and production of oil and natural gas. The Act provides for the equitable access to and sustainable development of mineral and petroleum resources. The MPRDA Regulations (GN R527 of 2004) provide for the application for and issuing of Reconnaissance Permits, Prospecting Rights, Exploration Rights, Mining Rights and Production Rights. The MPRDA also provides for the renewal of rights and permits. Rhino Oil and Gas currently holds an Exploration Right 12/3/294 and have made application to renew the ER in terms of Section 81 of the MPRDA.

ii. National Environmental Management Act, 1998

Chapter 5, Section 24 of the NEMA provides a framework for the granting of an Environmental Authorisation. Section 24(4) provides the minimum requirements for procedures for the investigation, assessment and communication of the potential impact of activities.

EIA Regulations 2014 (as amended) promulgated in terms of Chapter 5 of NEMA, provide for the control of certain listed activities. These activities are listed in GN No. R983 (Listing Notice 1), R984 (Listing Notice 2) and R985 (Listing Notice 3) of 4 December 2014 (as amended) and are prohibited until an Environmental Authorisation has been obtained from the competent authority.

The proposed exploration project triggers activities contained in both Listing Notice 1 – 21D and Listing Notice 2 - 18, thus an EIA process must be undertaken for PASA and DMRE to consider the application. Rhino Oil and Gas have made application for an EA in terms of Section 24 of the NEMA.

iii. National Heritage Resources Act, 1999

The National Heritage Resources Act, 1999 (No. 25 of 1999) (NHRA) provides for the identification, assessment and management of the heritage resources of South Africa. The NHRA requires that a person who intends to undertake a listed activity notify the relevant provincial heritage authority at the earliest stages of initiating such a development. The relevant provincial heritage authority would then, notify the person whether a Heritage Impact Assessment (HIA) should be submitted.

Section 38(1) of the NHRA lists development activities that would require authorisation by the responsible heritage resources authority. The proposed well drilling activities in the updated EWP do not trigger any activity set out in this section of the NHRA and thus there is no requirement for approval from the heritage authority.

