



**PALAEONTOLOGICAL IMPACT
ASSESSMENT FOR THE
DEVELOPMENT OF PEDESTRIAN
BRIDGES IN THE MONONTSHA
SETTLEMENT, PHUTHADITJABA, FREE
STATE**

CaseID 18019

APRIL 2022

**COMPILED ON BEHALF OF:
SPATIAL SOLUTIONS INC**



Declaration of Independence

I, Elize Butler, declare that –

General declaration:

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

**Disclosure of Vested Interest**

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

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SIGNATURE:



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

Table 1 - NEMA Table

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	Relevant section in report	Comment where not applicable.
1.(1) (a) (i) Details of the specialist who prepared the report	Page ii and Section 2 of Report – Contact details and company and Appendix A	-
(ii) The expertise of that person to compile a specialist report including a curriculum vita	Section 2 – refer to Appendix A	-
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page ii of the report	-
(c) An indication of the scope of, and the purpose for which, the report was prepared	Section 4 – Objective	-
(cA) An indication of the quality and age of base data used for the specialist report	Section 5 – Geological and Palaeontological history	-
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 10	-
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 1 and 11	
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 7 Approach and Methodology	-
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures	Section 1 and 11	



Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	Relevant section in report	Comment where not applicable.
and infrastructure, inclusive of a site plan identifying site alternatives;		
(g) An identification of any areas to be avoided, including buffers	Section 5	No buffers or areas of sensitivity identified
(h) A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 5 – Geological and Palaeontological history	
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 7.1 – Assumptions and Limitation	-
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 1 and 11	
(k) Any mitigation measures for inclusion in the EMPr	Section 12	
(l) Any conditions for inclusion in the environmental authorisation	Section 12	
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 12	
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Section 1 and 11	
(n)(iA) A reasoned opinion regarding the acceptability of the proposed activity or activities; and		
(n)(ii) If the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 1 and 11	-



Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	Relevant section in report	Comment where not applicable.
(o) A description of any consultation process that was undertaken during the course of carrying out the study	N/A	Not applicable. A public consultation process will be conducted as part of the EIA and EMPr process.
(p) A summary and copies if any comments that were received during any consultation process	N/A	
(q) Any other information requested by the competent authority.	N/A	Not applicable.
(2) Where a government notice by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Section 3 compliance with SAHRA guidelines	



EXECUTIVE SUMMARY

Banzai Environmental was appointed by Spatial Solutions Inc to conduct the Palaeontological Impact Assessment (PIA) to assess the proposed Monontsha pedestrian bridges in the following villages Khosheng, Poelong, Phophopho, Selahliwe and Sehlajaneng located on the remainder of the farm Witziesshoek No. 1926, in Phuthaditjaba, Free State Province. To comply with the National Heritage Resources Act (No 25 of 1999, section 38) (NHRA), this PIA is necessary to verify if fossil material could potentially be present in the planned development area, to evaluate the potential impact of the proposed development on the Palaeontological Heritage and to mitigate possible damage to fossil resources.

The proposed Monontsha pedestrian bridges is underlain by Quaternary alluvium and scree, Tarkastad Subgroup (Beaufort Group, Karoo Supergroup) and the Late Triassic to Early Jurassic Elliot Formation of the Stormberg Group. The PalaeoMap of the South African Heritage Resources Information System indicates that the Palaeontological Sensitivity of the Quaternary deposits is moderate, while that of the Tarkastad Subgroup, and Eliot Formation is Very High (Almond and Pether, 2009; Almond *et al.*, 2013).

A site-specific field survey of the development footprint was conducted on foot and by motor vehicle on 6 April 2022. No visible evidence of fossiliferous outcrops was found. However, the area is known to contain fossil heritage. A Moderate Palaeontological Sensitivity has been allocated to the proposed development. It is thus considered that the proposed development will not lead to detrimental impacts on the palaeontological reserves of the area and the construction of the development may thus be authorised in its whole extent.

It is thus recommended that:

- The Environmental Control Officer (ECO), responsible for the development should be aware of the distinct possibility of finding fossils in the Tarkastad Subgroup (Beaufort Group, Karoo Supergroup), and Elliot Formation of the Stormberg Group, while fossils may be present in the Quaternary deposits.
- Training of accountable supervisory personnel by a qualified palaeontologist in the recognition of fossil heritage is necessary.
- If Palaeontological Heritage is uncovered during surface clearing and excavations the **Chance find Protocol** attached should be implemented immediately. These discoveries ought to be protected (if possible, *in situ*) and the ECO must report to SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web:



www.sahra.org.za) so that correct mitigation (recording and collection) can be carried out by a paleontologist.

- Before any fossil material can be collected from the development site the specialist involved would need to apply for a collection permit from SAHRA. Fossil material must be housed in an official collection (museum or university), while all reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012). It is consequently recommended that no further palaeontological heritage studies, ground truthing and/or specialist mitigation are required pending the discovery of newly discovered fossils.



TABLE OF CONTENTS

1	INTRODUCTION	1
2	QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR.....	2
3	LEGISLATION.....	3
3.1	National Heritage Resources Act (25 of 1999)	3
4	OBJECTIVE	4
5	GEOLOGICAL AND PALAEONTOLOGICAL HISTORY.....	6
6	GEOGRAPHICAL LOCATION OF THE SITE	17
7	METHODS	18
7.1	Assumptions and Limitations	18
8	ADDITIONAL INFORMATION CONSULTED	18
9	SITE VISIT	19
9.1	Sehlajaneng Bridge	19
9.2	Selahliwe Bridge	21
9.3	Phophopho Bridge	22
9.4	Khosheng Bridge	22
9.5	Poelong Bridge	23
10	IMPACT ASSESSMENT METHODOLOGY	24
10.1	Summary of Impact Tables	28
11	FINDINGS AND RECOMMENDATIONS	29
12	CHANCE FINDS PROTOCOL	31
12.1	Legislation	31
12.2	Background	31
12.3	Introduction	31
12.4	Chance Find Procedure	31
13	REFERENCES	32

List of Figures

Figure 1:	Location of the proposed Monontsha pedestrian bridges in the Monontsha Settlement located on the remainder of the farm Witzieshoek No. 1926, in Phuthaditjaba, Free State Province.	1
Figure 2:	Regional Topography	2
Figure 3:	Regional geology of the proposed Monontsha Settlement pedestrian bridges	10



Figure 4: Geology of the proposed development.....	11
Figure 5: Regional Geology indicated by Shape Files	13
Figure 6: Geology indicated by Shape Files	14
Figure 7: Extract of the 1:250 000 SAHRIS PalaeoMap (Council of Geosciences, Pretoria) indicating the proposed development of the Monontsha Settlement pedestrian bridges in Phuthaditjaba, Free State Province.	15
Figure 8: Vertebrate biozonation range chart for the Main Karoo Basin of South Africa. (Figure modified from Smith et al, 2020).....	17
Figure 9: Upstream view with sand and sandstone deposits in river	19
Figure 10: Thick alluvium deposits on the river bank without any outcrop	20
Figure 11: Down-washed surface deposits	20
Figure 12: Alluvium riverbanks covered by lush vegetation. No outcrops were detected	21
Figure 13: Thick alluvium riverbanks covered by lush vegetation. No outcrops were detected	22
Figure 14: Thick alluvium riverbanks covered by lush vegetation. No outcrops were detected.	22
Figure 15: Possible Elliot Formation outcrops on the southern side of the proposed development . These outcrops were unfossiliferous.	23
Figure 16: Outcrops on the northern margin of the proposed development were found to be unfossiliferous.	24

List of Tables

Table 1 - NEMA Table	iv
Table 2:Legend of the 1:250 000 Harrismith 2828 (1998) Geological Map (Council for Geosciences, Pretoria)...	12
Table 3: Palaeontological Significance	16
Table 4: Project locality.....	18
Table 5: The rating system.....	25
Table 6: Summary of Impact Tables	29

Appendix A:

Curriculum Vitae	Elize Butler
Curriculum Vitae	Prof. WA van der Westhuizen



1 INTRODUCTION

Maluti-A-Phofung Local Municipality proposes the development of five pedestrian bridges in the Monontsha Settlement in the following villages: Khosheng, Poelong, Phophopho, Selahliwe and Sehlajaneng located on the remainder of the farm Witzieshoek No. 1926, in Phuthaditjaba, Free State Province (**Figure 1-2**). The Municipality would like to develop the pedestrian bridges to provide safe stream crossings for the local community.

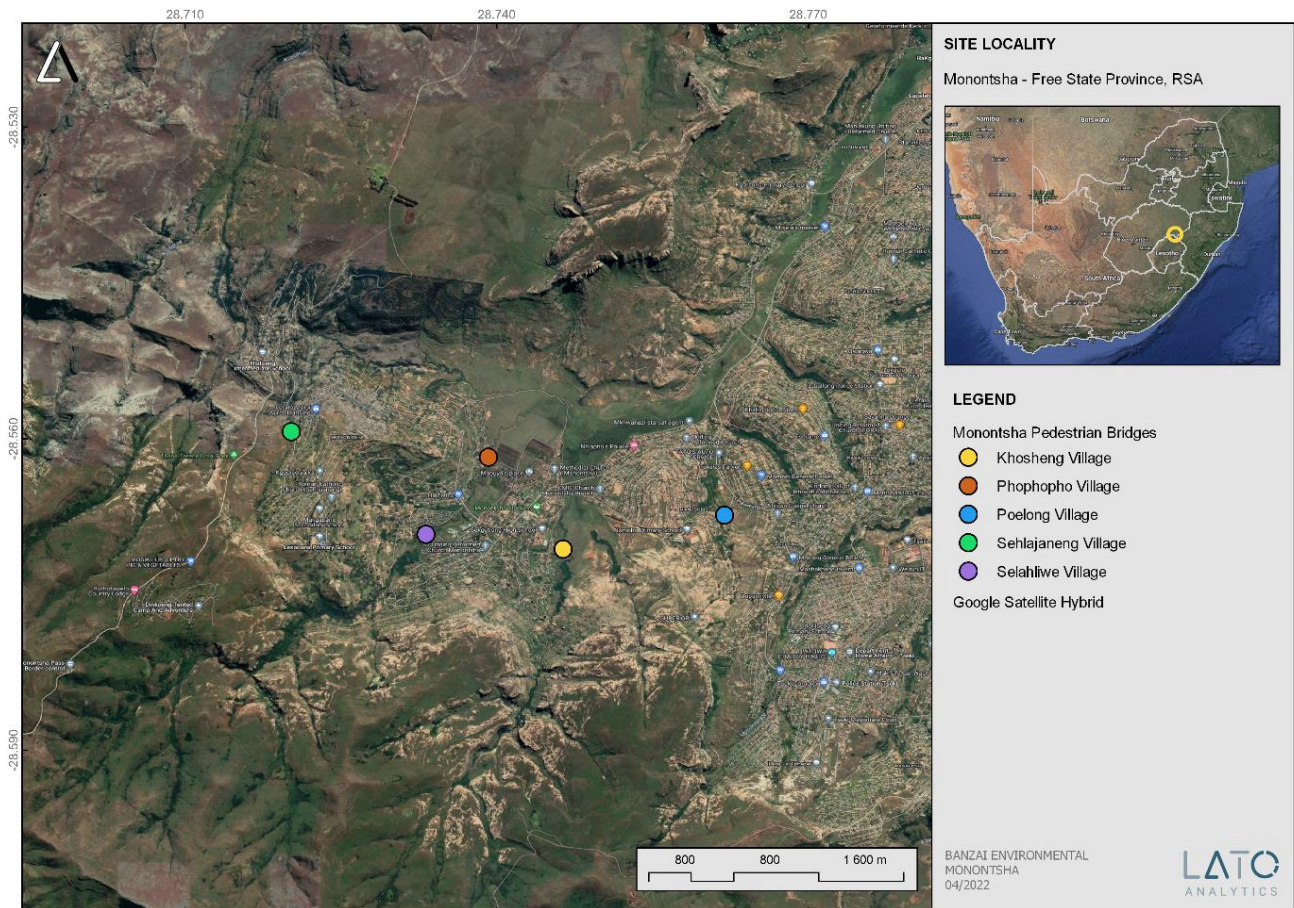


Figure 1: Location of the proposed Monontsha pedestrian bridges in the Monontsha Settlement located on the remainder of the farm Witzieshoek No. 1926, in Phuthaditjaba, Free State Province.

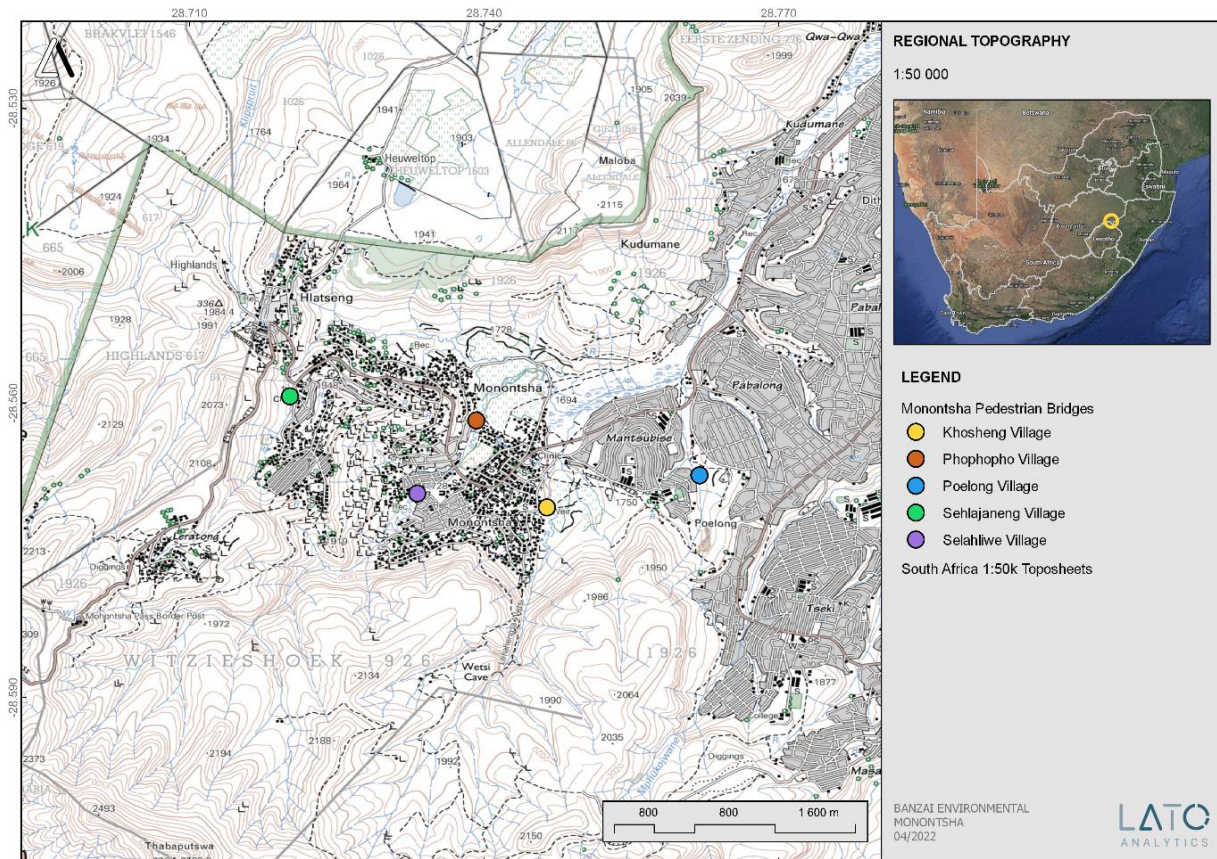


Figure 2: Regional Topography

2 QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

This present study has been conducted by Mrs Elize Butler. She has conducted approximately 300 palaeontological impact assessments for developments in the Free State, KwaZulu-Natal, Eastern, Central, and Northern Cape, Northwest, Gauteng, Limpopo, and Mpumalanga. She has an MSc (*cum laude*) in Zoology (specializing in Palaeontology) from the University of the Free State, South Africa and has been working in Palaeontology for more than twenty-five years. She has experience in locating, collecting, and curating fossils. She has been a member of the Palaeontological Society of South Africa (PSSA) since 2006 and has been conducting PIAs since 2014.

The geology of this project was verified by Professor WA van der Westhuizen. He obtained his Ph.D. in geochemistry from the University of the Free State, South Africa, in 1984. He acted as departmental chairperson (Geology Department) from 1998 to 2013. He retired as full professor in 2015. Research in southern Africa includes the Ventersdorp Supergroup, volcanology, mineralogy, geology of eastern Namaqualand, vanadium deposits in the Otavi Mountainland. Consulting work was conducted in South Africa, Namibia, Zimbabwe, and Malawi. Prof van der Westhuizen was an author and co-author for more than 70 peer reviewed articles and more



than 70 conference presentations at national and international level. Apart from being a registered professional scientist, up to his retirement he was a member of the following societies: Fellow of the Geological Society of SA, Archaeological Society of SA, International Association of Volcanology and Chemistry of the Earth's Interior, Spectroscopic Society of SA, International Liaison Group on Gold Mineralisation.

3 LEGISLATION

3.1 National Heritage Resources Act (25 of 1999)

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

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

- National Environmental Management Act (NEMA) Act 107 of 1998
- National Heritage Resources Act (NHRA) Act 25 of 1999
- Minerals and Petroleum Resources Development Act (MPRDA) Act 28 of 2002
- Notice 648 of the Government Gazette 45421- general requirements for undertaking an initial site sensitivity verification where no specific assessment protocol has been identified.

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

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

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

National Heritage Resources Act (NHRA) Act 25 of 1999

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

MPRDA Regulations of 2014



Environmental reports to be compiled for application of mining right – Regulation 48

- Contents of scoping report – Regulation 49
- Contents of environmental impact assessment report – Regulation 50
- Environmental management programme – Regulation 51
- Environmental management plan – Regulation 52

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

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

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

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

- the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length.
- the construction of a bridge or similar structure exceeding 50 m in length.
- any development or other activity which will change the character of a site—
- (Exceeding 5 000 m² in extent; or
- involving three or more existing erven or subdivisions thereof; or
- involving three or more erven or divisions thereof which have been consolidated within the past five years; or
- the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority
- the re-zoning of a site exceeding 10 000 m² in extent.
- or any other category of development provided for in regulations by SAHRA or a Provincial heritage resources authority.

4 OBJECTIVE

The aim of a Palaeontological Impact Assessment (PIA) is to decrease the effect of the development on potential fossils at the development site.



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

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

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

Mitigation usually precede construction or may occur during construction when potentially fossiliferous bedrock is exposed. Mitigation comprises the collection and recording of fossils. Preceding excavation of any fossils a permit from SAHRA must be obtained and the material will have to be housed in a permitted institution. When mitigation is applied correctly, a positive impact is possible because our knowledge of local palaeontological heritage may be increased

The terms of reference of a PIA are as follows:

General Requirements:

- Adherence to the content requirements for specialist reports in accordance with Appendix 6 of the EIA Regulations 2014, as amended.
- Adherence to all applicable best practice recommendations, appropriate legislation, and authority requirements.
- Submit a comprehensive overview of all appropriate legislation, guidelines.
- Description of the proposed project and provide information regarding the developer and consultant who commissioned the study.
- Description and location of the proposed development and provide geological and topographical maps.
- Provide Palaeontological and geological history of the affected area.
- Identification sensitive areas to be avoided (providing shapefiles/kml's) in the proposed development.



- Evaluation of the significance of the planned development during the Pre-construction, Construction, Operation, Decommissioning Phases and Cumulative impacts. Potential impacts should be rated in terms of the direct, indirect, and cumulative:
 - a. **Direct impacts** are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity.
 - b. **Indirect impacts** of an activity are indirect or induced changes that may occur as a result of the activity.
 - c. **Cumulative impacts** result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities.
- Fair assessment of alternatives (infrastructure alternatives have been provided):
- Recommend mitigation measures to minimise the impact of the proposed development; and
- Implications of specialist findings for the proposed development (such as permits, licenses etc).