6. Description of the Baseline Environment

i. Project location and geological context

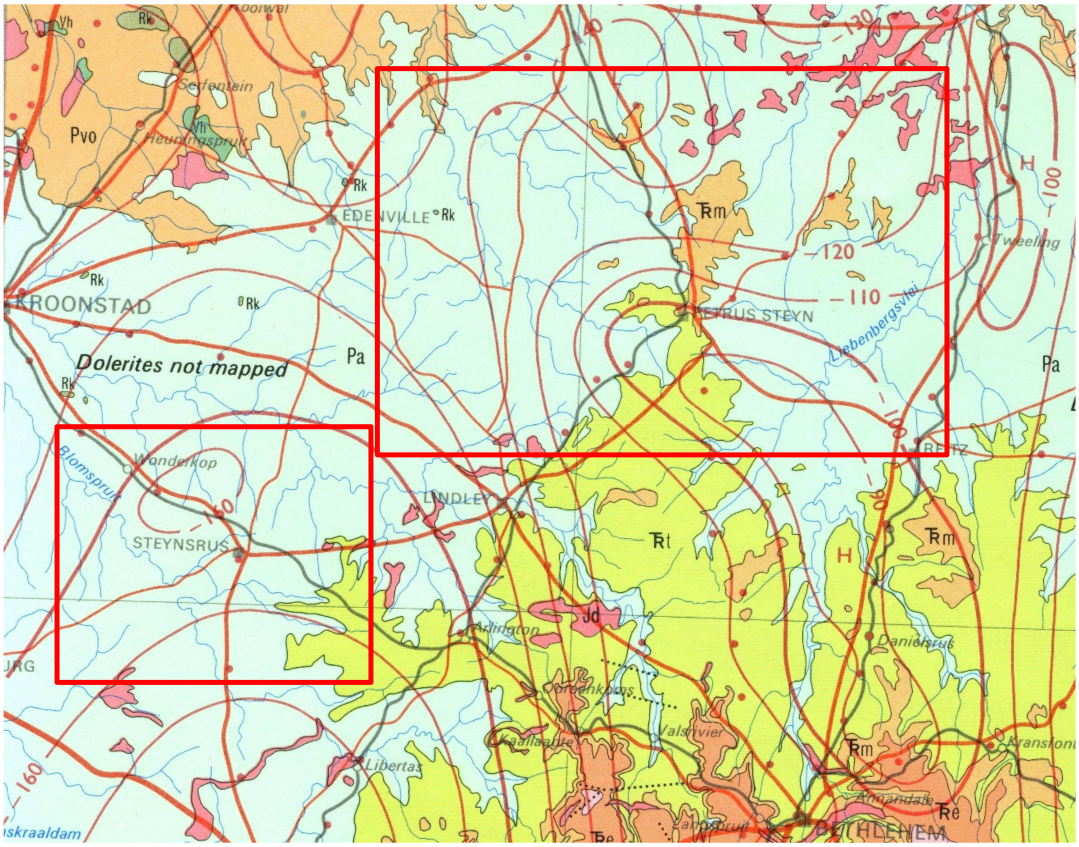

Figure 2: Geological map of the area around the ER294 Target Area 4 around Steynsrus and Target Area 5 around Petrus Steyn.

The approximate locations of the proposed projects are indicated within the red rectangles. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 1 000 000 map (Note – the 1:250 000 geology maps 2724 Kroonstad and 2824 Winburg will be used for the sites when determined).

Table 2: Explanation of symbols for the geological map and approximate ages (Eriksson et al., 2006. Johnson et al., 2006; Partridge et al., 2006).

SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Q	Quaternary	Alluvium, sand, calcrete	Quaternary Ca 1.0 Ma to present
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 183 Ma
Trm	Molteno Formation, Stormberg Group, Karoo SG	Siltstones, shales	Late Triassic Ca 242 - 219 Ma

Symbol	Group/Formation	Lithology	Approximate Age
Trt	Tarkastad Subgroup, Beaufort Group, Karoo SG	Mudstone, sandstone	Early Triassic Ca 251 - 242 Ma
Pa	Koonap Fm, Adelaide Subgroup, Beaufort Group, Karoo SG	Mudstone, sandstone	Late Permian, ca 266 - 260 Ma
Pvo	Volksrust Fm, Ecca Group, Karoo SG	Grey-black fine-grained mudstone, sandstone	Late Permian, ca 260 - 257 Ma
Pv	Vryheid Fm, Ecca Group, Karoo SG	Shale, mudstone, coal, sandstone	Middle Permian ca 266 – 260 Ma

The project lies in the central part of the main Karoo Basin where the Ecca Group sediments, Beaufort and Stormberg Group sediments are exposed (Figure 4). A few rare outcrops of the underlying and older Ventersdorp Supergroup lavas occur near Odendalsrus. Much younger Quaternary sands and alluvium unconformably overlie most of the Karoo Supergroup rocks that have not been extensively eroded.

The Karoo Supergroup rocks cover a very large proportion of South Africa and extend from the northeast (east of Pretoria) to the southwest and across to almost the KwaZulu Natal south coast. It is bounded along the southern margin by the Cape Fold Belt and along the northern margin by the much older Transvaal Supergroup rocks. Representing some 120 million years (300 – 183Ma), the Karoo Supergroup rocks have preserved a diversity of fossil plants, insects, vertebrates and invertebrates.

Overlying the basal Dwyka Group rocks are rocks of the Ecca Group that are Early Permian in age. There are eleven formations recognised in this group but they do not all extend throughout the Karoo Basin. In the central and eastern part are the following formations, from base upwards: Pietermaritzburg, Vryheid and Volksrust Formations. All of these sediments have varying proportions of sandstones, mudstones, shales and siltstones and represent shallow to deep-water settings, deltas, rivers, streams and overbank depositional environments.

Overlying the Ecca Group are the rocks of the Beaufort Group that has been divided into the lower Adelaide Subgroup for the Upper Permian strata, and the Tarkastad Subgroup for the Early to Middle Triassic strata. As with the older Karoo sediments, the formations vary across the Karoo Basin.

In this part of the basin, east of 24°E, three formations are recognised in the Adelaide Subgroup, the basal Koonap Formation, the Middleton Formation and the thick Balfour Formation. The latter has been divided into five members, from the base up are the Oudeberg, Daggaboersnek, Ripplemead, Elandsberg and Palingkloof Members. The topmost member is in the Triassic (Rubidge, 2005; Smith et al., 2020).

In the central and eastern part of the Karoo Basin the Tarkastad Subgroup of the Beaufort Group is composed of two formations, the lower Katberg and upper Burgersdorp Formations.

Overlying the Beaufort Group are the three formations of the Stormberg Group. They are absent from the western part of the basin but are more uniform across the eastern part of the basin. Capping the Stormberg Group are the Drakensberg Group basalts and dykes that signalled the end of deposition in the Karoo basin. The Stormberg Group formations are the lower Molteno Formation shales, the Elliot Formation that has recently been divided into the lower and upper Elliot Formation, and the upper Clarens Formation.

Minor exposures of Jurassic dolerite dykes occur throughout the area. These intruded through the Karoo sediments around 183 million years ago at about the same time as the Drakensberg basaltic eruption.

Quaternary Kalahari sands cover large parts of the rocks in this region, especially to the west. This is the largest and most extensive palaeo-erg in the world (Partridge et al., 2006) and is composed of extensive aeolian and fluvial sands, sand dunes, calcrete, scree and colluvium. Periods of aridity have overprinted the sands, and calcrete and silcrete are common. Most geological maps indicate these sands simply descriptively (aeolian sand, gravelly sand, calcrete) or they are lumped together as the Gordonia Formation because the detailed regional lithostratigraphic work has not been done, Nonetheless, these sands have eroded from the interior and have been transported by wind or water to fill the basin. Reworking of the sands or stabilisation by vegetation has occurred. Probable ages of dune formation are around 100 kya (thousand years), 60 kya, 27-23 kya and 17-10 kya (in Botha, 2021).

Along many of the rivers and watercourses are fluvially-transported sands and gravels that too are difficult to date. This sand is derived from the meandering channels and terraces and has been reworked in the past from rivers and re-captured rivers as the tectonic uplift has changed drainage patterns (de Wit, 1999; Botha, 2021). Human activities have also impacted the rivers and their sediment source.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figures 3-4. The sites for drilling are mostly in very highly sensitive rocks of the Karoo Supergroup.

Although there are no mapped outcrops of the various formations of the Adelaide or Tarkastad Subgroups in the central part of the basin, detailed mapping has been done for the southern and western parts of the Karoo Basin and vertebrate fossils have been used to recognise the different formations. Note, in the field it is very difficult to recognise the different animal species but bones will appear as white structures in the mudstones.

The **Adelaide Subgroup** is part of the eastern foredeep basin and was deposited in the overfilled or non-marine phase (Catuneanu et al., 2005) and so comprises terrestrial deposits. There are numerous fining-upward cycles, abundant red mudrocks and sedimentary structures that indicate deposition under fluvial conditions (Johnson et al., 2006). Some of the lower strata probably represent a subaerial upper delta-plain environment and the generally finer grained materials are typical of meandering rather than braided rivers. Channel deposits are indicated by sandstones while overbank deposits are indicated by the mudstones (Johnson et al., 2006).

The **Koonap Formation** (lower Adelaide Subgroup) has been divided into the *Eodicynodon* and *Tapinocephalus* Assemblage Zones based on the dominant basal therapsid genera.

Typical fossils of the *Eodicynodon* Assemblage Zone are fish, amphibians, dinocephalians, anomodonts (including *Eodicynodon*), gorgonopsians, therocephalians, invertebrate trace fossils and molluscs (Rubidge and Day, 2020). Plants are not common but there are leaves of *Glossopteris* and *Schizoneura* (sphenophyte) (Plumstead, 1969; Anderson and Anderson, 1985; Bamford, 2004).