5 GEOLOGICAL AND PALAEOONTOLOGICAL HISTORY

The geology of the pedestrian bridges in the Monontsha Settlement is indicated on the 1:250 000 Harrismith 2828 (Verster, 1998) Geological map (Council of Geoscience, Pretoria) (**Figure 3-4**). According to this map the proposed Monontsha Settlement is underlain by the following sediments: Quaternary alluvium and scree, Tarkastad Subgroup (Beaufort Group, Karoo Supergroup) and the Elliot Formation of the Stormberg Group).

Village	Lithology	Symbol
Khosheng village	Quaternary alluvium	Single bird figure
Selahliwe village	Quaternary scree	Yellow triangles and dots
Poelong village Phophopho village	Tarkastad Subgroup (Beaufort Group, Karoo Supergroup)	TRt, green
Sehlajaneng village	Elliot Formation (Stormberg Group)	TRe, red/orange

Recent Shape files produced by the Council of Geosciences (Pretoria) indicates that the proposed pedestrian bridges are underlain by the Tarkastad Subgroup (Khosheng, Poelong, Phophopho and Selahliwe villages) while the Sehlajaneng village is underlain by the Elliot Formation (Stormberg Group) (**Figure 5-6**).

The PalaeoMap of the South African Heritage Resources Information System indicates that the Palaeontological Sensitivity of the Quaternary alluvium is moderate, while that of the Tarkastad Subgroup and Elliot Formation is Very High (Almond and Pether, 2009; Almond *et al.*, 2013) (**Figure 7**).



The Quaternary superficial deposits (yellow, single bird figure and scree) are the youngest geological deposits formed during the most recent geological period (approximately 2.6 million years ago to present). Most of the superficial deposits are unconsolidated sediments and consist of clay, gravel, sand, silt, that form relatively thin, discontinuous patches of sediments or larger spreads onshore. These sediments comprise of channel, floodplain and stream deposits, talus gravels and glacial drift sediments. The Quaternary deposits are very important because palaeoclimatic changes are reflected in the different geological formations (Hunter et al., 2006). During the climate fluctuations in the Cenozoic Era most geomorphologic features in southern Africa were formed (Maud, 2012). Barnosky (2005) indicated that various warming and cooling events occurred in the Cenozoic but states that climatic changes during the Quaternary Period, specifically the last 1.8 Ma, were the most drastic climate changes relative to all climate variations in the past. Climate variations that occurred in the Quaternary Period were both drier and wetter than the present and resulted in changes in river flow patterns, sedimentation processes and vegetation variation (Tooth et al., 2004).

Quaternary fossil assemblages are normally rare and low in diversity and occur over a wide-ranging geographic area. These fossil assemblages may in some cases occur in extensive alluvial and colluvial deposits cut by dongas. In the past palaeontologists did not focus on Cenozoic superficial deposits although they sometimes comprise of significant fossil deposits. These fossil assemblages resemble modern animals and may comprise of mammalian teeth, bones and horn cores, reptile skeletons and fragments of ostrich eggs. Microfossils, non-marine mollusc shells are also known from Quaternary deposits. Plant material such as foliage, wood, pollens and peats are recovered as well as trace fossils like vertebrate tracks, burrows, termitaria (termite heaps/mounds) and rhizoliths (root casts). Quaternary scree comprises of rubble and will not contain fossils

The **Tarkastad Subgroup** (green, TRt; Beaufort Group, Karoo Supergroup, **Figure 8**) comprises of a lower Katberg (sandstone -rich) and upper Burgersdorp Formation (mudstone-rich). The Katberg Formation is an arenaceous unit which comprise of 90-95% of sandstone and 5 to 10% of mudstone. In the southern parts of the basin the Tarkastad Subgroup is 2000m thick and reduces to 800m in the centre of the basin and thins to 150m in the northern part of the basin (Groenewald, 1989). The sandstones of this Subgroup are moderately sorted, fine to medium grained, crossbedded, horizontally laminated and ripple cross laminated varying in colour from pale olive or greenish grey tabular subarkose sandstones. The mudstones are horizontally laminated or structureless horizontally laminated, and thick to medium bedded. These mudstones are minor green to red in colour. Thin mudstone beds occur, with red mudstone beds growing in abundance towards the upper border of the formation as it grades into the Burgersdorp Formation (Johnson, 1976; Johnson et al. 2006). The Burgersdorp Formation is mostly argillaceous and can be interpreted as a meandering fluvial to lacustrine deposit (Johnson et al, 2006; Groenewald, 1996).

The Vertebrate Assemblage Zone present in the Katberg Formation is the *Lystrosaurus declivis* Assemblage Zone (AZ) (Botha & Smith, 2020). In the western part of the basin this biozone spans the upper Palingkloof Member (Balfour Formation) as well as the overlying Katberg Formation. Two species dominate the



Lystrosaurus declivis AZ namely the small to medium-sized herbivorous dicynodonts *L. declivis* and *L. murrayi*. These species are small to medium -sized herbivores that are equally abundant in this biozone. Insectivores include *Galesaurus*, *Platycraniellus*, and *Thrinaxodon*, while therocephalians are represented by *Olivierosuchus*, *Promoschorhynchus* and *Regisaurus*. Small parareptiles include *Colleta*, *Phonodus* and *Procolophon*, *Saurodektes*, *Sauropareion*, while eureptilia are represented by immigrant taxa for example *Heleosuchus*, *Noteosuchus*, and *Prolacerta*. The large carnivores include the saber-toothed *Moschorhinus* as well as the long-snouted archosauromorph *Proterosuchus*. After the end-Permian mass extinction, small temnospondyl taxa like *Broomistega*, *Lydekkerina*, and *Micropholis* is abundantly found. This terrestrial biozone is well-known in the west of Gondwana with closely related species present in Antarctica and India.

The Tarkastad Subgroup is represented by the Burgersdorp Formation east of 24° E while it is known as the Driekoppen Formation in the Free State and KwaZulu-Natal. The Tarkastad Subgroup is an arenaceous unit which comprise of 90-95% of sandstone and 5 to 10% of mudstone. The sandstones of this Subgroup are moderately sorted, fine to medium grained, crossbedded, horizontally laminated and ripple cross laminated. The sandstones vary in colour from pale olive or greenish grey tabular subarkose sandstones. The mudstones are horizontally laminated or structureless horizontally laminated, thick to medium bedded. These mudstones are minor green to red in colour. Thin mudstone beds occur, with red mudstone beds growing in abundance towards the upper border of the formation as it grades into the Burgersdorp Formation (Johnson, 1976; Johnson et al. 2006). This unit is mostly argillaceous and can be interpreted as a meandering fluvial to lacustrine deposit (Johnson et al, 2006; Groenewald, 1996).

The Burgersdorp Formation comprise of the *Cynognathus Assemblage Zone*. This Assemblage Zone represents the youngest tetrapod biozone in the Beaufort Group. Numerous fossils from this biozone have been recovered and comprise of fossil vertebrates (mostly tetrapods namely amphibians: capitosaurids and trematosuchids; reptiles: archosaurs, rhynchosaurs, sphenodontids; therapsids includes dicynodonts, therocephalians, advanced cynodonts) as well as trace fossils (vertebrate and invertebrate burrows). A low diversity of plants has also been uncovered in this Formation and include *Dicroidium*, conifers, cycads, ferns, ginkgos, lycophytes, and gymnospermous fossil woods. Diverse groups of fishes include palaeoniscoid actinopterygians, lungfish, coelacanths and freshwater sharks. Microvertebrate and unionid molluscs remains have also been described (Anderson and Anderson, 1985; Kitching, 1995; Bamford, 2004; Abdala et al., 2005; Rubidge, 2005; Neveling et al., 2005; Abdala and Smith, 2009, Hancox et al, 2020).

The Elliot formation is known as the **red beds** of South Africa and is Upper Triassic and Lower Jurassic in age. This succession comprises of immature, fine- to medium-grained sandstones, mudstone, and siltstone. The strong red-purple-maroon diagenetic colouration is primarily argillaceous lithologies and lacks extensive marker beds. The Elliot Formation is 460 to 480m thick in the south of the Basin and thinness towards the Free State Drakensberg and KwaZulu-Natal where it varies between 28 and 150m. The formation was deposited in a fluviolacustrine environment that consists of two different types of sandstone (lower and upper part of the



Formation). These different sandstones were formed by different fluvial depositional styles. The upper part of the Formation comprises of tabular, multi-storey sheet sandstones and associated facies caused by loessic, aeolian ephemeral, fluvial, and playa lake processes (Visser and Botha, 1980; Eriksson, 1984, 1985; Smith et al., 1993; Bordy et al., 2004b). In the lower part of the Formation the sandstones consist of multi-storey, asymmetrical channelfills. Scientists believe that these sediments were deposits in a perennial, moderately meandering fluvial systems (Botha, 1968; Visser and Botha, 1980; Smith et al., 1993; Bordy et al., 2004b). In the distal Drakensberg regions, the lower part of the Formation becomes thinner. This part of the Formation is dominated by an association of seasonal to ephemeral anastomosing rivers with loessic floodplain fines, and semi-arid sheetflood deposits (Eriksson, 1984, 1985). The differences in fluvial style were generated by changes in the tectonic setting (like tectonic pulses and associated subsidence) as well as climatic conditions.

The Elliot Formation is represented by two Assemblage Zones. The *Scalenodontoides* Assemblage Zone (SAZ) is present in the Lower Elliot Formation (Stormberg Group, Karoo Supergroup) (Viglietti et al 2020a) while the *Massospondylus* Assemblage Zone (MAZ) is present in the Upper Elliot Formation (Viglietti et al 2020b). The SAZ is known for the traversodontid cynodont *Scalenodontoides macrodentes*, as well as the sauropodomorphs *Blikanasaurus cromptoni* and *Melanorosaurus readi* (Viglietti et al 2020a). The MAZ is the youngest tetrapod biozone in the Karoo Basin (upper Stormberg Group, Karoo Supergroup). This AZ represents the dinosaurs of southern Gondwana and include the ornithischian *Lesothosaurus diagnosticus*, sauropodomorph *Massospondylus carinatus* as well as the crocodylomorph *Protosuchus haughtoni*, (Viglietti et al 2020b).

This Formation is palaeontologically very important as it is known for its early dinosaur fauna that includes prosauropods, (the richest known sauropodomorphs) (McPhee, McPhee 2017), ornithischians, rare amphibians, turtles, crocodylomorphs, and crocodilians; cynodont therapsids and early mammals as well as fish. Other fossils include crustaceans, insects, woods, as well as tetrapod trackways (ichnofossils) (Bordy et al., 2015).