Typical fossils of the *Tapinocephalus* Assemblage Zone are fish, amphibians, parareptiles, eureptiles, biarmosuchians, dinocephalians (including *Tapinocephalus*), anomodontians, therocephalians, vertebrate and invertebrate trace fossils and molluscs (Day and Rubidge. 2020). There is a low diversity of fossil plants from this assemblage zone but they include glossopterids, sphenophytes and gymnosperm woods (Plumstead, 1969; Anderson and Anderson, 1985; Bamford, 2004).

The **Middleton Formation** (Adelaide Subgroup) has been divided into the *Endothiodon*, and lower *Cistecephalus* Assemblage Zones based on the dominance of various vertebrate taxa. Fauna of the ***Endothiodon* Assemblage Zone** include the co-occurrence of the dicynodonts *Endothiodon, Emydops, Pristerodon* as well as the gorgonopsian *Gorgonops* (Day and Smith, 2020). Other vertebrates are fish, amphibians, biarmosuchains, anomodontians, other gorgonopsians, therocephalians and vertebrate and invertebrate traces. Plants include glossopterids, lycopods and sphenophytes (Plumstead, 1969; Anderson and Anderson, 1985; Bamford, 2004).

The ***Cistecephalus* Assemblage Zone** is characterised by the co-occurrence of the *Aulacephalodon, Oudenodon* and *Odontocyclops*, which are medium- to large-sized dicynodonts, as well as *Diictodon, Pristerodon* and *Cistecephalus* which are smaller dicynodonts (Smith, 2020). Important components are the diverse, gorgonopsians *Aelurognathus, Cyonosaurus* and *Lycaenops*. The therocephalians *Theriognathus, Ictidosuchoides* and *Ictidosuchop*s are rare components, as is the early cynodont *Cynosaurus*. Of the parareptiles, *Pareiasaurus* is most common taxon. The much rarer small-bodied pareiasaurs *Anthodon, Nanoparia*, and *Pumiliopareia* make their first and last appearances in the upper *Cistecephalus* Assemblage Zone (ibid). Fossil plants are rare and include glossopterids, lycopods and sphenophytes (Plumstead, 1969; Anderson and Anderson, 1985; Bamford, 2004).

The **Balfour Formation** is represented by the *Daptoccephalus* Assemblage Zone
The **Daptocephalus Assemblage Zone** is recognised by the co-occurrence of the dicynodontoid *Daptocephalus leoniceps*, the therocephalian *Theriognathus microps*, and the cynodont *Procynosuchus delaharpeae* (Viglietti, 2020). This has been further divided into two subzones, the lower *Dicynodon -Theriognathus* Subzone (in co-occurrence with *Daptocephalus*), and the upper *Lystrosaurus maccaigi – Moschorhinus kitchingi* Subzone (ibid). Other taxa include fish, amphibians, parareptiles, eureptiles, biarmosuchians,

anomodontians, gorgonopsians, therocephaleans, cynodonts and molluscs. The flora is more diverse than the older Assemblage Zones and comprises glossopterids, mosses, ferns, sphenophytes, lycopods, cordaitaleans and gymnosperm woods (Plumstead, 1969; Anderson and Anderson, 1985; Bamford, 2004).

The early Triassic **Katberg Formation** (lower Tarkstad Subgroup) represents shallow, braided environment with pulsatory discharges. It also has abandoned channel fills and braidplain environments, and the latter just representing a braidplain environment (Catuneanu et al., 1998). The ***Lystrosaurus declivis*** **Assemblage Zone** occurs in this formation and it is typified by a low diversity of herbivorous vertebrates, the abundance of the dicynodont therapsid *Lystrosaurus declivis* in association with the dicynodont therapsid *Lystrosaurus murrayi* (Botha and Smith, 2020). Other fauna include the non-mammaliaform epicynodont therapsid *Thrinaxodon liorhinus*, the procolophonoid parareptile *Procolophon trigoniceps*, and the absence of the dicynodont therapsid *Daptocephalus leoniceps* (ibid). Apart from the usual range of fish, amphibians and therapsid groups, the plants (rare) include glossopterids, lycopods, sphenophytes, ferns and early gymnosperms (Plumstead, 1969; Anderson and Anderson, 1985; Bamford, 2004; Barbolini et al., 2018).