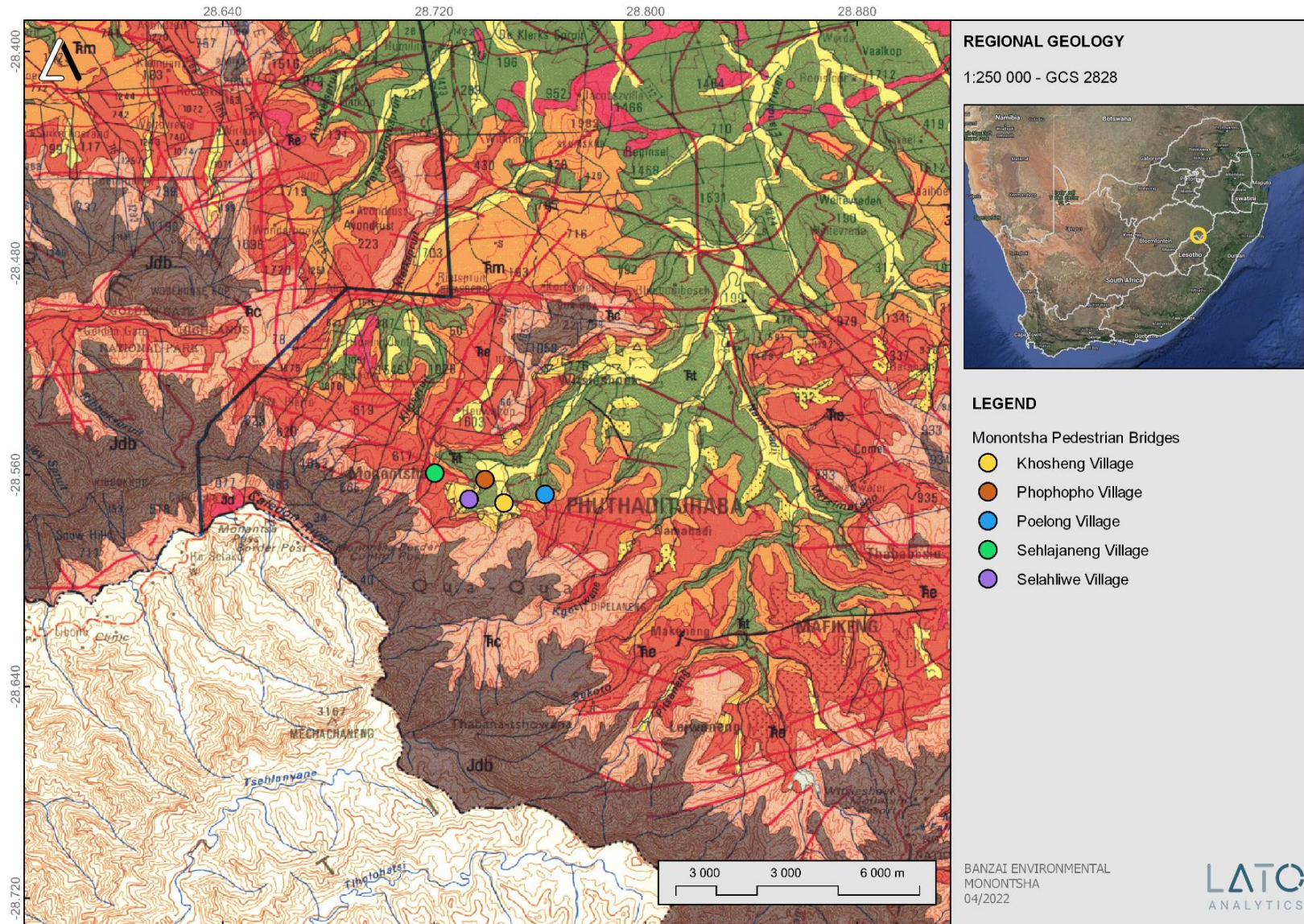


Figure 3: Regional geology of the proposed Monontsha Settlement pedestrian bridges

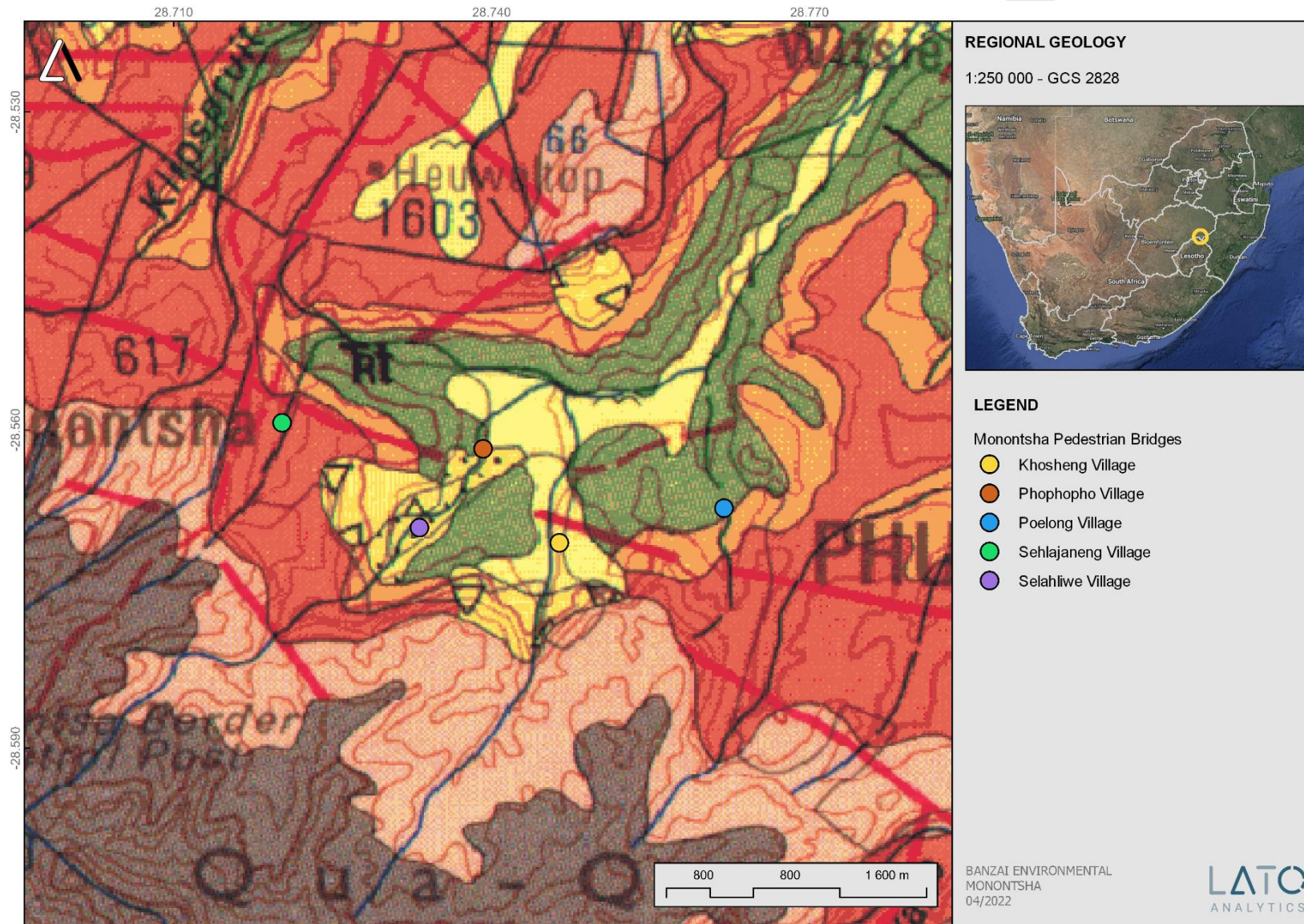


Figure 4: Geology of the proposed development



Table 2: Legend of the 1:250 000 Harrismith 2828 (1998) Geological Map (Council for Geosciences, Pretoria)

SEDIMENTARY AND VOLCANIC ROCKS SEDIMENTÊRE EN VULKANIESE GESTEENTES		INTRUSIVE ROCKS INTRUSIEWE GESTEENTES	
GROUP GROEP	FORMATION FORMASIE		LITHOLOGY LITOLOGIE
QUATERNARY KWARTER			Alluvium Alluvium
			Scree Glooiingspuin
			Partly consolidated fine-grained sediments with silcrete nodules Gedeeltelik gekonsolideerde fynkorrelrige sedimente met silkreetsknoles
	Masotcheni		
JURASSIC JURA			Jd Dolerite; dolerite dyke Doleriet; dolerietgang
			Jdb Basalt Basalt
TRIASSIC TRIAS	Drakensberg		Tc Yellow to pale-red, fine-grained sandstone Geel tot ligrooi, fynkorrelrige sandsteen
	Clarens		Te Red and purple mudstone; interbedded yellow to grey siltstone; fine- to medium-grained sandstone Rooi en pers moddersteen; tussengelaagde geel tot grys slijksteen; fyn- tot middelkorrelrige sandsteen
	Elliot		Tm Medium- to coarse-grained glittering sandstone; gritstone; subordinate green and red mudstone; carbonaceous shale Middel- tot grofkorrelrige glinsterende sandsteen; grintsteen; ondergeskikte groen en rooi moddersteen; koolstofryke skalie
	Molteno		Tt Fine- to medium-grained sandstone; red, green and blue mudstone Fyn- tot middelkorrelrige sandsteen; rooi, groen en blou moddersteen
PERMIAN PERM	Tarkastad Subgroup/Subgroep		Pa Grey mudstone; dark-grey shale (carbonaceous in places); siltstone; sandstone Grys moddersteen; donkergrys skalie (koolstofhoudend op plekke); slijksteen; sandsteen
	Adelaide Subgroup/Subgroep		Pvo Blue-grey to dark-grey shale Blougrys tot donkergrys skalie
	Volksrust		Pv Medium- to coarse-grained sandstone; micaceous shale; coal Middel- tot grofkorrelrige sandsteen; glimmerryke skalie; steenkool
	Vryheid		