The Early to middle Triassic **Burgersdorp Formation** (Tarkstad Subgroup) is home to the ***Cynognathus*** **Assemblage Zone**. This post Permo-Triassic extinction event and recovery phase has a lower diversity of fauna and flora. It is typified by the presence of the cynodont genus *Cynognathus* (Kitching, 1995; Hancox et al., 2020), and has been divided into three subzones, namely the lower *Langbergia-Garjainia* Subzone, the *Trirachodon-Kannemeyeria* Subzone and the upper *Cricodon-Ufudocyclops* Subzone (Hancox et al., 2020). Other fauna include, fish, amphibians, parareptiles, eureptiles, therocephalians, cynodontians and trace fossils. Plants of the Burgersdorp Formation no longer include the glossopterids; there are lycopods (*Gregicaulis*), sphenophytes (*Calamites)*, ferns (*Asterotheca, Cladophlebis*), seed ferns (*Lepidopteris, Dicroidium*), cycads (*Pseudoctenis, Nilssonia*), ginkgos (*Ginkgoites, Sphenobaiera*) and conifers (*Sewardistrobis, Agathoxylon, Podocarpoxylon*) (Plumstead, 1969; Anderson and Anderson, 1985; Bamford, 2004; Barbolini et al., 2018).

Stormberg Group

The **Molteno Formation**, of upper Triassic age, represents braided streams on a vast braid plain, rare coal deposits with a few filled in abandoned channel tracts and some ponded bodies of water (Catuneanu et al., 1998). It was a part of the ever-shrinking Karoo Basin and only occurs around the margins of the Drakensberg Mountains. There are no vertebrate fossils in this formation but footprints of three-toed vertebrates are common in some parts (Anderson et al., 1998).

In contrast, the flora is extremely rich and diverse in pockets around Little Switzerland, Molteno, Birds River and others (Anderson and Anderson, 1985). The flora includes the lower plants such as bryophytes, ferns, lycopods and sphenophytes, the now extinct seed ferns such as *Dicroidium* (dominant), *Lepidopteris, Yabiella, Taeniopteris, Dejerseya*, cycads such as *Pseudoctenis, Nilssoniopteris*, gymnosperms such as *Ginkgoites, Sphenobaiera, Rissikia, Voltziopsis, Heidiphyllum, Pagiophyllum,* and incertae sedis

(Plumstead, 1969; Anderson and Anderson, 1983, 1985, 2002. 2020; Bamford 2004). There is no vertebrate assemblage zone for the Molteno Formation.