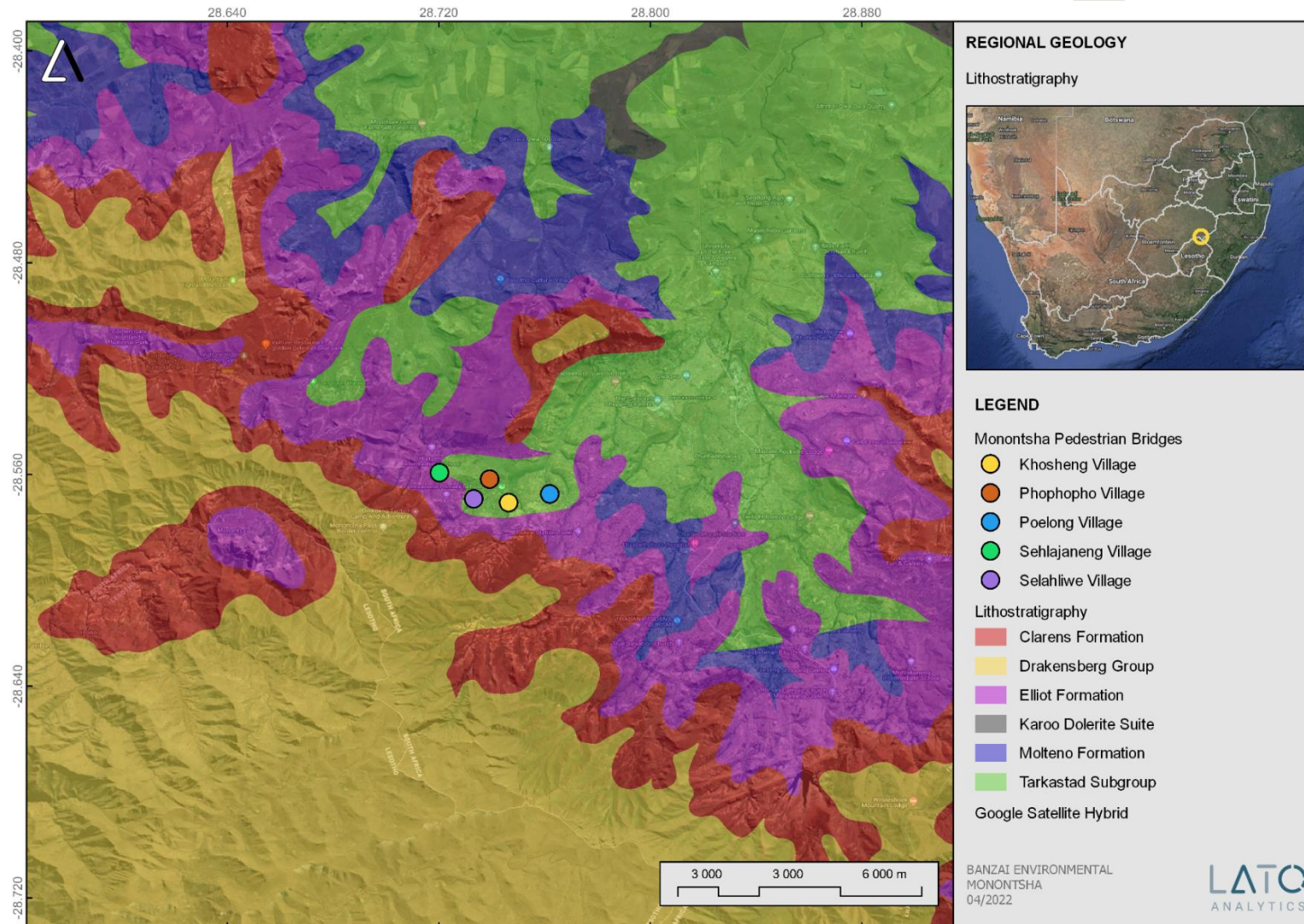


Figure 5: Regional Geology indicated by Shape Files

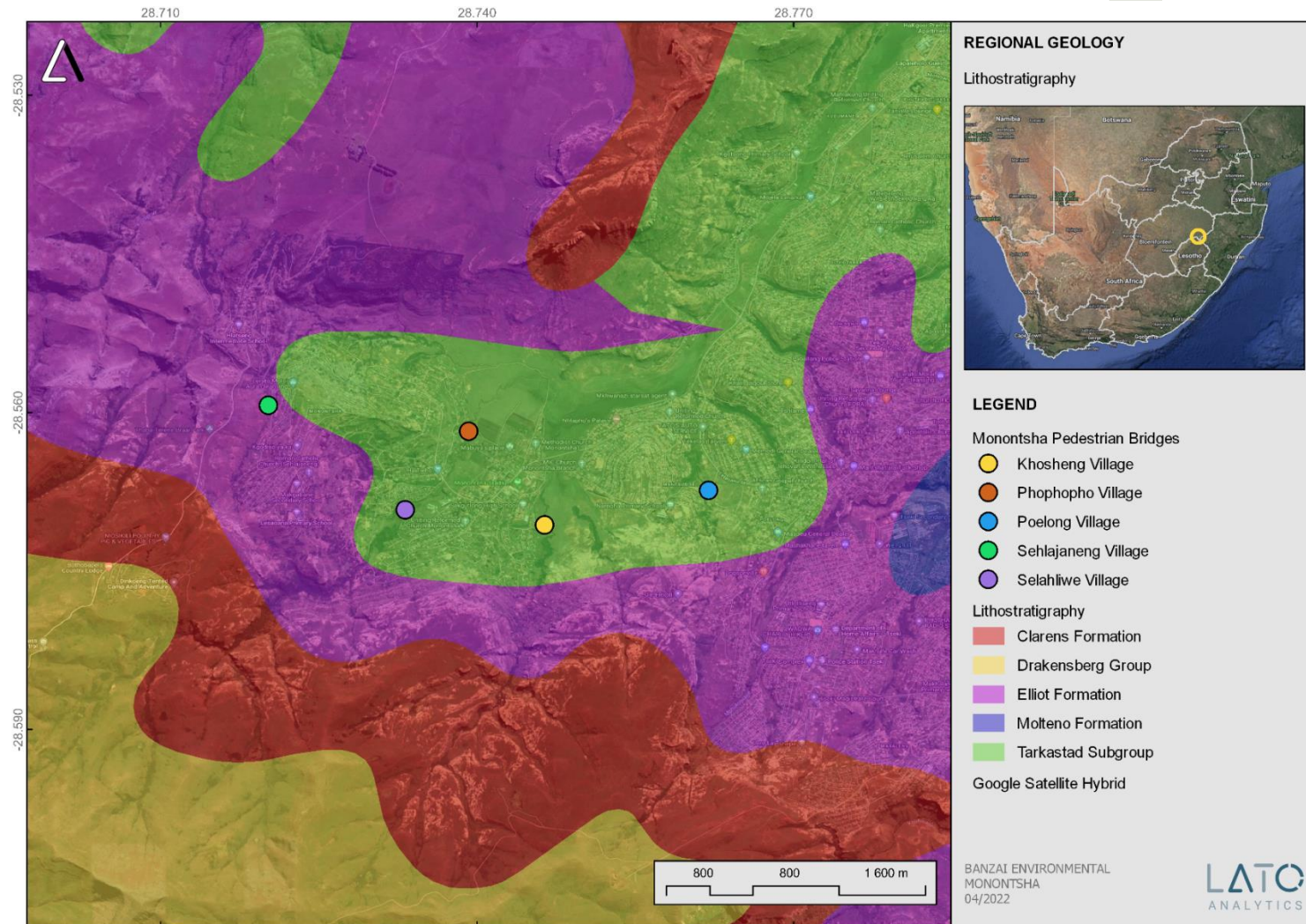


Figure 6: Geology indicated by Shape Files

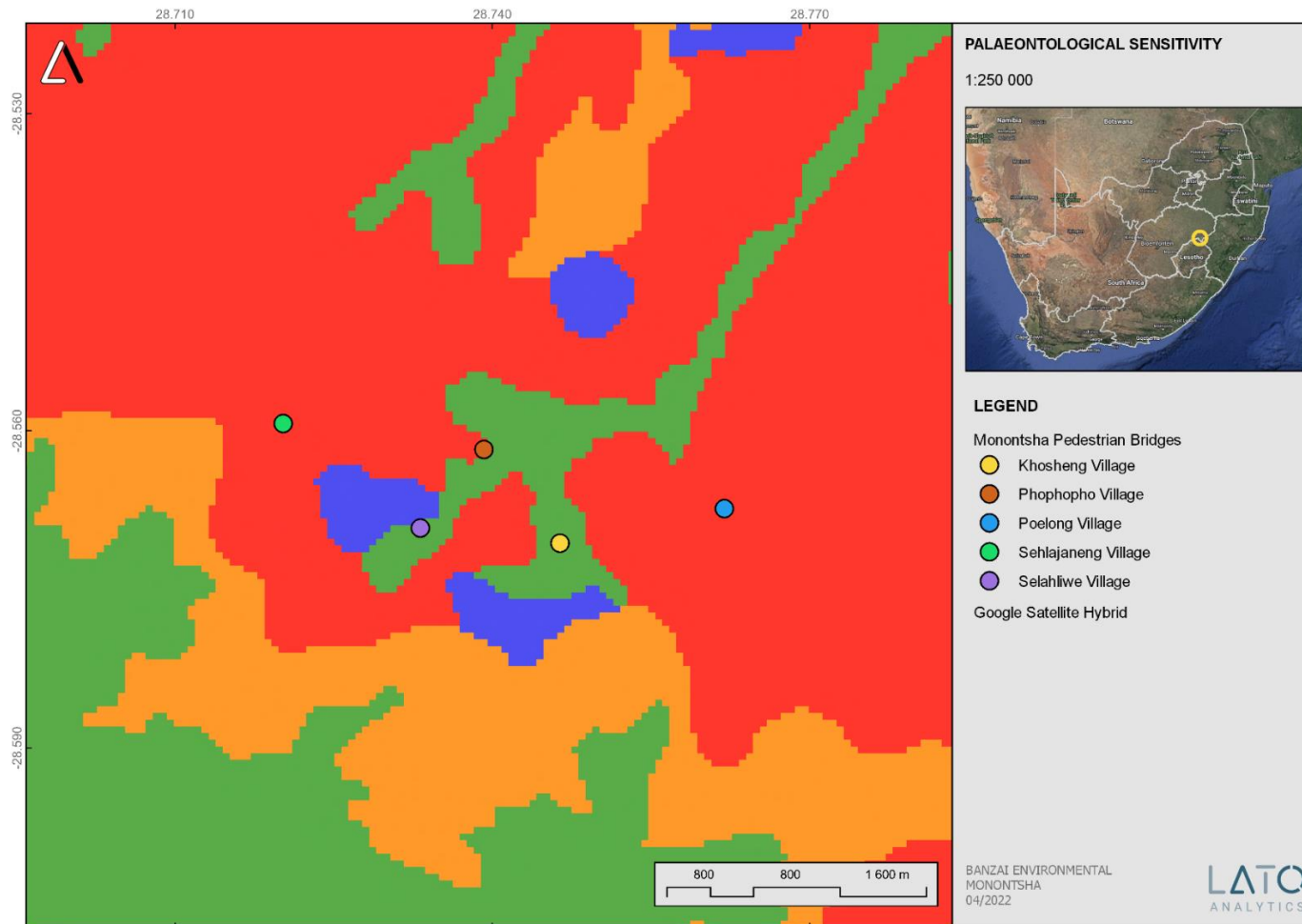


Figure 7: Extract of the 1:250 000 SAHRIS PalaeoMap (Council of Geosciences, Pretoria) indicating the proposed development of the Monontsha Settlement pedestrian bridges in Phuthaditjaba, Free State Province.



According to the SAHRIS Palaeosensitivity map (**Figure 8**) the proposed development is underlain by sediments of Very High (red) and Moderate (green) Palaeontological Sensitivity.

Table 3: Palaeontological Significance

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

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

The PalaeoMap thus follows the geology of the 1:250 000 Harrismith 2828 (1998) Geological Map (Council for Geosciences, Pretoria).



Age	Gp			West of 24° E	East of 24° E	Free State / KwaZulu-Natal	Vertebrate Assemblage Zones	Vertebrate Subzones				
JURASSIC	STORMBERG				Drakensberg Gp	Drakensberg Gp	Massospondylus					
			Clarens Fm		Clarens Fm							
			upper Elliot Fm		upper Elliot Fm	Scalenodontoides						
			lower Elliot Fm		lower Elliot Fm							
TRIASSIC	Tarkastad Subgp		Molteno Fm		Molteno Fm	Cynognathus	Cricodon-Ufudocyclops Trirachodon-Kannemeyeria Langbergia-Gargainia					
			Burgersdorp Fm		Driekoppen Fm							
			Katberg Fm		Verkykerskop Fm			Lystrosaurus declivis				
			Palingkloof M.									
		PERMIAN	BEAUFORT		Adelaide Subgp	Teekloof Fm	Balfour Fm			Elandsberg M.	Normandem Fm	Harrismith M.
								Ripplemead M.	Schoondraai M.			
Daggaboersnek M.	Rooinekke M.											
Oudeberg M.	Frankfort M.											
Oukloof M.	Volksrust Fm							Cistecephalus				
Hoedemaker M.												
Poortjie M.						Middleton Fm	Endothiodon	Tropidostoma-Gorgonops Lycosuchus-Eumotosaurus				
Abrahamskraal Fm						Koonap Fm	Tapinocephalus	Diictodon-Styracocephalus Eosimops-Glanosuchus				
ECCA							Waterford Fm	Waterford Fm				
							Tierberg/Fort Brown	Fort Brown				

Figure 8: Vertebrate biozonation range chart for the Main Karoo Basin of South Africa. (Figure modified from Smith et al, 2020)

Solid lines indicate known ranges, dotted lines indicate suspected but not confirmed ranges, single dot represents the stratigraphy is 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-Supgroup, Fm=Formation, M=Member. Elliot Formation is indicated by the black arrow.

6 GEOGRAPHICAL LOCATION OF THE SITE

The proposed five pedestrian bridges in the Monontsha Settlement are located on the remainder of the farm Witziesshoek No. 1926, in Phuthaditjaba, Free State Province.



Table 4: Project locality

Villages	Decimal Degrees (S) Latitude	Decimal Degrees(E) Longitude
Sehlajaneng	-28,559505	28,720282
Selahliwe	-28,569017	28,732883
Phophopho	-28,561888	28,739520
Khosheng	-28,570593	28,746480
Poelong	-28,567234	28,762205

7 METHODS

The aim of a desktop study is to evaluate the risk to palaeontological heritage in the proposed development. This includes all trace fossils and fossils. All available information is consulted to compile a desktop study and includes Palaeontological impact assessment reports in the same area, aerial photos, and Google Earth images, topographical as well as geological maps. Scientific research articles of research conducted in the area is also sourced and included in the Impact Assessment.

7.1 Assumptions and Limitations

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

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

8 ADDITIONAL INFORMATION CONSULTED

In compiling this report the following sources were consulted:

- Geological map 1:100 000, Geology of the Republic of South Africa (Visser 1984).
- A Google Earth map with polygons of the proposed development was obtained from Spatial Solutions Inc



- 1:250 000 Harrismith 2828 (Verster, 1998) Geological map (Council of Geoscience, Pretoria)
- Shape files produced by the Council of Geosciences (Pretoria).
- Impact assessments in this area include that of Durand, 2017; Groenewald, 2017; Groenewald 2011
- Scientific articles that of Groenewald, 1996; Groenewald 1989; Groenewald et al 2001

9 SITE VISIT

9.1 SehlaJaneng Bridge

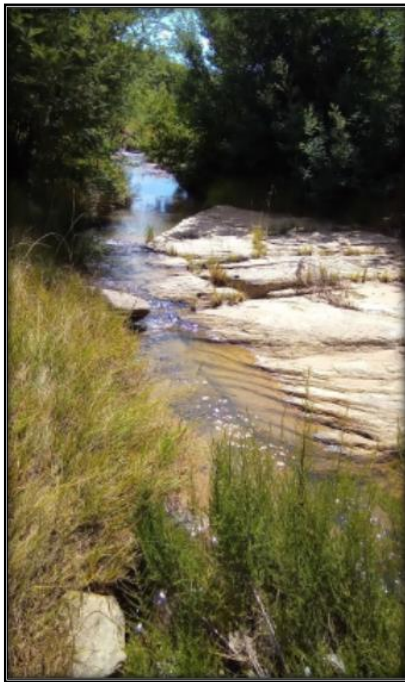


Figure 9: Upstream view with sand and sandstone deposits in river



Figure 10: *Thick alluvium deposits on the river bank without any outcrop*



Figure 11: *Down-washed surface deposits on a sandstone outcrop*



9.2 Selahliwe Bridge



Figure 12: Alluvium riverbanks covered by lush vegetation. No outcrops were detected



9.3 Phophopho Bridge



Figure 13: Thick alluvium riverbanks covered by lush vegetation. No outcrops were detected

9.4 Khosheng Bridge



Figure 14: Thick alluvium riverbanks covered by lush vegetation. No outcrops were detected.



9.5 Poelong Bridge