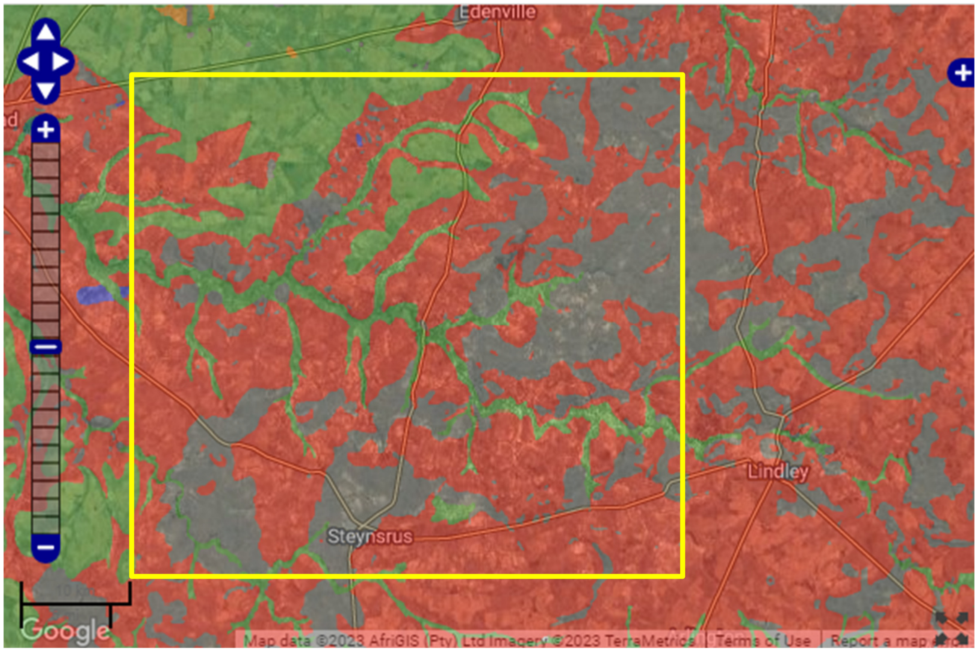

Figure 3: SAHRIS palaeosensitivity map for the site for the proposed ER294 Target Area 4 around Steynsrus shown within the yellow rectangle.

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

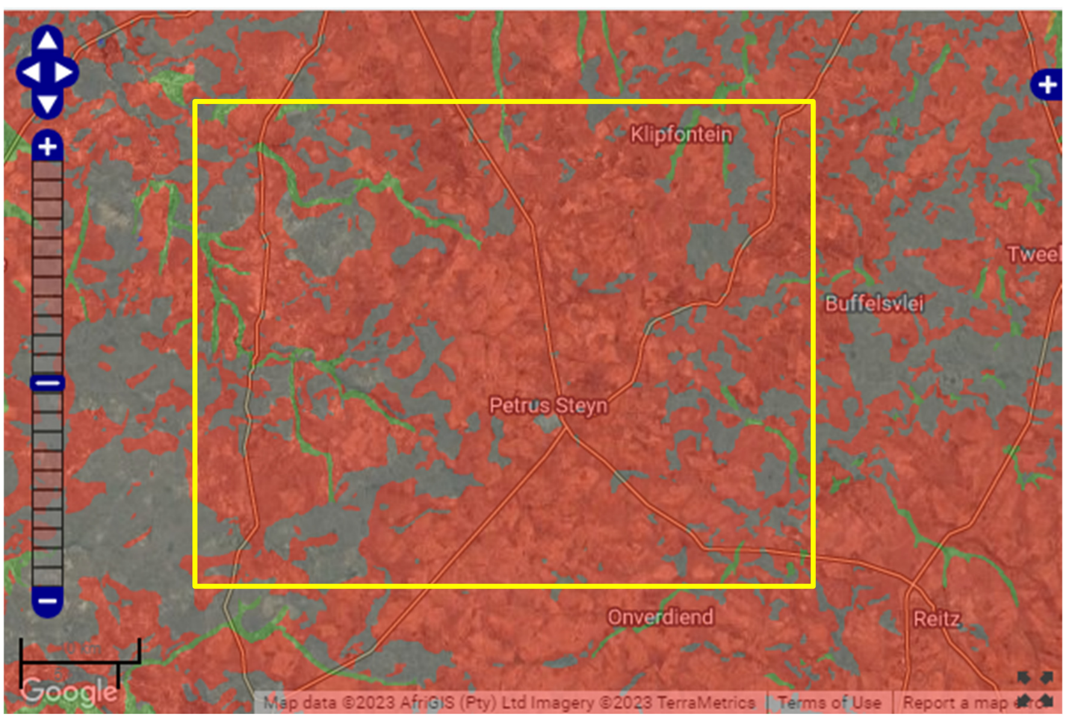

Figure 4: **SAHRIS palaeosensitivity map for ER294 Target Area 5 around Petrus Steyn.** Background colours as for Figure 6.

From the SAHRIS maps above the area is indicated as very highly sensitive (red) for the Adelaide and Tarkastad Subgroups, moderately sensitive (green) for the Quaternary sands and alluvium and zero sensitivity (grey) for the dolerite.

7. Methodology

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in **Error! Reference source not found.**:

PART A: DEFINITIONS AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of intensity, spatial extent and duration**
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.