Figure 15: Possible Elliot Formation outcrops on the southern side of the proposed development. These outcrops were unfossiliferous.



Figure 16: Outcrops on the northern margin of the proposed development were found to be unfossiliferous.

10 IMPACT ASSESSMENT METHODOLOGY

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

- Construction.
- Operation; and
- Decommissioning.

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



Table 5: The rating system

NATURE		
The Nature of the Impact is the possible destruction of fossil heritage		
GEOGRAPHICAL EXTENT		
This is defined as the area over which the impact will be experienced.		
1	Site	The impact will only affect the site.
2	Local/district	Will affect the local area or district.
3	Province/region	Will affect the entire province or region.
4	International and National	Will affect the entire country.
PROBABILITY		
This describes the chance of occurrence of an impact.		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
DURATION		
This describes the duration of the impacts. Duration indicates the lifetime of the impact as a result of the proposed activity.		
1	Short term	The impact will either disappear with mitigation or will be mitigated through natural processes in a span shorter than the construction phase (0 – 1 years), or the impact will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).



2	Medium term	The impact will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 30 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered indefinite.

INTENSITY/ MAGNITUDE

Describes the severity of an impact.

1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).
3	High	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired. Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.

REVERSIBILITY



This describes the degree to which an impact can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures.
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible, and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.
CUMULATIVE EFFECT		
This describes the cumulative effect of the impacts. A cumulative impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		
1	Negligible cumulative impact	The impact would result in negligible to no cumulative effects.
2	Low cumulative impact	The impact would result in insignificant cumulative effects.
3	Medium cumulative impact	The impact would result in minor cumulative effects.
4	High cumulative impact	The impact would result in significant cumulative effects
SIGNIFICANCE		



Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The calculation of the significance of an impact uses the following formula:

(Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity = X.

The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.

Points	Impact significance rating	Description
6 to 28	Negative low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive low impact	The anticipated impact will have minor positive effects.
29 to 50	Negative medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	Positive medium impact	The anticipated impact will have moderate positive effects.
51 to 73	Negative high impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive high impact	The anticipated impact will have significant positive effects.
74 to 96	Negative very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive very high impact	The anticipated impact will have highly significant positive

10.1 Summary of Impact Tables

Loss of fossil heritage will be a negative impact. Only the site will be affected by the proposed development. The expected duration of the impact is assessed as potentially permanent to

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long term. In the absence of mitigation procedures, the damage or destruction of any palaeontological materials will be permanent. Impacts on palaeontological heritage during the construction phase could potentially occur and are regarded as having a high probability. As fossil heritage will be destroyed the impact is irreversible. The significance of the impact occurring will be high pre-mitigation and medium post-mitigation.

Table 6: Summary of Impact Tables

	Site	Probability	Duration	Magnitude	Reversibility	Irreplicable Loss	Cumulative Effect	Significance
Pre-mitigation	1	2	4	4	4	4	2	68
Post-mitigation	1	2	4	2	4	4	2	32

11 FINDINGS AND RECOMMENDATIONS

The proposed Monontsha pedestrian bridges is underlain by Quaternary alluvium and scree, Tarkastad Subgroup (Beaufort Group, Karoo Supergroup) and the Late Triassic to Early Jurassic Elliot Formation of the Stormberg Group. The PalaeoMap of the South African Heritage Resources Information System indicates that the Palaeontological Sensitivity of the Quaternary deposits is moderate, while that of the Tarkastad Subgroup, and Eliot Formation is Very High (Almond and Pether, 2009; Almond *et al.*, 2013).