	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE							
			EXTENT				
			A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
			VL	**L**	**M**	**H**	**VH**
INTENSITY = VL							
DURATION	Very long	**VH**	**Low**	**Low**	**Medium**	**Medium**	**High**
	Long term	**H**	**Low**	**Low**	**Low**	**Medium**	**Medium**
	Medium term	**M**	**Very Low**	**Low**	**Low**	**Low**	**Medium**
	Short term	**L**	**Very low**	**Very Low**	**Low**	**Low**	**Low**
	Very short	**VL**	**Very low**	**Very Low**	**Very Low**	**Low**	**Low**
INTENSITY = L							
DURATION	Very long	**VH**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Long term	**H**	**Low**	**Medium**	**Medium**	**Medium**	**High**
	Medium term	**M**	**Low**	**Low**	**Medium**	**Medium**	**Medium**
	Short term	**L**	**Low**	**Low**	**Low**	**Medium**	**Medium**
	Very short	**VL**	**Very low**	**Low**	**Low**	**Low**	**Medium**
INTENSITY = M							
DURATION	Very long	**VH**	**Medium**	**High**	**High**	**High**	**Very High**
	Long term	**H**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Medium term	**M**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Short term	**L**	**Low**	**Medium**	**Medium**	**Medium**	**High**
	Very short	**VL**	**Low**	**Low**	**Low**	**Medium**	**Medium**

INTENSITY = H							
DURATION	Very long	VH	High	High	High	Very High	Very High
	Long term	H	Medium	High	High	High	Very High
	Medium term	M	Medium	Medium	High	High	High
	Short term	L	Medium	Medium	Medium	High	High
	Very short	VL	Low	Medium	Medium	Medium	High
INTENSITY = VH							
DURATION	Very long	VH	High	High	Very High	Very High	Very High
	Long term	H	High	High	High	Very High	Very High
	Medium term	M	Medium	High	High	High	Very High
	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High
			VL	L	M	H	VH
			A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
			EXTENT				

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	VH	Very Low	Low	Medium	High	Very High
	Probable	H	Very Low	Low	Medium	High	Very High
	Possible/ frequent	M	Very Low	Very Low	Low	Medium	High
	Conceivable	L	Insignificant	Very Low	Low	Medium	High
	Unlikely/ improbable	VL	Insignificant	Insignificant	Very Low	Low	Medium
			VL	L	M	H	VVH
			CONSEQUENCE				

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

8. Impact Assessment

i. Impact Assessment for Palaeontology

Issue: PALAEONTOLOGY
Description of impact: Destruction of fossils that might be present in the drill site and laydown area.
Impact Assessment

Issue: Palaeontology		
Phases: Laydown of drill site and operation (drilling)		
Criteria	Without Mitigation	With Mitigation
Intensity	High	Low
Duration	Permanent	Permanent
Extent	Site	Site
Consequence	Medium	Low
Probability	Conceivable	Unlikely
Significance	Low	Insignificant
Additional Assessment Criteria		
Degree to which impact can be reversed	Irreversible impact.	
Degree to which impact may cause irreplaceable loss of resources	Fossils are irreplaceable. However, the implementation of a chance finds protocol will enable the monitoring and where required documentation of such resources.	
Degree to which impact can be avoided	**High**	
Degree to which impact can be mitigated	**High:** implementation of a chance finds protocol will enable the monitoring and where required documentation of such resources	
Cumulative Impacts		
Nature of cumulative impacts	General loss of fossils and scientific knowledge to national palaeontological record.	
Extent to which a cumulative impact may arise	Negligible because each site is unique	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Insignificant	Insignificant
Residual impacts	Low	
Mitigated outcome	None, with mitigation (removal of any fossils) the impact will be insignificant	

Mitigation actions
The following measures are recommended (see Fossil Chance Find Protocol in Appendix A) – removal of any surface fossils from the drill site laydown area.:

Monitoring
The following monitoring is recommended (see EMPr):

When the drill core has been extracted and while it being logged, the geologist should look for fossil plants in the shales and photograph and retrieve them if possible. Noting that the drill core diameter is 135mm no complete fossils are likely to be retrieved.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are the right age and type to contain fossils but much of the area has been altered by the removal of rocks to clear the lands for agriculture. Since there is an extremely small chance that vertebrate fossils from the Beaufort Group may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low.