A site-specific field survey of the development footprint was conducted on foot and by motor vehicle on 6 April 2022. No visible evidence of fossiliferous outcrops was found. However, the area is known to contain fossil heritage. A Moderate Palaeontological Sensitivity has been allocated to the proposed development. It is thus considered that the proposed development will not lead to detrimental impacts on the palaeontological reserves of the area and the construction of the development may thus be authorised in its whole extent.

It is thus recommended that:

- The Environmental Control Officer (ECO), responsible for the development should be aware of the distinct possibility of finding fossils in the Tarkastad Subgroup (Beaufort Group, Karoo Supergroup), and Elliot Formation of the Stormberg Group, while fossils may be present in the Quaternary deposits.



- Training of accountable supervisory personnel by a qualified palaeontologist in the recognition of fossil heritage is necessary.
- If Palaeontological Heritage is uncovered during surface clearing and excavations the **Chance find Protocol** attached should be implemented immediately. These discoveries ought to be protected (if possible, *in situ*) and the ECO must report to SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) so that correct mitigation (recording and collection) can be carry out by a paleontologist.
- Before any fossil material can be collected from the development site the specialist involved would need to apply for a collection permit from SAHRA. Fossil material must be housed in an official collection (museum or university), while all reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012). It is consequently recommended that no further palaeontological heritage studies, ground truthing and/or specialist mitigation are required pending the discovery of newly discovered fossils.



12 CHANCE FINDS PROTOCOL

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

12.1 Legislation

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

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

12.2 Background

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

12.3 Introduction

This informational document is intended for workmen and foremen on the construction site. 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.

12.4 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.
- In the event that the fossil cannot be stabilized the fossil may be collected with extreme care by the ESO (site manager). Fossils finds must be stored in tissue paper and in an appropriate box while due care must be taken to remove all fossil material from the rescue site.
- Once Heritage Agency has issued the written authorization, the developer may continue with the development on the affected area.

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Appendix A

Elize Butler CV

CURRICULUM VITAE

ELIZE BUTLER

PROFESSION: Palaeontologist

YEARS' EXPERIENCE: 26 years in Palaeontology

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

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

Management Course, 1991
University of the Orange Free State

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

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

MEMBERSHIP

Palaeontological Society of South Africa (PSSA) 2006-currently

EMPLOYMENT HISTORY



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

TECHNICAL REPORTS

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

Butler, E. 2014. Palaeontological Impact Assessment for the proposed upgrade of existing water supply infrastructure at Noupoot, Northern Cape Province. 2014. Bloemfontein.

Butler, E. 2015. Palaeontological impact assessment of the proposed consolidation, re-division, and development of 250 serviced erven in Nieu-Bethesda, Camdeboo local municipality, Eastern Cape. Bloemfontein.

Butler, E. 2015. Palaeontological impact assessment of the proposed mixed land developments at Rooikraal 454, Vrede, Free State. Bloemfontein.

Butler, E. 2015. Palaeontological exemption report of the proposed truck stop development at Palmiet 585, Vrede, Free State. Bloemfontein.

Butler, E. 2015. Palaeontological impact assessment of the proposed Orange Grove 3500 residential development, Buffalo City Metropolitan Municipality East London, Eastern Cape. Bloemfontein.

Butler, E. 2015. Palaeontological Impact Assessment of the proposed Gonubie residential development, Buffalo City Metropolitan Municipality East London, Eastern Cape Province. Bloemfontein.

Butler, E. 2015. Palaeontological Impact Assessment of the proposed Ficksburg raw water pipeline. Bloemfontein.

Butler, E. 2015. Palaeontological Heritage Impact Assessment report on the establishment of the 65 mw Majuba Solar Photovoltaic facility and associated infrastructure on portion 1, 2 and 6 of the farm Witkoppies 81 HS, Mpumalanga Province. Bloemfontein.

Butler, E. 2015. Palaeontological Impact Assessment of the proposed township establishment on the remainder of portion 6 and 7 of the farm Sunnyside 2620, Bloemfontein, Mangaung metropolitan municipality, Free State, Bloemfontein.



Butler, E. 2015. Palaeontological Impact Assessment of the proposed Woodhouse 1 photovoltaic solar energy facilities and associated infrastructure on the farm Woodhouse 729, near Vryburg, North West Province. Bloemfontein.

Butler, E. 2015. Palaeontological Impact Assessment of the proposed Woodhouse 2 photovoltaic solar energy facilities and associated infrastructure on the farm Woodhouse 729, near Vryburg, North West Province. Bloemfontein.

Butler, E. 2015. Palaeontological Impact Assessment of the proposed Orkney solar energy farm and associated infrastructure on the remaining extent of Portions 7 and 21 of the farm Wolvehuis 114, near Orkney, North West Province. Bloemfontein.

Butler, E. 2015. Palaeontological Impact Assessment of the proposed Spectra foods broiler houses and abattoir on the farm Maiden Manor 170 and Ashby Manor 171, Lukhanji Municipality, Queenstown, Eastern Cape Province. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed construction of the 150 MW Noupoot concentrated solar power facility and associated infrastructure on portion 1 and 4 of the farm Carolus Poort 167 and the remainder of Farm 207, near Noupoot, Northern Cape. Prepared for Savannah Environmental. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed Woodhouse 1 Photovoltaic Solar Energy facility and associated infrastructure on the farm Woodhouse 729, near Vryburg, North West Province. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed Woodhouse 2 Photovoltaic Solar Energy facility and associated infrastructure on the farm Woodhouse 729, near Vryburg, North West Province. Bloemfontein.

Butler, E. 2016. Proposed 132kV overhead power line and switchyard station for the authorised Solis Power 1 CSP project near Upington, Northern Cape. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed Senqu Pedestrian Bridges in Ward 5 of Senqu Local Municipality, Eastern Cape Province. Bloemfontein.

Butler, E. 2016. Recommendation from further Palaeontological Studies: Proposed Construction of the Modderfontein Filling Station on Erf 28 Portion 30, Founders Hill, City of Johannesburg, Gauteng Province. Bloemfontein.

Butler, E. 2016. Recommendation from further Palaeontological Studies: Proposed Construction of the Modikwa Filling Station on a Portion of Portion 2 of Mooihoek 255 Kt, Greater Tlhabane Local Municipality, Limpopo Province. Bloemfontein.

Butler, E. 2016. Recommendation from further Palaeontological Studies: Proposed Construction of the Heidedal filling station on Erf 16603, Heidedal Extension 24, Mangaung Local Municipality, Bloemfontein, Free State Province. Bloemfontein.

Butler, E. 2016. Recommended Exemption from further Palaeontological studies: Proposed Construction of the Gunstfontein Switching Station, 132kv Overhead Power Line (Single or Double Circuit) and ancillary infrastructure for the Gunstfontein Wind Farm Near Sutherland, Northern Cape Province. Savannah South Africa. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed Galla Hills Quarry on the remainder of the farm Roode Krantz 203, in the Lukhanji Municipality, division of Queenstown, Eastern Cape Province. Bloemfontein.

Butler, E. 2016. Chris Hani District Municipality Cluster 9 water backlog project phases 3a and 3b: Palaeontology inspection at Tsomo WTW. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed construction of the 150 MW Noupoot concentrated solar power facility and associated infrastructure on portion 1 and 4 of the farm Carolus Poort 167 and the remainder of Farm 207, near Noupoot, Northern Cape. Savannah South Africa. Bloemfontein.



Butler, E. 2016. Palaeontological Impact Assessment of the proposed upgrading of the main road MR450 (R335) from Motherwell to Addo within the Nelson Mandela Bay Municipality and Sunday's River valley Local Municipality, Eastern Cape Province. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment construction of the proposed Metals Industrial Cluster and associated infrastructure near Kuruman, Northern Cape Province. Savannah South Africa. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment for the proposed construction of up to a 132kv power line and associated infrastructure for the proposed Kalkaar Solar Thermal Power Plant near Kimberley, Free State and Northern Cape Provinces. PGS Heritage. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed development of two burrow pits (DR02625 and DR02614) in the Enoch Mgijima Municipality, Chris Hani District, Eastern Cape.

Butler, E. 2016. Ezibeleni waste Buy-Back Centre (near Queenstown), Enoch Mgijima Local Municipality, Eastern Cape. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment for the proposed construction of two 5 Mw Solar Photovoltaic Power Plants on Farm Wildebeestkuil 59 and Farm Leeuwbosch 44, Leeudoringstad, North West Province. Bloemfontein.

Butler, E. 2016. Palaeontological Impact Assessment for the proposed development of four Leeuwberg Wind farms and basic assessments for the associated grid connection near Loeriesfontein, Northern Cape Province. Bloemfontein.

Butler, E. 2016. Palaeontological impact assessment for the proposed Aggeneys south prospecting right project, Northern Cape Province. Bloemfontein.

Butler, E. 2016. Palaeontological impact assessment of the proposed Motuoane Ladysmith Exploration right application, KwaZulu Natal. Bloemfontein.

Butler, E. 2016. Palaeontological impact assessment for the proposed construction of two 5 MW solar photovoltaic power plants on farm Wildebeestkuil 59 and farm Leeuwbosch 44, Leeudoringstad, North West Province. Bloemfontein.

Butler, E. 2016: Palaeontological desktop assessment of the establishment of the proposed residential and mixed-use development on the remainder of portion 7 and portion 898 of the farm Knopjeslaagte 385 Ir, located near Centurion within the Tshwane Metropolitan Municipality of Gauteng Province. Bloemfontein.

Butler, E. 2017. Palaeontological impact assessment for the proposed development of a new cemetery, near Kathu, Gamagara local municipality and John Taolo Gaetsewe district municipality, Northern Cape. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of The Proposed Development of The New Open Cast Mining Operations on The Remaining Portions Of 6, 7, 8 And 10 Of the Farm Kwaggafontein 8 In the Carolina Magisterial District, Mpumalanga Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment for the Proposed Development of a Wastewater Treatment Works at Lanseria, Gauteng Province. Bloemfontein.

Butler, E. 2017. Palaeontological Scoping Report for the Proposed Construction of a Warehouse and Associated Infrastructure at Perseverance in Port Elizabeth, Eastern Cape Province.

Butler, E. 2017. Palaeontological Desktop Assessment for the Proposed Establishment of a Diesel Farm and a Haul Road for the Tshipi Borwa mine Near Hotazel, In the John Taolo Gaetsewe District Municipality in the Northern Cape Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment for the Proposed Changes to Operations at the UMK Mine near Hotazel, In the John Taolo Gaetsewe District Municipality in the Northern Cape Province. Bloemfontein.



Butler, E. 2017. Palaeontological Impact Assessment for the Development of the Proposed Ventersburg Project-An Underground Mining Operation near Ventersburg and Henneman, Free State Province. Bloemfontein.

Butler, E. 2017. Palaeontological desktop assessment of the proposed development of a 3000 MW combined cycle gas turbine (CCGT) in Richards Bay, Kwazulu-Natal. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment for the Development of the Proposed Revalidation of the lapsed General Plans for Elliotdale, Mbhashe Local Municipality. Bloemfontein.

Butler, E. 2017. Palaeontological assessment of the proposed development of a 3000 MW Combined Cycle Gas Turbine (CCGT) in Richards Bay, Kwazulu-Natal. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed development of the new open cast mining operations on the remaining portions of 6, 7, 8 and 10 of the farm Kwaggafontein 8 10 in the Albert Luthuli Local Municipality, Gert Sibande District Municipality, Mpumalanga Province. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed mining of the farm Zandvoort 10 in the Albert Luthuli Local Municipality, Gert Sibande District Municipality, Mpumalanga Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment for the proposed Lanseria outfall sewer pipeline in Johannesburg, Gauteng Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of open pit mining at Pit 36W (New Pit) and 62E (Dishaba) Amandelbult Mine Complex, Thabazimbi, Limpopo Province. Bloemfontein.

Butler, E. 2017. Palaeontological impact assessment of the proposed development of the sport precinct and associated infrastructure at Merrifield Preparatory school and college, Amathole Municipality, East London. PGS Heritage. Bloemfontein.

Butler, E. 2017. Palaeontological impact assessment of the proposed construction of the Lehae training and fire station, Lenasia, Gauteng Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of the new open cast mining operations of the Impunzi mine in the Mpumalanga Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the construction of the proposed Viljoenskroon Munic 132 KV line, Vierfontein substation and related projects. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed rehabilitation of 5 ownerless asbestos mines. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of the Lephalale coal and power project, Lephalale, Limpopo Province, Republic of South Africa. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed construction of a 132KV powerline from the Tweespruit distribution substation (in the Mantsopa local municipality) to the Driedorp rural substation (within the Naledi local municipality), Free State province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of the new coal-fired power plant and associated infrastructure near Makhado, Limpopo Province. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed construction of a Photovoltaic Solar Power station near Collett substation, Middelburg, Eastern Cape. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment for the proposed township establishment of 2000 residential sites with supporting amenities on a portion of farm 826 in Botshabelo West, Mangaung Metro, Free State Province. Bloemfontein.



Butler, E. 2017. Palaeontological Desktop Assessment for the proposed prospecting right project without bulk sampling, in the Koa Valley, Northern Cape Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment for the proposed Aroams prospecting right project, without bulk sampling, near Aggeneys, Northern Cape Province. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed Belvior aggregate quarry II on portion 7 of the farm Maidenhead 169, Enoch Mgijima Municipality, division of Queenstown, Eastern Cape. Bloemfontein.

Butler, E. 2017. PIA site visit and report of the proposed Galla Hills Quarry on the remainder of the farm Roode Krantz 203, in the Lukhanji Municipality, division of Queenstown, Eastern Cape Province. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed construction of Tina Falls Hydropower and associated power lines near Cumbu, Mthlontlo Local Municipality, Eastern Cape. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed construction of the Mangaung Gariep Water Augmentation Project. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed Belvoir aggregate quarry II on portion 7 of the farm Maidenhead 169, Enoch Mgijima Municipality, division of Queenstown, Eastern Cape. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed construction of the Melkspruit-Rouxville 132KV Power line. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of a railway siding on a Portion of portion 41 of the farm Rustfontein 109 is, Govan Mbeki local municipality, Gert Sibande district municipality, Mpumalanga Province. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed consolidation of the proposed Ilima Colliery in the Albert Luthuli local municipality, Gert Sibande District Municipality, Mpumalanga Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed extension of the Kareerand Tailings Storage Facility, associated borrow pits as well as a storm water drainage channel in the Vaal River near Stilfontein, North West Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed construction of a filling station and associated facilities on the Erf 6279, district municipality of John Taolo Gaetsewe District, Ga-Segonyana Local Municipality Northern Cape. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed of the Lephalale Coal and Power Project, Lephalale, Limpopo Province, Republic of South Africa. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment of the proposed Overvaal Trust PV Facility, Buffelspoort, North West Province. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed development of the H₂ Energy Power Station and associated infrastructure on Portions 21; 22 And 23 of the farm Hartebeestspuit in the Thembisile Hani Local Municipality, Nkangala District near Kwamhlanga, Mpumalanga Province. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed upgrade of the Sandriver Canal and Klippan Pump station in Welkom, Free State Province. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed upgrade of the 132kv and 11kv power line into a dual circuit above ground power line feeding into the Urania substation in Welkom, Free State Province. Bloemfontein.



Butler, E. 2017. Palaeontological Desktop Assessment of the proposed Swaziland-Mozambique border patrol road and Mozambique barrier structure. Bloemfontein.

Butler, E. 2017. Palaeontological Impact Assessment of the proposed diamonds alluvial & diamonds general prospecting right application near Christiana on the remaining extent of portion 1 of the farm Kaffraria 314, registration division HO, North West Province. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment for the proposed development of Wastewater Treatment Works on Hartebeesfontein, near Panbult, Mpumalanga. Bloemfontein.

Butler, E. 2017. Palaeontological Desktop Assessment for the proposed development of Wastewater Treatment Works on Rustplaas near Piet Retief, Mpumalanga. Bloemfontein.

Butler, E. 2018. Palaeontological Impact Assessment for the Proposed Landfill Site in Luckhoff, Letsemeng Local Municipality, Xhariep District, Free State. Bloemfontein.

Butler, E. 2018. Palaeontological Impact Assessment of the proposed development of the new Mutsho coal-fired power plant and associated infrastructure near Makhado, Limpopo Province. Bloemfontein.

Butler, E. 2018. Palaeontological Impact Assessment of the authorisation and amendment processes for Manangu mine near Delmas, Victor Khanye local municipality, Mpumalanga. Bloemfontein.

Butler, E. 2018. Palaeontological Desktop Assessment for the proposed Mashishing township establishment in Mashishing (Lydenburg), Mpumalanga Province. Bloemfontein.

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Curriculum Vitae

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Postal Address: P.O. Box 17302, Bainsvlei, 9338, Rep. of South Africa.

Tel. Work. 083 625 4695.

School: Grey College Bloemfontein 1968.

University Training:	B.Sc. (Geology, chemistry)	1973
	B.Sc. Honours (Geology)	1974
	M.Sc. (Geology)	1977
	Ph.D. (Geochemistry)	1984

All degrees obtained at the University of the Free State.

Research

Research included the following visits:

- 1 Mineral Exploration Research Institute (Universities of Montréal and McGill) in Montréal (1986).
- 2 Study volcanic successions in Channel Islands, France, and Whales in 1986.
- 3 Visit Australia in 1988 to study gold deposits (Kalgoorlie).
- 4 Study gold deposits in Brazil in 1991.
- 5 Excursion to the active volcanoes of Sicily and the Aeolian islands (1994).
- 6 Mineral Resource Management (value tracking) symposium in Australia in 2002.
- 7 Excursion to study high-pressure metamorphic rocks in Turkey in 2005.
- 8 Excursion to northern Spain with students from Wales and South Africa 2008.
- 9 Attended workshop on gold mineralisation in Namibia (\pm 2007).
- 10 Visited New Zealand in 2019 to investigate volcanological aspects of active volcanoes.

Research in southern Africa includes the Ventersdorp Supergroup, volcanology, mineralogy, geology of eastern Namaqualand, vanadium deposits in the Otavi Mountainland, Witwatersrand geology and mineralisation.

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Consulting work in South Africa, Namibia, Zimbabwe and Malawi.

Author and co-author of more than 70 peer reviewed articles and more than 70 conference presentations at national and international level.

Positions held:

Employed by the University of the Free State since 1974. Started as technical assistant at the Institute for Groundwater Studies and then the Department of Geology. Promoted to X-ray fluorescence analyst in charge of the analytical laboratory and later to lecturer, senior lecturer and associate professor.

Departmental chairperson (geology department) since 1998.

Professor and departmental chairperson from 2003 until 2013.

Supervised and co-supervised 16 M.Sc. students and 4 Ph.D. students. Involved with two more Ph.D. candidates.

Supervised 75 mini-dissertations from MRM (mineral resource management) students.

Retired end of 2015.

Appointed part-time 2016 – 2018.

Teaching

Taught courses in mineral exploration, geochemical exploration, economic geology and analytical techniques (geochemistry).

Introduced a course in Mineral Resource Management at the University of the Free State in 2000 in collaboration with private sector (Comparex, now Business Connection) and Kumba.

Societies

Member of the following societies:

Fellow of the Geological Society of SA.

Archaeological Society of SA.

International Association of Volcanology and Chemistry of the Earth's Interior.



Spectroscopic Society of SA.

International Liaison Group on Gold Mineralisation.

Chairman Maccauw Gun Club (clay target shooting) for four years.

Registered as a professional scientist.

Most of above lapsed since retiring.

Business

Director Woodland Hills Wildlife Estate from 2001 until present (property development on the outskirts of Bloemfontein (includes houses, sectional title units and hospital).

Trustee of the Hillandale Homeowners association since inception (chairperson for four years).

Director and chairperson of the board of Hillandale Hospital (property investment and a private company leases the buildings.

Conducted some geotechnical and environmental work for Woodland Hills Wildlife Estate.