9. Recommendations

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the overlying soils and the river valley alluvium of the Quaternary. There is a very small chance that fossils may occur in the mudstones and sandstones of the Adelaide and Tarkastad Subgroups (Beaufort Group) but there is a lack of rocky outcrop in this part of the Karoo Basin. Once the drill sites have been finalised based on other criteria, there are three courses of action (mitigation):

1. Sites that fall in very highly sensitive rocks (but not on ploughed lands where rocks have been removed), should be visited by a palaeontologist to determine if any fossils occur on the land surface. If present they should be collected with a valid SAHRA permit.
2. For ploughed lands and for highly or moderately sensitive rocks, a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found by the environmental officer or other responsible person once the site has been determined and before any disturbance has commenced then they should be rescued by that person, photographed and a palaeontologist called to assess and collect a representative sample.
3. For low sensitivities or dolerite, no action is required and the drilling can commence, as far as the palaeontology is concerned.

Overall, the impact on the palaeontological heritage would be insignificant pre-mitigation and insignificant post-mitigation.

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11. Appendix A - Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations / drilling activities begin.

1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations commence.
2. When excavations begin the rocks and discard must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone or coal) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of similar fossils must be provided to the developer to assist in recognizing the fossil plants, vertebrates, invertebrates or trace fossils in the shales and mudstones (for example see Figures 8-10). This information will be built into the EMP's training and awareness plan and procedures.
4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the developer/environmental officer then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

12. Appendix B – Examples of fossils from the Beaufort Group

Figure 8: Photographs of vertebrate fossil bones from the Beaufort Group. Bottom left shows a typical exposure of bones in rock = unidentifiable white bits.

Figure 9: Photographs of fossil plants that might occur in the Beaufort Group rocks.

13. Appendix C – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
January 2023

Present employment: Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DSI Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa
Telephone : +27 11 717 6690
Cell : 082 555 6937
E-mail : marion.bamford@wits.ac.za ; marionbamford12@gmail.com

ii) **Academic qualifications**
Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) **Professional qualifications**
Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) **Membership of professional bodies/associations**
Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

v) **Supervision of Higher Degrees**

All at Wits University

Degree	Graduated/completed	Current

Honours	13	0
Masters	13	3
PhD	13	7
Postdoctoral fellows	14	4

vi) **Undergraduate teaching**
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 12 - 20 students per year.

vii) **Editing and reviewing**
Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Associate Editor: Cretaceous Research: 2018-2020
Associate Editor: Royal Society Open: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international journals

viii) **Palaeontological Impact Assessments**
25 years' experience in PIA site and desktop projects

- Selected from recent projects only – list not complete:
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for Enviropro
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe
- Glosam Mine 2022 for AHSA
- Wolf-Skilpad-Grassridge OHPL 2022 for Zutari
- Iziduli and Msenge WEFs 2022 for CTS Heritage
- Hendrina North and South WEFs & SEFs 2022 for Cabanga
- Dealesville-Springhaas SEFs 2022 for GIBB Environmental
- Vhuvhili and Mukondelei SEFs 2022 for CSIR
- Chemwes & Stilfontein SEFs 2022 for CTS Heritage
- Equestria Exts housing 2022 for Beyond Heritage
- Zeerust Salene boreholes 2022 for Prescali
- Tsakane Sewer upgrade 2022 for Tsimba
- Transnet MPP inland and coastal 2022 for ENVASS
- Ruighoek PRA 2022 for SLR Consulting (Africa)
- Namli MRA Steinkopf 2022 for Beyond Heritage

ix) **Research Output**
Publications by M K Bamford up to January 2022 peer-reviewed journals or scholarly books: over 170 articles published; 5 submitted/in press; 14 book chapters.
Scopus h-index = 30; Google Scholar h-index = 39; -i10-index = 116 based on 6568 citations.
Conferences: numerous presentations at local and international conferences.